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Research Article

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Naturalism Fails an Empirical Test: Darwin's "Dangerous" Idea in Retrospect

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Abstract: In his theory of evolution by natural selection, Charles Darwin provided a plausible alternative to Christianity's creation account of human origins. In response, the Christian botanist Asa Gray suggested that the variation that drives evolution might be generated by God. Darwin rejected Gray's hypothesis, invoking philosophical naturalism, a hallmark scientific paradigm. Darwin's conclusion was reached on ideological grounds rather than empirical ones. I frame the question of the source of biological variation in a way that is accessible to modern experimental science and trace historical advances in biology that have accumulated to favor Gray's theistic view. In particular, I show that empirical evidence collected subsequent to Darwin's time contradicts the assumption of randomness in the mutation process, and thereby undermines the basis for his invocation of naturalism in the origins of biological variation.

Keywords: mutation, recombination, theistic evolution, Darwin, naturalism, genetics

1 Introduction

Charles Darwin hypothesized that life evolves by natural selection operating on abundant naturally occurring variation. Natural selection is the effect of differential reproduction rates due to differential fitness. Much discussion has ensued about whether life evolves by natural selection. Underlying the discussion is the question of the existence of God, whose creative role is subsumed by the paired processes of random variation and natural selection. However, randomness, considered in isolation, provides no support for theism. Randomness denies purpose. As will be shown, attributes are not randomly assigned to individuals, as would be expected if variations were indeed random. This article traces the history of the science behind genetic mutation and recombination, the two major sources of phenotypic variation. Both phenomena exhibit bias by gene function, the very characteristic that would be expected if attributes were being assigned to individuals in a purposeful manner. This bias has no known natural explanation. Darwin's assertion that random variation arises independently of its usefulness to the individual establishes a testable hypothesis.

Focusing on the question of whether life evolves by natural selection, in fact, obfuscates the question of God's existence. It is the absence of purpose in the introduction of variation, not the natural selection process itself, that refutes the existence of God. Rather than using natural selection as a proxy test for the existence of God, it is instructive to focus instead on the related but more fundamental question of whether variation is really random. By reframing the issue appropriately, it can be seen that evolution, in fact, supports God's existence. For the purpose of determining whether God exists, natural selection, *per se*, is a red herring. The ultimate creative processes in evolution, genetic mutation, and recombination are demonstrably nonrandom. Moreover, these processes exhibit bias by gene function, revealing purposefulness in

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the assignment of attributes to individual living beings. This result defies the scientific premise that all observable phenomena are explicable in natural terms. The nonrandom processes of spontaneous genetic mutation and recombination, unlike other observable natural phenomena, provide a means to know of the existence of God by observing the world.

2 Genetic Variation and Philosophical Naturalism

Darwin, lacking an understanding of genetics, could not explain the source of the variation on which natural selection acts.[1] Over 150 years after the publication of his *On the Origin of Species*,[2] modern genetics attributes genetic novelty to spontaneous DNA mutation and recombination.[3] Mutation accounts for the origin of new alleles or gene variations. Recombination is the source of new combinations of gene alleles, another kind of genetic novelty. Mate choice is a form of recombination, as is the Mendelian mechanism of independent assortment, the shuffling of homologous chromosomes during sexual reproduction. Another form of recombination is the "crossing over" process that shuffles DNA between individual chromosomes during meiosis. Broadly, whereas mutation creates the attributes, recombination creates the individuals that are combinations of these attributes. Ultimately, mutation is the original source of variation, but subsequent recombination supplies significant variation as well.[4]

Asa Gray, an American botanist and contemporary of Darwin and the primary supporter of his theory in the United States, suggested that God might be the source of the variation on which natural selection acts. Referring to Darwin's inability to account for the source of variation, historian of science Edward Larson explains, "Asa Gray… immediately seized on this gap in Darwin's argument to propose that God guided the evolutionary process by causing the beneficial variations that selection acts upon in evolving new species. Over the years, he developed this insight into a fully articulated theory of theistic evolution, but Darwin rejected it."[5]

Although Asa Gray's ideas were consistent with the empirical observations that Darwin made in his *Origin of Species*, Darwin relied exclusively on natural explanations. In so doing, Darwin conformed to, and helped to establish, the naturalistic paradigm of modern science. Larson explains, "Darwin's theory dispensed with the need for a Creator to design species: Natural processes alone could produce each feature, trait, and instinct of every species."[6]

This naturalistic account incorporates a random source of variation (Darwin used the word "chance"). Specifically, Darwin conceived that variation arises without any relation to survival needs – that is, it is independent of the fitness value of the variation.[7] Curtis Johnson observes that Darwin reworked his wording to adopt the phrase "spontaneous variation" to substitute for "chance variation" in later editions of his *Origin of Species*, largely to allay criticism from Christians. The use of the term "spontaneous" persists to this day in describing the occurrence of genetic mutations.[8] Johnson notes, "[…]'chance' (in its primary meaning for Darwin) would be regarded as a 'dangerous' idea."[9] The idea of chance, or random, variation would be developed further in the neo-Darwinian evolutionary synthesis that later reconciled evolution with Mendelian genetics.[10]

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[1] Larson, *Evolution*, 85.

[2] Darwin, *On the Origin of Species*.

[3] Mayr, *What Evolution Is*, 96–8.

[4] Futuyma, *Evolutionary Biology*, 283.

[5] Larson, *Evolution*, 86.

[6] Ibid., 90.

[7] Johnson, *Darwin's Dice*, xxi–xxiv.

[8] Ibid., 110.

[9] Ibid., xiii; Dennett, *Darwin's Dangerous Idea*.

[10] Mayr and Provine, *The Evolutionary Synthesis*.

Where Darwin invoked chance, Gray invoked its opposite, purpose. Based on the facts available to Darwin and Gray, the natural and supernatural explanations provide competing accounts for the source and nature of biological variation. In general, naturalism is “a theory denying that an event or object has a supernatural significance; specifically, the doctrine that scientific laws are adequate to account for all phenomena.”[11] Supernaturalism is “belief in a supernatural power and order of existence.”[12] In the philosophy of science terminology, Darwin’s theory of natural selection was underdetermined by the information available at the time. Absent any prior ideological commitment to naturalism or theism, but with openness to either possibility, Gray’s supernatural explanation was as valid as Darwin’s naturalistic one in terms of its ability to explain Darwin’s observations about evolution.

The tiebreaker in this debate was the application of the naturalistic paradigm of science, which says that all natural phenomena are explicable in terms of other natural phenomena. Darwin, who had attended a seminary with the intention of entering the ministry before his journey to the Galapagos, ultimately adopted the agnostic perspective of his protégé, T. H. Huxley. A Gray biography says of Huxley, “His agnosticism, not Gray’s argument from design, became the official policy of the Darwinian movement.”[13]

The problem with supernatural explanations in science, it has been said, comes down to the need for testability. A publication of the National Academy of Sciences (NAS) explains:

> In science, explanations must be based on naturally occurring phenomena. Natural causes are, in principle, reproducible and therefore can be checked independently by others. If explanations are based on purported forces that are outside of nature, scientists have no way of either confirming or disproving those explanations. Any scientific explanation has to be *testable* – there must be possible observational consequences that could support the idea *but also ones that could refute it*. Unless a proposed explanation is framed in a way that some observational evidence could potentially count against it, that explanation cannot be subjected to scientific testing.[14]

This statement by a leading publisher of empirical scientific research gives criteria for scientific truth: reproducibility and testability. Implicit in this statement is the assumption that all causes in nature are “natural causes” and purported nonnatural causes cannot be reproduced. In other words, they do not recur in a manner that can be tested. However, a statistical randomness test applied to DNA mutation and crossing over provides a way for the NAS criteria to be met for phenomena whose cause may in fact lie outside of nature. The phenomena are both reproducible and testable. The only factor preventing such a test from establishing divine action (referring to supernatural intervention by God in the natural world) is an ideological commitment to naturalism in scientific explanations. This singular violation of naturalism, given the absence of any natural explanation, falsifies the idea as a universal principle.

A lesson on the preeminence of naturalism in science can be found in Thomas Kuhn’s The Structure of Scientific Revolutions.[15] Kuhn’s groundbreaking thesis held that, in practice, scientists work within an established discipline. Such a discipline provides examples of the way to do science based on a tried-and-true framework that has been successful in the past. “Normal science,” what practitioners of a particular discipline do day in and day out, consists of “puzzle solving.” The current paradigm provides a framework that is accepted as valid, and scientific practice involves extending that paradigm to cover new applications. Like puzzle solving, there is an expectation that there will be a way to fit the pieces of data together in a sensible manner. There is presumed to be an answer that is consistent with the established paradigm. The scientist’s challenge in interpreting new experimental data is to find how the data fit the prevailing paradigm.

Kuhn showed that scientists can be misled when they appeal to a prevailing explanatory paradigm in spite of evidence to the contrary. His primary example was the Ptolemaic geocentric solar system model, which was eventually shown to be wrong and ultimately abandoned in favor of the Copernican heliocentric

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[11] Merriam-Webster, “Naturalism.”

[12] Merriam-Webster, “Supernaturalism.”

[13] Dupree, *Asa Gray*, 301.

[14] National Academy of Sciences, *Science, Evolution, and Creationism*, 10.

[15] Kuhn, *The Structure of Scientific Revolutions*.

system. Is it possible that science has been lulled into blind reliance on the naturalistic paradigm such that it is unable to recognize a miracle if it were to occur? Philosophical naturalism constitutes just such an ideological commitment to the naturalistic paradigm in scientific explanations.

Ironically, science has explained so much of the natural world that it has never been better equipped than it is now to certify a genuine miracle. A miracle is "an extraordinary event manifesting divine intervention in human affairs" (the healing miracles described in the Gospels are examples).[16] Science is "knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method." The domain of "natural science" is the physical world, or the "natural world."[17] At the same time that science has cemented the naturalistic paradigm by example after example where it has explained natural phenomena in entirely naturalistic terms, it has blinded itself to supernatural phenomena by making naturalism a matter of ideology. Philosophical naturalism refers to this ideological commitment to naturalism in scientific explanations.

3 Naturalism and God of the Gaps

Unlike Asa Gray, who was an interventionist, modern theistic evolutionists have by-and-large adopted the non-interventionist naturalism of the Darwinian and neo-Darwinian evolutionists.[18] This has blinded them to recognizing any miraculous processes active in the world. The success of naturalistic explanations would appear to provide support for naturalism as a universal principle, where God never intervenes in nature, precluding a "God of the Gaps" argument such as the one Asa Gray made. However, Darwin's naturalism and Gray's supernaturalism arguably both beg the question of the presence or absence of divine intervention. Darwin assumes all observable natural phenomena have natural causes, despite his admitted inability to identify them in the case of the origin of biological variation. Asa Gray's invocation of the supernatural to explain the origin of traits is condemned by modern theistic evolution as a "God of the Gaps" argument since it presumes the involvement of God in creating individual traits.

Robert Larmer has argued that there is nothing wrong with the reasoning behind God of the Gaps arguments since an adequate search constitutes logical grounds to establish the absence of whatever is being sought.[19] These arguments are more than simple arguments from ignorance, which would be fallacious:

> Usually, we find them utilizing a premise, whether it be implicit or explicit, that if a proposition P were true (or not true) then we should reasonably expect to find evidence for it being true (or not true). When we do not find such evidence we can take this as a kind of evidence that P is false (or true). If my son tells me that there is a Great Dane in our bathroom and I go look and find no evidence of a Great Dane, I conclude that it is false there is a Great Dane in our bathroom. My lack of evidence for it being the case that there is a Great Dane in our bathroom is good evidence that there is not a Great Dane in our bathroom because I have knowledge that if a Great Dane were there, there should be positive evidence to confirm its presence.[20]

Making the additional premise explicit transforms the argument in a positive way. Douglas Walton observed, "[…] [t]he transformation is based on the conditional that if you have looked for something, and clearly it is not there, then this observation can count as a kind of positive evidence that it is not there."[21]

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[16] Merriam-Webster, "Miracle."

[17] Merriam-Webster, "Science."

[18] Peters and Hewlett, *Evolution from Creation to New Creation*; Meyer and Nelson, "Should Theistic Evolution Depend on Methodological Naturalism?;" Leidenhag, "The Blurred Line between Theistic Evolution and Intelligent Design," 915–6.

[19] Larmer, "Is There Anything Wrong with "God of the Gaps" Reasoning?"

[20] Ibid., 130–1.

[21] Walton, *Arguments from Ignorance*, 134–5.

Larmer addresses the assumption that the "advance of science has increasingly diminished the gaps in our understanding of how natural causes can account for phenomena previously attributed to direct supernatural intervention."[22] Such an assertion is historically naïve according to Larmer, "[…]it is a cultural myth that such reasoning is or ever was the stock in trade of theologians."[23] More importantly for the Darwin/Gray debate over the source of variation is the other side of this double-edged sword of the advance of science:

> The claim of those defending gaps arguments is that we can know enough about the operation of natural causes to conclude that the explanation of certain phenomena in purely naturalistic terms is either unlikely or impossible. This claim can be undermined if, as science progresses, it becomes clear that a complete explanation of such phenomena purely in terms of natural causes can be given. Equally, however, it must be acknowledged that *this claim is strengthened if, as science progresses, the prospects of providing completely naturalistic explanations become increasingly remote*. Put a little differently, *this line of argument must grant the possibility that the progress of science has strengthened, rather than weakened, "God of the gaps" arguments*. The real issue is not whether "God of the gaps" arguments are in principle inadmissible, but whether there is good evidence for the claim that natural causes are inadequate to explain certain phenomena.[24]

The merits of Gray's invocation of supernatural causes are assessed here by considering the evidence uncovered by subsequent research. This evidence includes affirmative support for supernatural intervention in the form of observed bias by gene function, as well as an absence of natural causes that might explain such bias. In this field of science at least, the ground for a natural explanation has greatly diminished with each advance in understanding the nature and emergence of genetic novelty. The evidence accumulated by scientists in the years since Darwin wrote his *Origin of Species* strongly favors Gray's supernatural cause over Darwin's random variation plus natural selection.

4 Theistic Evolution (TE) and Intelligent Design (ID)

Modern theistic evolutionists have adopted a particular form of naturalism known as "methodological naturalism." This form differs from philosophical naturalism (also known as metaphysical naturalism or ontological naturalism), in that it does not claim that naturalism necessarily encompasses all of reality.[25] This agnosticism allows the theist to hedge on whether naturalism is a universal metaphysical principle by adopting naturalism only as a methodological constraint. However, to the extent that divine action is observable in the natural world, methodological naturalism nevertheless blinds the theist to seeing any divine action at all. If a supernatural process is at work in guiding evolution, the theistic evolutionist bound by methodological naturalism is as blind to it as is the Darwinian evolutionist. Like all forms of naturalism, this form adheres to the definition given earlier: "a theory denying that an event or object has a supernatural significance; specifically, the doctrine that scientific laws are adequate to account for all phenomena." Thus, to adopt naturalism as a methodological constraint is to accept the explanatory adequacy of natural laws and to deny any direct supernatural causation. Claiming this to be merely a methodological choice exempts the scientist from taking a philosophical position on whether naturalism holds as a general principle. Yet, the choice puts blinders on those who adopt it regardless of the motivation. Calling it merely a methodological constraint does not change that fact.

The Divine Action Project, convened to analyze theories of divine action, adopted methodological naturalism from the outset, precluding its participants from finding any observable miracles at work in the natural world.[26] One of its participants, Robert John Russell, advocates a theory of noninterventionist

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[22] Larmer, "Is There Anything Wrong with "God of the Gaps" Reasoning?," 136.

[23] Ibid.

[24] Ibid., [emphasis added].

[25] Larmer, "The Many Inadequate Justifications of Methodological Naturalism."

[26] Wildman, "The Divine Action Project, 1988-2003," 33.

objective divine action (NIODA), whereby God's providence, including the production of genetic mutations, paradoxically works without observable intervention in the natural world. Russell's view seeks a way to satisfy a liberal view of theistic evolution that denies divine intervention while also accommodating a conservative view that affirms intervention as necessarily a part of God's providence. In the liberal view, the problem with intervention is that it is anti-science in that it violates natural laws. Russell seeks a middle ground that invokes quantum indeterminacy to account for providential action, particularly as it applies to genetic mutation, within the bounds of natural law while preserving God's hiddenness in such processes. God causes mutations without violating natural causation.[27] Rather than showing the processes to be ontologically indeterminant, Russell and others advocating this view simply assert that God's providence must be scientifically unobservable.[28] Divine action in such a form is, in fact, interventionist, just not discernable by scientific observation.

Yet, whether a variation is supernaturally or naturally caused, its patterns are clearly apparent to scientific observation. Mutations manifest as phenotypic differences that have varying levels of fitness. Darwin attributed the directedness of evolution to natural selection acting on random variation. Scientists subsequently discovered that the differences correspond to differences in the genotype. The differences are due to different alleles with different DNA coding. These differences are not hidden. They are not due to indeterminism in genetic traits but rather to observable, identifiable differences in gene products. DNA copying errors are not due to indeterminacy in the outcome of the copying process but, rather, to failures to faithfully duplicate gene sequences during meiotic reproduction, or to the incorporation of alternative alleles from the homologous chromosome due to crossing over. DNA coding determines the protein phenotype through the specific amino acid sequence encoded in the gene. As will be shown, divine action is openly observable by examining the DNA sequences behind the phenotypes. Far from being hidden, the result of such action defies naturalistic expectations and consequently exposes divine action to scientific scrutiny.

Intervention in the natural order is not a violation of natural laws. C. S. Lewis observed: "The divine art of miracle is not an art of suspending the pattern to which events conform but of feeding new events into that pattern. It does not violate the law's proviso, 'If A, then B': It says, 'But this time instead of A, A2,' and Nature, speaking through all her laws, replies 'Then B2' and naturalises the immigrant, as she well knows how."[28a]

Larmer further explains

> Once it is understood that divine intervention violates no laws of nature, it becomes clear there is no justification for the typical NIODA claim that a condition of the possibility of special divine acts is that nature exhibits ontological indeterminism. Whether or not nature exhibits causal indeterminacy, God as its Creator is capable of acting upon it. The fundamental issue is not whether it is a closed or isolated system. It is true that if God brings about a special event that would not otherwise occur there will exist an explanatory gap solely in terms of natural processes, but such a gap is best understood as the result of God's action, not the prerequisite of such action. …to insist otherwise undermines any robust conception of special divine acts inasmuch as it sets immensely restrictive limits on what God can be thought to be able to bring about.[29]

A survey of modern theistic evolutionists concludes, "[m]ost theistic evolutionists today are noninterventionists." In this form, theistic evolution affirms a role for providence without requiring that God's involvement be scientifically observable. Science interacts with the world only at the level of secondary causes, which can be identified as natural laws and regularities, rather than primary causes, which refer to direct divine intervention.[30] God does not intervene in the natural world according to these theists. This is actually deism, not theism.[31] Asa Gray, on the other hand, saw unmediated divine action – a miracle – as the primary cause in the creation of variation, the engine behind Darwin's natural selection.

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27 Russell, "Special Providence and Genetic Mutation." Note that Nancy Murphy and John Polkinghorne advanced similar views.

28 Larmer, "Special Divine Acts," 78.

28a Lewis, *Miracles*.

29 Ibid., 80–1.

30 Peters and Hewlett, *Evolution from Creation to New Creation*, 32.

31 Meyer, "Scientific and Philosophical Introduction," 45.

Francis Collins, a well-known modern theistic evolutionist, asserted, "evolution could appear to us to be driven by chance, but from God's perspective the outcome would be entirely specified. Thus, God could be completely and intimately involved in the creation of all species, while from our perspective … this would appear a random and undirected process."[32]

Steven C. Meyer critiques this kind of reasoning:

> This tangled – indeed, even convoluted – view of the origin of living systems adds nothing to our scientific understanding of what caused living organisms to arise. As such, it also represents an entirely vacuous explanation. Indeed, it has no empirical or scientific content beyond that offered by strictly materialistic evolutionary theories. It tells us nothing about God's role in the evolutionary process or even whether or not he had a role at all. It, thus, renders the modifier "theistic" in the term "theistic evolution" superfluous. It does not represent an alternative theory of biological origins, but a reaffirmation of some materialistic version of evolutionary theory restated using theological terminology.[33]

Mikael Leidenhag similarly argues that such views, which he dubs Natural Divine Causation (NDC), are overdetermined[34] and suffer from a variety of other difficulties that make them conceptually unworkable: "[…]it is not only difficult to make conceptual sense of NDC, but … it more problematically introduces significant ambiguities into theistic evolutionism and … it makes God-talk redundant. My advice for those who subscribe to TE is to reject NDC in order to affirm a more robust notion of divine agency." However, he observes "if the theistic evolutionists were to give up on NDC, then they would move their position significantly closer to ID."[35]

Leidenhag discusses overdetermination as it relates to theistic evolution. He identifies it as "the philosophical problem of overdetermination; we cannot posit two sufficient explanations for one single event."[36] The idea draws on work by Philosopher Jaegwon Kim on his "causal exclusion" theory.[37] Leidenhag discusses epistemic compatibilism between agential/psychological causes (including divine causes) and mechanistic causes (including naturalistic evolutionary causes) in light of Kim's work. Compatibalism is the belief that free will and determinism are mutually compatible and that it is possible to believe in both without being logically inconsistent.[38] The discussion continues in critiques and responses to Leidenhag's article.[39] The issue is germane to whether naturalistic evolution and theistic evolution are really two different things or are, in fact, indistinguishable. If they are indistinguishable, then the idea of theistic evolution (and divine action) is simply redundant to naturalism and therefore explanatorily superfluous.

However, lost in the debate is the observation that Darwin's invocation of randomness to characterize biological variation in a sense is just a way of giving up in the quest for explanation. It is not a causal explanation at all but a characterization of the nature of the variation whose cause was unknown to Darwin, and only an unverified hypothesis at that. Darwin punted on the source of variation, and much subsequent scholarship has taken his stopgap explanation as a final word. To say that natural and theistic evolution posit two competing and incompatible causes for the same event is not a valid critique of theistic evolution, at least in its interventionist form, since Darwin did not really explicate a cause for the variation that he called random. Later, I sketch an experimental design that enables a scientific test of Darwin's hypothesis that variation is random and unrelated to the needs of the individual. The test employs statistical hypothesis testing, which is the workhorse tool of experimental science.

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[32] Collins, *The Language of God*, 205.

[33] Meyer, "Scientific and Philosophical Introduction," 48.

[34] Leidenhag, "The Blurred Line between Theistic Evolution and Intelligent Design," 917.

[35] Ibid., 910.

[36] Ibid., 928.

[37] Kim, *Supervenience and Mind*; Kim, *Mind in a Physical World*; Kim, *Physicalism, or Something Near Enough*.

[38] Coates and McKenna, "Compatibalism."

[39] Skogholt "I Walk the Line;" Leidenhag, "The Problem of Natural Divine Causation and the Benefits of Partial Causation;" Lim, "Natural Divine Causation, Causal Exclusion, and Overdetermination."

In adopting naturalism, non-interventionist theistic evolution implicitly accepts the Darwinian notion that evolutionary processes are able to produce the same adaptive result that was previously attributed to divine agency under Creationism. However, supporters of Darwinian theory have principally used it to make the point that since no divine intervention is necessary to produce the appearance of design in nature, God is explained away: "Far from pointing to a designer, the illusion of design in the living world is explained with far greater economy and with devastating elegance by Darwinian natural selection."[40] Intelligent Design takes up the mantle of the design argument by arguing that evolutionary processes are not sufficient for the task.

In contrast to theistic evolution, Intelligent Design (ID) advocates argue that supernatural intervention is the best explanation for observed design in nature. Michael Behe, a prominent ID advocate, asserts that there are biological features, such as bacterial flagellum, which are irreducibly complex and therefore cannot be accounted for by natural selection[41] Behe claims that, like a mousetrap, such features cannot function without all of their parts intact, and therefore, there is no way for them to have evolved by an incremental process. Behe later analyzed cases of actual mutation with respect to various bodily defenses against the malarial virus and found that the Darwinian mechanism of random variation and natural selection cannot or is unlikely to produce minimally complex biological machinery to effectively defeat malaria in humans.[42] The implication is that natural selection is ineffective. Behe conceives of the Darwinian mechanism occurring in the evolution of life but never passing the threshold of complexity necessary for an effective defense.

Behe's "edge of evolution" argument is similar to the specified complexity concept articulated by William Dembski, another ID theorist. Dembski identified an explanatory filter that would discern what threshold level of complexity would justify an inference of design. Dembski envisioned a stepwise filter that would explain complexity by known causes; failing that, by chance; beyond that, complexity exceeding the highest threshold would indicate design.[43]

In more recent years, Behe observed that studies have emerged which show natural selection to act only by disabling existing capabilities, thereby forestalling any future possibility of marshaling the genes that encode them for unforeseen challenges in the future.[44] One example is the genetic code that gives polar bears their white coat, which serves to conceal them in a snowy environment from their prey. The color is achieved by disabling the gene that imparts color to the ancestor brown bear's coat. Once the gene is disabled, it is no longer possible to recover its function for similar challenges that might arise in the future.

Behe proposes intelligent design as a solution to all of these deficiencies in Darwinism. However, the argument from design is based on the complexity of the end product rather than the features of the process (es) that produce it. Behe's critiques of Darwinism, spanning over 1,000 pages, are negative arguments. As such, he fails to offer a specific process alternative to Darwin's random mutation and natural selection account. Behe's lapse exposes a significant gap in his intelligent design arguments – the leap from process to end product is missing. Possibly, this is the vestige of long-running "evolution vs creation" debates that polarized the issue into opposing worldviews without allowing for the nuances of the real world. Out of an aversion to the atheistic implications of Darwinism, Behe has turned a blind eye to the study of evolutionary processes. His intelligent design proposal fails to engage with the component processes that make up evolutionary theory and thereby loses the ability to recognize the God acting within them to produce the actual manifestation of design. Thus, for different reasons, both the theistic evolution and ID camps are hamstrung from seeing divine involvement in evolution.

In *Darwin's Doubt*, Stephen C. Meyer, another ID theorist, focuses on Darwin's misgivings about his own theory in light of the lack of fossil evidence supporting the evolutionary origins of the animals first

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[40] Dawkins, *The God Delusion*, 24.

[41] Behe, *Darwin's Black Box*.

[42] Behe, *The Edge of Evolution*.

[43] Dembski, "The Logical Underpinnings of Intelligent Design."

[44] Behe, *Darwin Devolves*.

identified in the Cambrian explosion. This work builds on his earlier foray into chemical evolution as an explanation of the origin of life in *Signature in the Cell*. There, the case is made that the complex specified information encoded in cells can only be the result of intelligent design. *Darwin's Doubt* more directly addresses Darwin's theory. What is missing from the fossil evidence is a trail of more rudimentary predecessors building to the more advanced animals in the fossil record. Such a trail would corroborate Darwin's gradualist evolutionary theory. Meyer provides compelling arguments that the complexity of the animals that do appear in the fossil record is out of reach of the process of random variation plus natural selection. The information content of functional genes is tiny compared to the number of possibilities. Meyer's argument mirrors Behe's argument that random variation plus natural selection could not produce even a single novel protein.

Intelligent Design posits a designer but previously did not identify that designer as God. In Return of the God Hypothesis, Meyer connects the dots to support the existence of the personal God of theism. His argument uses the method of inference to the best explanation to adjudicate between the competing metaphysics of deism, theism, pantheism, and scientific materialism. Theism best accounts for the existence of a world with a finite origin. Additionally, a vast search space renders a trial-and-error process like Darwin's intractable. The existence of the digitally encoded information encapsulating the traits of DNA-based life is directly analogous to the known sources of intelligently designed artifacts from computer science, human literature, engineering, and other examples. Meyer's body of work is a thoroughly thought-out explication of design arguments for the existence of God.

Like Behe's ID, what is missing from Meyer's analysis is a process alternative to Darwin's random variation plus natural selection. Science has accumulated massive amounts of data supporting evolution. By exploiting evidence from genetics and microbiology, it is possible to formulate a scientifically testable hypothesis about the existence of God. It is possible to show that evidence from evolution in fact supports the existence of God. This requires embracing the data from these sciences, rather than denying or ignoring it. Further, it is possible to establish the hypothesis by statistical testing, the prevailing methodology in empirical science, and therefore more definitive (i.e., more "scientific") than inference to the best explanation.

Meyer offers arguments for why Darwin's mechanism could not have produced the beings discovered in the Burgess Shale, the site where the Cambian explosion occurred. However, like Behe, the central thesis of Meyer's Intelligent Design is not directly commensurable with that of evolution. Evolution is a claim about the process that produces all the varieties of life, whereas Intelligent Design is a claim about the nature of the purported end product. Darwin's challenge to the creationism that prevailed in his time was to assert that the appearance of design could be achieved through entirely natural processes. Meyer discredits this challenge by showing the process to be incapable of achieving such a feat. Further, Meyer argues that the evidence from the fossil record does not support the claims of the theory. If evolution driven by random variation cannot produce the appearance of design, it begs the question of what process in fact did produce the designed end product. An advantage that evolutionary theory has over Intelligent Design is that it accounts for the physical presence of its subject. It answers the question of where each creature came from. For DNA-based life, each individual was born of two parents, through a combination of the traits of the parents and the injection of some number of novel traits not present in the parents, by way of de novo mutation and/or recombination. The DNA encoded in the cells arises as a combination of genes contributed by the parents through the process of meiosis that precedes gestation and birth. Darwin asserted that the novel traits that accompany the parental ones are random changes. The range of novel information is greatly reduced since, for the most part, the individual is a combination of parental traits. It is not clear through what process the novelty arises in Intelligent Design, although the nature of the end product attests that it was intelligently designed. No process is identified.

Biology has made great strides in explaining the processes that account for the features of living beings. The unique structure of DNA, elucidated in 1953 by Crick and Watson, provides an unprecedented means for testing the randomness of variation. For DNA-based life, such a test is possible, as discussed below. It is known that features of humans and other eukaryotes are encoded in their DNA. Each offspring inherits most of its features from its parents. The differences are principally the results of the mutation of parental features and the remixing of various features from each parent to assemble a new combination (recombination). Intelligent design fails to address the details of the processes that produce each individual, instead focusing only on the apparent design of the completed product. However, evolution evidently occurs. Biologist Theodosius Dobzhansky famously opined, “Nothing in biology makes sense except in the light of evolution.”[44a] The regular structure of DNA presents a groundbreaking vehicle to experimentally test whether evolution is directed by a guiding intelligence.

Rather than consider philosophically whether naturalistic evolution could have accomplished the feat of producing the appearance of design, this article addresses instead the empirically testable question of whether it has in fact done so. The empirical observations surrounding genetic mutation and recombination from classical and molecular genetics are accepted in the manner that science approaches such information. They are used to test prevailing theories that purport to explain their occurrence. Such theories are always tentative and subject to revision when empirical evidence shows them to be wrong or inadequate. The question is shifted from whether evolution could produce an adaptive design to whether it has in fact done so, given the evidence that biologists have uncovered. The argument here is empirical rather than philosophical. The hurdle is that those who accept naturalism need to be open to the possibility that it may not always apply. Naturalism is the theory. If naturalism holds, then certain testable attributes of the evolutionary process should be true. It requires getting into the details of what scientific study has revealed about biological organisms and how they evolve.

5 Classical Genetics and Recombination

In Darwin’s day, Asa Gray’s suggestion, that God supplies the variation that powers evolution, could not be evaluated empirically because the mechanism for representing genetic information was unknown. Gregor Mendel’s work was unknown to Darwin. Even beyond the insights of classical genetics, the molecular basis of genetics would need to be worked out before scientists could begin to assess the processes involved in generating genetic variation. Mendelian genetics was not enough. What would be required is knowledge of the biochemical basis of heredity and the mechanisms of reproduction, the province of molecular biology.

Thomas Hunt Morgan’s fruit fly lab was instrumental in reconciling Mendelian genetics with evolutionary theory.[45] Morgan’s lab found experimental support for the chromosome theory of inheritance. That theory held that chromosomes are the bearers of genetic information. Historian of science, Larson observed, “Thomas Hunt Morgan sealed the bond between Mendel’s laws of heredity and material chromosomes during the early 1910s. In doing so, Morgan’s team laid the groundwork for the modern synthesis of genetics and Darwinism that has dominated biological thought ever since.”[46]

Morgan’s lab found experimental evidence that genes occupy particular locations on the chromosomes. After a long search that included attempts to generate mutations artificially, Morgan identified the “white eye” mutation in male fruit flies (Drosophila), an exception to the normal red eye. This mutation was found to be sex-linked and ultimately enabled the identification of gender as a trait that is genetically determined, specifically by the presence of certain chromosomes. Discoveries of many more gene alleles followed in subsequent years. These mutations were discrete changes to the nominal values found in most individuals. Changes of the type observed by Morgan’s group might serve as the raw material for natural selection when they confer a competitive advantage. The group also identified modifier genes that could explain continuously variable heritable “quantitative” traits such as height.

The mutations identified by Morgan’s group could each be identified with a particular location on one of the four Drosophila chromosomes. The observable attributes associated with the mutations were discrete variations from the more common “wild type” alleles, to which Morgan’s group gave descriptive names

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[44a] Dobzhansky, “Nothing in biology makes sense except in the light of evolution.”

[45] Morgan, *The Scientific Basis of Evolution.*

[46] Larson, *Evolution*, 166.

such as “scute,” “vermillion,” “eosin,” “truncate,” “bar eye,” and “speck.” As such, they were similar to the factors originally identified by Mendel in peas – attributes such as “wrinkled versus smooth,” “green versus yellow,” and “tall versus short.” Some factors are linked and therefore inherited together, while others are independent. The ones inherited independently are located on different chromosomes, while those inherited together are located on the same chromosome as each other.

Whereas Mendel’s factors all assorted independently, some of the fruit fly factors exhibit more complex inheritance patterns. Linked genes occasionally assort independently from the other genes on the same chromosome. These genes “crossover” from one chromosome to the homologous chromosome (the one from the other parent among each chromosome pair). Crossovers allow linked genes to assort independently to some extent, even though they lie on the same chromosome as each other. Such crossovers, which are recombination of existing alleles, constitute a second source of genetic novelty in addition to mutation. Therein lies the foundational importance of the Morgan group’s Drosophila work for evolutionary theory. Morgan biographer Garland Allen summarizes, “The new combinations of old characters, as well as the appearance of additional mutants and their successive recombination, provided the raw material on which natural selection could act.”[47]

Morgan hypothesized that the frequency of crossovers between two linked genes would increase with the distance between them on the chromosome, due to the greater number of chances for crossovers to occur provided by the additional chromosomal material. Those that lie close together would seldom crossover, while those farther apart would crossover more often. The frequency of crossovers between any two genes would correspond to the number of points between the genes at which a crossover could potentially occur. Based on this insight, Alfred Sturtevant, a student in Morgan’s lab, constructed the first gene map based on recombination rates between known gene alleles in Drosophila.[48] However, “Sturtevant noted… that the mapping procedure rested on the assumption that chromosome breaks were equally likely to occur at any point along the length of the chromosome.”[49] Sturtevant surmised that differences in map distances could be due to weak spots in the chromosomes rather than differences in the space between chromosome breaks.[50]

Morgan was an experimentalist. In his time, experimentalism was a new approach to science. Morgan criticized the approach of naturalists as speculative. Experiments allowed testing theories. Hypotheses are affirmed or contradicted by experimental evidence. Experimentalism provides a way to get at the truth by designing experiments to test theories. The approach went beyond simple empiricism. Morgan looked for a way to verify his conclusions independently by a different method when checking observations against a theory.[51] As an example, in the process of checking the gene map based on rates of recombination, he cited physical cytological (cellular) evidence that crossovers follow a non-random pattern with respect to chromosome location, an effect first observed in Drosophila by Theodosius Dobzhansky.[52] Consequently, the physical distances computed using recombination rates are not accurate, due to unequal rates of crossing over in different genetic regions. Morgan explains:

> An important reservation must be made here – one that geneticists have always been aware of. We have assumed that the chance of crossing over is the same at every level of the chromosomes. As will be shown presently, this may be inexact. The point is illustrated by a railroad time-table. The time a train takes between stations is a fair measure of their distance apart, but it is not exact. There may be grades or variations in speed, or waits at certain points in consequence of which the time between stations is not always an exact measure of their distance from each other. So it may be with the map distances. For, if crossing over should be more frequent in certain regions than in others, the map distances are only approximately true.[53]

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[47] Allen, “The Evolutionary Synthesis,” 372.

[48] Sturtevant, *A History of Genetics*, 47.

[49] Allen, *Thomas Hunt Morgan*, 176.

[50] Ibid., 177.

[51] Ibid., 328.

[52] Dobzhansky, “Translocations Involving the Third and the Fourth Chromosomes of Drosophila Melanogaster.”

[53] Morgan, *The Scientific Basis of Evolution*, 78.

The observation of crossover bias by chromosome location has been confirmed to be the case for all eukaryotic organisms that have been analyzed for such. DNA exhibits hot spots and cold spots of recombination activity in fruit flies, yeast, and mammals. Some DNA sites show high rates of crossovers; others show low rates or no crossover activity.[54] However, there is nothing about the structure of the DNA that would suggest the presence of weak spots to account for the varying rates of crossing over.

Morgan was a militant atheist.[55] His colleague Theodosius Dobzhansky explains:

> […]the direction of his scientific activity and his personality are incomprehensible without appreciating Morgan's deep-seated and uncompromising opposition to religion. It can be gleaned from some of his writings, although for obvious reasons he did not talk about it explicitly, except with a few intimates. The main goal of basic biology, in fact of natural science, was to show the invalidity of religious views of man and the universe. To do so one must dispel mysteries enveloping man and the world, because mysteries are the foundations and supports of religion. Because heredity was one of the mysteries, genetics was an important science demystifying this particular phenomenon of nature. Evolution was, needless to say, tremendously important, because it did away with the biblical story of creation of the world and man.[56]

Morgan's ideological commitment to atheism precluded supernatural explanations for physical phenomena. Morgan was fully committed to the naturalistic paradigm of science. The discrepancy between genetic distances and physical distances that he observed, along with the observation that genes occupy particular locations on the chromosome, suggests an obvious explanation that Morgan could not see. The observed recombination bias by chromosome location amounts to evidence of purpose in the assignment of traits to individual beings. Given that genes correspond to particular chromosome loci, the bias in rates of chromosome crossovers by locus amounts to a bias for particular gene alleles in the assignment of traits to individuals. Genes correspond to physical traits – their purpose so to say – as the white eye allele illustrates. A bias for crossover events at particular chromosome loci amounts to a bias for particular traits.

Absent a physical explanation for such bias, the process is inherently teleological. Absent any natural explanation for recombination bias by gene location, the correlation between gene location and gene function means that recombination bias amounts to evidence of divine action. The crossover events exhibit a preference for some functions over others, the very behavior one would expect if genetic attributes were being assigned to individual living beings in a purposeful manner. The process is evidently purposeful.

Morgan's work in classical genetics preceded the revolution in molecular biology that would later reveal the chemical basis of heredity in the form of DNA. Morgan himself did not know that DNA was the carrier of genetic information, nor did he know of the genetic code that specifies the production of proteins of varying lengths by corresponding variable-length sequences of DNA containing the genetic code. There were many unanswered questions. Given the success of the experimental approach to biology pioneered by Morgan and his colleagues at the fly lab, the prospect of explaining the mutation and recombination processes in natural terms must have seemed inevitable. Indeed, Morgan commented, "If the causal factors of variations that are inherited were known, it might be quite unnecessary to consider ultra-naturalistic arguments that attempt to give an 'explanation' of evolution. But it cannot be said that the causal factors of such variations have been discovered …. But with every advance in our knowledge of the chemistry and physics of living material, the possibility of finding a naturalistic explanation seems improved."[57]

6 Molecular Biology

Molecular biology was born when James Watson and Francis Crick solved the puzzle of the molecular basis of heredity by elucidating the structure of DNA. The four DNA bases always pair in the same manner,

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[54] Petes, "Meiotic Recombination Hot Spots and Cold Spots."

[55] Allen, "The Evolutionary Synthesis," 380.

[56] Dobzhansky, "Morgan and His School in the 1930s," 446.

[57] Morgan, *The Scientific Basis of Evolution*, 238–9.

Adenine with Thymine (“AT”) and Glutamine with Cytosine (“GC”). The pairs form the rungs of a spiral staircase-like structure. Since the bases always occur in the same pair-wise combinations, a means for replication is suggested where the rungs are split between each pair and two copies are constructed by completing each new pair by adding the corresponding missing base. Crick and Watson reported their result in 1953.[58]

The structure of DNA establishes an expectation for the distribution of point mutations, a term coined by Morgan to signify those mutations caused by a change at a single site on the chromosome, or more precisely now, DNA. Point mutations include base insertions, deletions, and substitutions and are the most common types of human DNA mutation.[59] In DNA, the individual base pairs are naturally isolated from each other. There are no chemical bonds between adjacent bases. Instead, bases are bonded to the sugar-phosphate backbone, which only indirectly holds bases next to each other. The nucleotide backbone carrier is the same regardless of the particular base bonded to it at a given site. The backbone, a sugar-phosphate polymer, is therefore independent of the sequence of bases bonded to it. As a polymer, it repeats the same chemical structure for each base. The two base pair types, GC and AT, are nearly identical to each other in shape,[60] differing by a single additional hydrogen bond in GC pairs. The independence of particular sites from each other is key to the suitability of the molecule as a stable information storage medium. Support for the independence of the particular base pairs at each site comes from Crick and Watson: “It should further be emphasized that whatever pair of bases occurs at one particular point in the DNA structure, no restriction is imposed on the neighboring pairs, and any *sequence* of pairs can occur. This is because all the bases are flat, and since they are stacked roughly one above another like a pile of pennies, it makes no difference which pair is neighbor to which.”[61]

7 A Test of Randomness

Considerations such as these indicate that each site is equally likely to mutate. Indeed, Watson’s molecular biology text makes the commonly invoked assumption that point mutations, which are rare in practice, are expected to be independent of each other and equally probable at each site on the DNA strand.[62] These characteristics match the assumptions of the Poisson probability distribution. The expected distribution, therefore, implies a test to determine whether mutations are random. A goodness-of-fit test comparing the actual number of sites having each mutation frequency with those predicted by the Poisson distribution constitutes a randomness test.[63] The null hypothesis for the test is that point mutations are randomly distributed versus the alternative that they are not.

However, this test yields a crucial epistemic bonus. Since gene location corresponds to gene function, a test for randomness with respect to gene location is equivalent to a test for randomness with respect to purpose, where the purpose is the function encoded by the gene. Darwin’s original conception that variation occurs independently of its fitness value is represented in this test because fitness is directly attributed to gene function and gene location equals gene function. Thus, randomness with respect to gene location is randomness with respect to fitness. Given that DNA sites correspond to particular genes and therefore particular biological functions, the null hypothesis corresponds to the naturalistic explanation and the alternative to the supernatural one. The test detects teleology or supernatural agency. As a test for randomness with respect to physical DNA location, this test meets the NAS criterion that scientific phenomena be testable. As an equivalent test for randomness with respect to purpose, the test reveals the involvement of a

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[58] Watson and Crick, “A Structure of Deoxyribose Nucleic Acid.”

[59] Antonarakis and Cooper, “Human Gene Mutation.”

[60] Watson, *The Double Helix*, 114.

[61] Watson and Crick, “The Structure of DNA,” 264.

[62] Alberts et al., *Molecular Biology of the Cell*, 243.

[63] Mead et al., *Statistical Methods in Agriculture and Experimental Biology*, 316–22.

purposeful agent. The epistemic obstacle to detecting purposeful supernatural agency cited by NAS is overcome through its relation as the logical negation of random naturalistic agency. The supernatural alternative hypothesis entails the existence of God.

This test sidesteps a problem inherent in design arguments for the existence of God based on the complexity, adaptiveness, usefulness, or other attributes of the end product in question. Such arguments include William Paley's watchmaker analogy,[64] Michael Behe's irreducible complexity,[65] Stephen C. Meyer's complex specified information, William Dembski's specified complexity,[66] and fine-tuning.[67] Darwinism asserts that the appearance of design in the end product is only an illusion. According to the theory, evolution can produce results that are indistinguishable from those that are purposefully designed.[68] There is no way to discern from looking at the end product whether it is the result of purposeful agency or random variation and natural selection. Darwinian evolution mimics purposeful agency. Variation occurs without purpose, and natural selection favors a serendipitous result that is indistinguishable from an intelligently designed one.

By contrast, the test here is a process test rather than a test of the end product. The process that generates genetic novelty is assessed directly rather than through the attributes of the end product to which it contributes. It detects God in the act of creation. The test does not depend on what the attribute's fitness value (or purpose) may or may not be, only on whether it is generated independently of the location (and therefore purpose/fitness value), as the physical characteristics of DNA predict it should, and as Darwin originally predicted. Simply stated, if variation occurs independently of its purpose, mutations should be equally likely at each DNA site. The Poisson test amounts to a methodology to compare mutation rates between sites. Since they each have the same physical characteristics, they should have the same mutation rates under the assumption that naturalism applies.

By way of precedent, a well-known example where the Poisson distribution was used to detect purposeful agency was a study of the pattern of buzz bomb attacks on London during World War II. The British had accurate data on the geographical coordinates of each hit and wanted to know if the bombs were being directed precisely to each target or were simply landing haphazardly. They divided a section of London into small, equally sized squares and counted the number of hits in each square. They compared the number of squares with zero hits, one hit, and so on to those predicted by the Poisson distribution. In their case, the fit was considered to be a good one. The author concluded that the pattern was random and the enemy was not precisely targeting their guided bombs.[69] The squares making up the London neighborhood in the British study can be compared to the sites on the DNA. The agent directing the bombs in the London study was found to be random. If the data had not fit the pattern predicted by the Poisson distribution, the null hypothesis would have been rejected in favor of the alternative hypothesis that the bombs were indeed intentionally guided to their ultimate destinations.

When the range of explanations for scientific phenomena is expanded to include nonnatural causes, a test for the randomness of spontaneous mutations or crossovers with respect to DNA site is effectively a test for the existence of God due to the identification of gene function, and therefore purpose, with DNA location. Mutation or crossover bias by DNA site is purposeful since, over 150 years on from Mendel and Darwin, the processes involved in the introduction of genetic variation are well known, yet there is no natural cause that would account for such bias, given the simple, regular DNA chemical structure.

Confirmation of a random distribution supports the null hypothesis, whereas a nonrandom distribution favors the alternative. The alternatives exhaust all possibilities. Such techniques are part and parcel of the tool kit used by empirical science every day. The hypothesis that mutation is random, and the alternative hypothesis that it is not, form the kind of null/alternative hypothesis pair that is the standard formulation in

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[64] Ratzsch, "Teleological Arguments for God's Existence."

[65] Behe, *Darwin's Black Box.*

[66] Dembski, "The Logical Underpinnings of Intelligent Design," 311–30.

[67] Sober, *The Design Argument*, 61–76.

[68] Crick, *What Mad Pursuit*, 138.

[69] Clark, "An Application of the Poisson Distribution," 481.

empirical science and statistical hypothesis testing in general. Observational data that refute a null hypothesis that mutation is random argue for the acceptance of the alternative hypothesis that it is not. A non-random distribution of mutation events is a testable observational consequence of the existence of God, thereby meeting the testability requirement of the NAS.

8 Point Mutations

Seymour Benzer first noted a lack of fit as reflected in hot spots and cold spots of mutation activity on his frequency plots of point mutations of the bacteriophage rII gene. Hot and cold spots violate the equal probability of point mutations at each site required by the Poisson distribution.[70]

Benzer and Watson had both done genetic research with bacteriophages (bacterial viruses). Benzer had been pursuing a line of research aimed at determining the structure of genes. He was thus approaching the same problem that Crick and Watson had been pursuing, but Benzer worked from the angle of genetic analysis in the tradition of Morgan's fly lab, albeit in a finer-grained form applied to individual nucleotides, whereas Crick and Watson sought a structural chemistry explanation. Benzer had happened upon an experimental technique that allowed him to isolate the precise location of genetic mutations on a section of a bacteriophage chromosome, the rII gene. His technique could identify locations with resolving power sufficient to locate individual nucleotide pairs.[71] He had been working on mapping the rII genes in detail. His "Fine Structure of a Genetic Region in Bacteriophage,"[72] followed Crick and Watson's article on DNA by two years. Benzer's study showed that the rII gene mutations occur at sequential locations consistent with the linear arrangement of bases hypothesized by Crick and Watson. His work thus provided timely experimental support for Crick and Watson's theory,[73] as did similar work by Milislav Demerec.[74]

Benzer referred to his map of the location of mutations in the rII region as a topology, a map showing the spatial relationships between genetic material. In the case of DNA sites, the map is linear. Benzer followed his topology with an analysis of mutation rates – that is, a study of the rates of occurrence of the mutations he had isolated in his topology. He referred to this latter analysis as topography. The topographical map invoked the visual image of a frequency bar plot to provide the elevations of genetic change to go along with the locations of genetic data on the topological map.

Benzer's topographical map was an echo of Morgan's analogy of travel time between the waypoints on a train route, where elevated rates of mutation at some sites represented the variations in mutation rates among DNA locations like the variations in travel time between equidistant waypoints. For a given DNA site, the topography showed the rate of change for the particular bit of DNA data located at that site. Whereas the topology showed the waypoints on the DNA map, representing individual DNA bases, the topography showed their pattern of change in a given unit of time, or more specifically, for a given number of replications. This latter study, "On the Topography of the Genetic Fine Structure,"[75] sought to answer the question "are all the subelements equally mutable? If so, mutations should occur at random throughout the structure and the topography would be trivial."[76]

The anomalous result was a topography that was far from trivial. The rates of spontaneous mutation are highly non-random, contrary to the expectation from the DNA structure. Some sites were dubbed "hot spots" for their exceptionally high rates of mutation. Moreover, when compared to mutations induced by human intervention through chemical mutagenic agents, the pattern of spontaneous mutation was

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[70] Benzer, "On the Topography of the Genetic Fine Structure."

[71] Benzer, "The Fine Structure of the Gene," 74.

[72] Benzer, "Fine Structure of a Genetic Region in Bacteriophage."

[73] Crick, "The Double Helix," 143.

[74] Carlson, *Mutation*, 87.

[75] Benzer, "On the Topography of the Genetic Fine Structure."

[76] Ibid., 403.

significantly different. Whereas the topography should have been characteristic of a simple Poisson distribution where each site was equally likely to mutate, it was in fact an intricate landscape with irregular peaks and valleys, representing unexpected persistent hot spots of varying magnitudes as well as cold spots.

Benzer did fit his data to a Poisson distribution as a way of estimating the number of sites with no mutations, which would not otherwise be apparent from his technique. Although he did not perform a formal goodness-of-fit test, the fact that he fit his data to the Poisson distribution reflects an expectation that, theoretically, mutation should be equally likely at each site. When the possibility is considered that Benzer was observing raw divine action, unmediated by any natural cause, his explanation of the anomaly is earth-shattering: "[…]the distribution of repeats is far from random. The topography for spontaneous mutation is evidently quite complex, the structure consisting of elements with widely different mutation rates."[77] This is an apt description for the methodical action of a divine craftsman fashioning new living beings; not so for the blind action of random chance.

Benzer, who expressed a complete lack of interest in religion from childhood,[78] was unlikely to see miraculous causes behind his results. He attempted a naturalistic explanation. Benzer speculated that genetic sequences that were higher in AT content would be more mutable due to a weaker pair bond between the bases as compared to GC.[79] Could this simple bimodal effect explain the high level of variability in mutation rates among DNA sites in his reported data, particularly in light of the factors isolating individual base pairs from each other mentioned previously? In a letter to Sydney Brenner, he emphasized the perplexity of the nonrandom pattern in apparent contradiction to his simple pair-bonding explanation: "But the mutation rates still make no sense in terms of simple-minded ideas (i.e. without recourse to very long range 'paragenetic resonance' or 'benzerine')."[80] Benzer's work predated the discovery of the genetic code as well as later gene sequencing technology. He did not know the DNA sequences behind his mutation rates. Francis Crick acknowledged the anomalous mutation pattern in a letter of his own to Sydney Brenner after a 1956 conference he attended where Benzer presented his findings up to that point: "However, the mutation behaviour does *not* fit the [Watson-Crick] simple mechanisms. In general, the back rates [that is, the frequency of reversions from a mutant to the wild form] appear too fast, and the observed rates are all over the place."[81] Horace Judson further comments, "Crick tried out a couple explanations – unconvincing ones that signified only that he had begun to give thought once more to the mechanisms of mutation."[82]

Benzer's work with the humble bacteriophage was published over fifty years ago. In the intervening period, mutation rates have been studied for all sorts of life. The DNA code is universal to all higher plants and animals.[83] James Watson, in his book *DNA: The Secret of Life* captured this observation succinctly: "a piece of DNA after all is finally still DNA, its chemical properties the same irrespective of its source."[84] In spite of the universality of DNA to all life, a modern genetics textbook notes, "the [spontaneous mutation] rate varies considerably among different organisms," and "even within the same species, the spontaneous mutation rate varies from gene to gene."[85] Neither effect is expected given the omnipresent characteristic DNA structure among different organisms and among individual genes within a particular species. Moreover, the same nonrandom pattern first seen in bacteriophage has also been observed in mammals.[86] The nonrandom pattern of spontaneous mutation by DNA site is as universal as the DNA code itself. What's

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[77] Benzer, "The Fine Structure of the Gene," 80–1.
[78] Benzer, "Seymour Benzer, Interview by Heidi Aspaturian."
[79] Ibid.
[80] Benzer, "Letter from Seymour Benzer to Sydney Brenner," 299.
[81] Crick, "Letter from Francis Crick to Sydney Brenner."
[82] Judson, *The Eighth Day of Creation*, 323.
[83] Crick, *What Mad Pursuit*, 170.
[84] Watson and Berry, *DNA*, 94.
[85] Klug and Cummings, *Concepts of Genetics*, 465.
[86] Wolfe et al., "Mutation Rates Differ Among Regions of the Mammalian Genome."

more, nonrandomness by DNA site has been observed for chromosome crossover recombination events, just as it has for mutation, as noted earlier.

The presence of bias by gene location was recently reaffirmed in a study of mutation rates at different genetic locations in the plant *Arabidopsis thaliana* published in the journal Nature.[87] A researcher noted evidence that mutation bias is the cause of the variation, in a commentary on the phenomenon, "differences between genomic regions in DNA-sequence variation within a species (known as polymorphism) and between species have been commonly explained by variation in selection – but they might also be caused by a variation in mutation rate. Indeed, the authors observe a striking similarity between mutation-rate variation and polymorphism variation among genomic regions in *A. thaliana*, suggesting that the latter is largely attributable to the former."[88]

James Watson remarks on the phenomenon of site-specific spontaneous mutation bias in his classic text on the gene: "The overall rate at which new mutations arise spontaneously at any given site on the chromosome ranges from about 10^{-6} to 10^{-11} per round of DNA replication, with some sites on the chromosome being 'hotspots' where mutations arise at high frequency and other sites undergoing alterations at a comparatively low frequency."[89] There is nothing in the structure of the DNA to account for this variability. Individually, mutations are rare since the vast majority of sites replicate faithfully. However, when mutations do occur, they often exhibit bias for particular sites (hotspots); that is, they tend to occur at the same sites as other mutations. The magnitude of the variability is large, as Watson's text acknowledged: "Thus, an average nucleotide is likely to be changed by mistake only about once every 10^9 times it is replicated, although error rates for individual bases can vary over a 10,000-fold range."[90] Watson's characterization of these mutations as mistakes and errors reflects his commitment to the prevailing naturalistic paradigm of science.

Despite the ubiquity of site-specific mutation bias throughout DNA, science has only offered partial explanations for such phenomena. Watson's text cites the example of DNA sequence CA repeats: "The replication machinery has difficulty copying such repeats accurately, frequently undergoing 'slippage'."[91] This is a possible partial account for one type of insertion or deletion mutation but does not amount to an explanation for pervasive mutation bias. Without a description of the "slippage" mechanism, it amounts to empty hand-waving. Explanations like this one and Benzer's invocation of a relatively weaker AT pair bond propose to explain some cases, but there are numerous anomalies and unexplained observables that remain unaccounted for by any comprehensive theory. These are the kind of "partial fit" explanations that one would expect to occur when applying naturalism to a phenomenon that defies explanation in naturalistic terms.

Watson, an atheist,[92] would presumably be no more open to a miraculous cause than was Benzer or Morgan. Nor would Francis Crick, who, like Morgan, cited his atheism as a motivation for his work in biology, in a conversation reported by Horace Judson: "An important reason Crick changed to biology, he said to me, was that he is an atheist, and was impatient to throw light into the remaining shadowy sanctuaries of vitalistic illusions."[93] The biologists closest to the discovery of the processes that originate genetic novelty were firmly wedded to the naturalistic scientific paradigm.

9 The Advance of Science and Genetic Variation

Is there now good evidence for the claim that natural causes are inadequate to explain the origin of genetic variation? Robert Larmer notes: "A key question in addressing this issue is the question of under what

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[87] Monroe et al., "Mutation Bias Reflects Natural Selection in *Arabidopsis thaliana*."

[88] Zhang, "Important Genomic Regions Mutate Less Often," 39.

[89] Watson et al., *Molecular Biology of the Gene*, 236–7.

[90] Ibid., 257.

[91] Ibid., 237.

[92] Watson and Berry, *DNA*, 403.

[93] Judson, *The Eighth Day of Creation*, 109.

conditions is the failure to find evidence of something good reason to conclude that it is not present. The failure to find something can only be considered good evidence that it is not present if it is reasonable to suppose that one's search procedure was adequate to detect it."[94] Larmer identifies sufficient time and research thoroughness as factors necessary for an adequate search procedure.[95]

Biologists have been searching for over 150 years and are no more able today to identify a naturalistic cause for biological variation than was Charles Darwin. Recent attempts to explain observed mutation bias in natural terms have been as inconclusive as those in Benzer's time. A recent review study seeks connections between gene sequence and the rate of mutation at the sites where the genes are encoded and attempts to find statistical correlations between gene sequence and mutation rates.[96] What is lacking in such accounts is a mechanism, or causal story, whereby a gene influences its own mutation rate. Correlation does not imply causation. Unlike the well-understood molecular mechanisms whereby DNA is translated into RNA and then into proteins by the action of ribosomes, which then perform myriad functions by the way the proteins fold, there is no equivalent Rube Goldberg connection between gene sequence and a gene's mutation rate.

Lee Spetner suggested that the genome controls its own mutation rate by epigenetic mechanisms, whereby random mutations are increased in response to environmental stress. However, no such mechanism has been identified. Its existence is simply a matter of speculation. While thoroughly critiquing commonly accepted mechanisms from the neo-Darwinian evolutionary synthesis, Spetner's second book on the subject only conjectures about the presence of an alternative epigenetic mechanism and leaves the specification of the actual apparatus itself as a subject for future research.[97] No specific DNA sequences, enzymes or other proteins, or molecular apparatus are identified. The fact that scientists continue to publish accounts attempting naturalistic explanations demonstrates that no consensus explanation for mutation bias has emerged.

Darwin conjectured that variation must arise "spontaneously," independent of its usefulness to the individual. Yet, it was subsequently established that variation is highly biased by gene location, and therefore by gene function, and consequently by usefulness to the individual. About 75 years after Darwin, Morgan admitted that a naturalistic cause for genetic variation was still unknown.[98] Recent studies admit to an ongoing inability to find naturalistic explanations for what causes genetic variations to arise or, crucially, why variation strongly favors some DNA sites over others: "Although there is substantial evidence that mutation rates vary among taxa, relatively little is known about the factors that underlie this variation at an empirical level, particularly in multicellular eukaryotes."[99] "The mutation rate varies over many different scales, from adjacent sites to whole chromosomes, with the strongest variation seen at the smallest scales. Some of these patterns have clear mechanistic bases, but much of the rate variation remains unexplained, and some of it is deeply perplexing."[100]

10 Conclusion

In the introduction of genetic variation, the general failure of fit between observational data and the expected distribution constitutes an exception to the naturalistic paradigm. Empiricism and naturalism demand contradictory conclusions in this case. Only if the requirement that all phenomena be explainable in naturalistic terms is relaxed, is it possible to see that the observational data favor a miraculous cause.

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[94] Larmer, "Is There Anything Wrong with "God of the Gaps" Reasoning?" 136.

[95] Ibid., 137.

[96] Rogozin, "Theoretical Analysis of Mutation Hotspots and their DNA Sequence Context Specificity."

[97] Spetner, *The Evolution Revolution*, 139–45.

[98] Morgan, *The Scientific Basis of Evolution*, 238–9.

[99] Baer et al., "Mutation Rate Variation in Multicellular Eukaryotes."

[100] Hodgkinson and Adam, "Variation in the Mutation Rate Across Mammalian Genomes."

Absent an ideological commitment to philosophical naturalism, the empirical data favor an extrinsic nonrandom cause over an intrinsically random one. The data favor Asa Gray's interventionist theistic evolution hypothesis with a purposeful, nonrandom source of variation over the naturalistic evolution hypothesis of the neo-Darwinian synthesis with its random variation. The empirical evidence from the creative engines of evolution, namely, genetic mutation and recombination, supports rather than refutes the existence of God.

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