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Article

Teleology and the Origin of Evolution

Sy Garte

Darwinian evolution is not synonymous with change; it is a uniquely biological process. The biochemical mechanism of evolution is distinct from the observations made by Darwin on hereditable variation and natural selection. The key to biological evolution is a tight linkage between inheritable genotype and gene-directed phenotype, which allows the phenotype to be the target of selection. It is theoretically possible for some forms of life to exist without evolution; thus, the origin of life and the origin of evolution are two separate research questions. The classical problem of teleology in biology may be approached by a close examination of the mechanism behind the universal genotype-phenotype linkage: the protein synthesis or translation system. This solution to the problem of converting nucleic acid chemistry into protein chemistry may be the fundamental root of teleonomy and inherent teleology in living organisms.

If we believe that God created life to evolve to humans as image bearers,[1] then we can think of God's will to have living animals capable and desirous of a relationship with him as the final cause of evolution. However, some Christian thinkers, both currently and in the past, have found it difficult to reconcile Darwin's theory of evolution with the theological view that God created our universe and all life purposefully. Claims from biologists that evolution is a blind process, reliant on random mutations, and without any apparent direction or purpose other than to produce creatures able to survive in a particular environmental niche do not seem to be consistent with the Christian concept of an actively creative God who used evolution to produce creatures able to worship him. Most scientists and philosophers, including Christians, have been skeptical at best about the idea of purpose in evolution, and some have claimed that any form of teleology is contrary to the very fabric of Darwinism.

However, there are indications that evolutionary biology itself is moving toward a far more complex view of how biological variation is produced,[2] and a good deal of evidence has shown that there are, very likely, sufficient constraints on evolutionary developments to allow for at least some degree of direction.[3] I will, in what follows, lay out a case for a positive view of the role of teleology in the progress of life based on our scientific knowledge of the origins of evolution.

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Evolution in Biology and Elsewhere

Evolution is a form of change, and change is a universal feature of our universe. Stars form and explode, planets collide with asteroids, black holes absorb huge amounts of matter, and galaxies move farther from each other. On our planet change has always been the rule: changing climates, changing atmospheres, changing landscapes. When Charles Lyell and Charles Darwin looked at natural history, they saw change as a key feature of geology and biology, respectively.

Habitats changed and species went extinct. Darwin used his observations of living forms—as well as his knowledge of changes made by humans to plants and animals—to propose his theory of evolution of life based on natural selection of the most fit variants in a population.[4]

It has become a commonplace theme that evolution by natural selection is a universal phenomenon that not only leads to the origin of new species, but also to changes in human societies, technology, language, culture, and many other areas. We now talk about the evolution of computer programs, music-playing devices, memes, and just about everything else—and it is, of course, true that selection can operate outside the biological evolutionary framework. But selection alone is not sufficient for a process to be considered equivalent to Darwinian evolution.

Chemical selection allows for molecules that are more resistant to hydrolysis to survive longer. Everything from RNA molecules[5] to computer programs[6] has exhibited selection, in that individuals with higher fitness tend to survive longer and eventually dominate their populations. Some have pointed to all of technology as being subject to natural selection,[7] as competition between brands leads to innovative and improved types of computers, cell phones, and so on. There is extinction (sometime even mass extinction such as that of all brands of 8-track tape players); there are explosions of brand-new functions (telephones becoming cameras); and there is also slow, steady progress in some lineages in which the basic form and function have hardly changed at all (automobiles, for example). Human societies also evolve through processes that seem quite similar to the model of survival of the fittest described by Darwinian evolution.[8]

But none of this nonbiological change is really Darwinian evolution. In some cases, the selection step is conscious and volitional, arising from choices made by human beings, and is therefore akin to what Darwin knew as artificial selection in the breeding of plants and animals.[9] Technological evolution is removed from the Darwinian paradigm in that devices do not replicate themselves, so the target of selection is not the device but the mind of the consumer and/or the decisions of corporate manufacturers and marketing specialists. Furthermore, there is no Darwinian mechanism that can be applied to the innovation of new technologies.[10]

In reality, and contrary to the assertions of some leading Darwinists, Darwinian evolution by natural selection is a strictly biological theory, and does not apply to any of the myriad of nonbiological examples of change. Evolution by natural selection requires three uniquely biological characteristics before it can operate. These are mortality, inheritance, and genetic variation, each of which is a property of all modern living cells.

Mortality allows for the emergence of new individuals with similar but not identical features. Inheritability is achieved by accurate replication of the genetic informational molecule. Darwinian natural selection requires that the genetic sequence of the replicator is passed on to progeny with enough accuracy so that the selective advantage possessed by the original sequence is still present in the offspring.

Natural selection acts on the phenotype, but only the genotype can be passed from one organism to its progeny by biochemical means;[11] therefore the key to biological evolution is a tight linkage between inheritable genotype and gene-directed phenotype. In modern evolvable life, when an organism inherits a particular genotype, it also inherits the corresponding phenotype that is produced (or coded for) by that genotype. This allows the phenotype of the individual or a group of individuals to be the target of selection imposed by the environment. Advantageous genetic mutations are passed down, increasing the fitness of populations, and eventually creating new species and producing diverse patterns of complexity and adaptation of living beings to their surroundings.[12]

The linkage of genotype and phenotype is an essential characteristic of evolution by natural selection. Once a cell that can connect genotype and phenotype in this way exists, it can begin to evolve—but until we have such a cell, no evolution is possible.

The Origin of Evolution

Since evolution provides an enormous selective advantage to life, it seems to be a very straightforward conclusion that evolution evolved early on, and once in place, non-evolving life forms rapidly went extinct. Therefore, it is generally assumed that the origin of life and the origin of evolution were contemporaneous and inextricably linked together.

It is not at all clear, however, whether the first life forms could evolve, or how evolution first evolved. The mystery of the origin of life should really be called the mystery of the origin of evolution. The origin of evolution is, in fact, the "hard problem" in abiogenesis. It is very difficult to imagine a Darwinian type of evolution that could produce Darwinian evolutionary mechanisms including genetic inheritance, genetic variation, and genotype-phenotype linkage.

The central issue of the origin of evolution is chemistry becoming biology. For that to happen, early life had to solve a very difficult chemical problem: to take one chemical system (nucleic acid chemistry) and have it interact with and provide information to a completely different chemical system (protein and amino acid chemistry).

Life could exist without facing that problem, but it would not evolve. It might change and it might even improve (transiently), but it cannot undergo any kind of long-term Darwinian evolution in which improvements are maintained in succeeding generations unless the chemical system that gets inherited (nucleic acids) can be translated into the chemical system that is the target of evolution (proteins). In other words, there needs to be a chemical link between the genotype and the phenotype for evolution to happen. While there are some affinities between certain amino acids and some arrangements of nucleic acids,[13] the chemistry of DNA and the chemistry of amino acids or proteins are fundamentally different. It is, therefore, worthwhile to further explore the existence of a nucleic acid-to-protein transformation code (the genetic code), and the amazing molecular mechanism that allows the information in the genes to become the characteristics of the cell.

We know that in most cases of biological evolution, new structures or functions start out as rudimentary and are perfected with time. This is called the Continuity Principle.[14] For the replication/translation system, this would imply starting with an error-prone mechanism that gradually improves through natural selection. But if either genotype replication or DNA-to-protein translation were highly error-prone, then evolution as we know it would not occur. Wolf and Koonin discuss "… the formidable difficulty of breaking this transition into incremental steps associated with a biologically plausible selective advantage, thus making the entire transition compatible with the Continuity Principle."[15] These authors postulate that the RNA world could provide an answer to this conundrum, while admitting that "staggering complexity is inherent even in the minimally functional translation system."[16]

This does not, however, rule out other forms of evolution, such as highly error-prone systems, that are still in the process of being elucidated.[17] The possibility that the modern system arose from a more primitive system is strengthened by the fact that the ribosome, a structure at the heart of modern protein synthesis, contains not only proteins but also ribozymes, enzyme-like catalysts made of RNA (see below). This is consistent with theories of a precursor to modern life based on RNA, with no single genotype molecule, and only a few protein enzymes.[18] But there is not enough information currently available to be able to construct a solid theory about the origins of the biochemical mechanisms that provided the modern, universal genotype-phenotype linkage required for evolution to operate.

Leaving aside the question of how the translation system complete with genetic code appeared, we can look at the final working system as the engine of all subsequent Darwinian evolutionary changes, and ask questions about the philosophical implications of such a system existing at the heart of all of biology. How all of this fits into the question of teleological processes in evolution will be discussed below.

Teleology in Biology

The idea of biological progress was attacked by Stephen Jay Gould, who reminded us that there are still more bacteria than everything else combined, by both numbers and mass.[19] And yet, evolutionary progress, in one sense, does appear to be real as attested to by a wide spectrum of thinkers, from Richard Dawkins[20] to Conor Cunningham.[21] While many measures of such progress can be used, the increasing degree of complexity of the most complex creatures is evident throughout the vast period of evolutionary time. Related to evolutionary progress is the concept of teleology.

Early biological theories of change included William Paley's design-based teleology (God as the Designer) and the Aristotelian concept of final causation (the end purpose of the change) as crucial components.

As an example of the latter, it was believed that giraffes kept straining their necks in order to reach the tall leaves, and eventually got longer necks that they passed down to their descendants. The Lamarckian idea that creatures can pass on altered traits to their offspring fit into this teleological view quite nicely.

Several authors have pointed out that one of the most important contributions of Darwin's great theory was to refute the teleological view and to place biology squarely in line with the other sciences, independent of purpose.[22] The Aristotelian concept of telos as the final cause of a chain of events no longer held in the light of natural selection.[23] Darwin's proposal that natural selection is the alternative to purposeful causation (e.g., artificial selection) was the crowning achievement of the effort to take biology out of the realm of the mystical and supernatural.

Almost a century later, when the modern synthesis of evolution and genetics had begun to revitalize Darwinism and led to the birth of neo-Darwinism,[24] teleology in biology was dealt another blow by research into the nature of mutations. Although DNA was yet to be discovered as the genetic molecule, biologists were examining mutations in experimental systems of bacteria to answer questions about purpose and chance in mutation production. The issue was whether bacteria undergo mutations specifically in those genes that would help them survive an environmental stress such as starvation or exposure to toxic drugs. If they do not, the alternative is that mutations are generated randomly and the environment selects those that confer a survival benefit.

Luria and Delbrück seemed to have answered this question with an elegant system called fluctuation analysis.[25] The results of these experiments were clear: mutations were random, and then selected for their relative fitness. This finding contributed to the emerging neo-Darwinian synthesis, with molecular genetics playing the key role in the production of phenotypic variation. It also confirmed the idea that purpose is replaced by chance in the mechanism of the first stage of evolution.[26]

This idea became ingrained in the biological dogma, and as more and more data regarding the nature of genes and how they operate and change became available, the prevailing consensus grew stronger. For most scientists, evolution became a theory that neither required nor admitted to any degree of purpose or design.[27] However, this is a philosophical, rather than an empirically demonstrated scientific position.

But while evolution is blind, inherent teleology is clearly present in the biological world, either as human-like deliberate purpose or as the more automatic form of teleonomy.[28]

Ernst Mayr's definition of teleonomy as a program written in the genes fits well for the vast majority of living organisms, including all of the plants, bacteria, and archaea.[29] It also applies to most animals, including some vertebrates. But for animals with nervous systems that have a degree of complexity allowing for more than simple stimulus-response networks, the extended definition that includes "open" programming starts to become important.[30]

As Alister McGrath points out, agreeing with Mayr, "some criticisms of the notion of 'teleology' in a biological context actually rest on philosophical precommitments, rather than on biological observations." The fact that Darwinism might not disclose any sense of purpose in life does not lead to Dawkins's conclusion that there *is* no purpose to life.[31]

Daniel Dennett says that all living organisms do things *for* a purpose, even if they are oblivious to what that purpose is.[32] Humans—uniquely, he continues—*have* purposes, and are even able to discern the purposes behind the blind process of natural selection that the animal beneficiaries of such purposes are totally unaware of. I think it possible that Dennett (who is, after all, a philosopher) might have been gently chiding some of his anti-theistic scientific colleagues, who tend to lump inherent teleology in the Aristotelian sense (for which natural selection could be considered the final cause) with external teleology as related to God's purpose. This confusion has led to a general rejection of any notion of purpose in biology, and indeed a discomfort with any teleological language,[33] which brings to mind J.B.S. Haldane's famous quote: "Teleology is like a mistress to a biologist: he cannot live without her but he's unwilling to be seen with her in public."[34]

I agree that the roots of biological teleology do not lie in the *action* of evolutionary processes. Instead, I believe they can be found in the very *fabric* of the evolutionary process. In other words, purpose is built into the central, deepest biochemical meaning of what evolution is. It is therefore inevitable that what we see first as biological teleonomy, and then as human purpose exemplified by free will, will arise as a result of evolution, even though the evolutionary process is not itself teleological. The mechanism of evolution itself represents a purpose, just as, according to Dennett, humans are creatures that represent reasons for action.[35] I am suggesting that, for evolution, purposeful reasons are represented by the genetic code. To understand the rationale behind this suggestion, we need to deconstruct the link between evolution and life.

Is Evolution a Necessity for Life?

The answer depends a great deal on one's working definition of life. Since some definitions include the ability to evolve, the question only makes sense if we use a definition that is as broad and unrestricted as possible. If we use the metabolism-first model of abiogenesis, we can define life according to Sousa et alteri as "the harnessing of chemical energy in such a way that the energy-harnessing device makes a copy of itself."[36]

Terrestrial life began shortly after the young Earth cooled. We know that at some point between 3.5 and 4 billion years ago, the modern form of DNA-based life appeared on Earth. During the entire period of the evolution of life, Earth was in a constant state of geologic and climate flux. In the Archean and Proterozoic eons, which lasted for most of Earth's history, there were a number of extreme ice ages, periods of intense volcanic activity, impacts from meteors and comets, formation and breaking apart of supercontinents, as well as major changes in the composition of the atmosphere, land, and water, and in the temperature and extent of the oceans. All of this continual, slow environmental change was the engine for natural selection-based evolution. Francisco Ayala stressed,

> Environmental diversity and environmental change are responsible for the continuous evolution of natural populations. If life existed in only a single uniform and constant environment, evolution might conceivably have produced a genotype optimally fitted to that environment with no further change.[37]

As a thought experiment, imagine a planet much like Earth, about the same size, with the same amount of gravity, in the habitable zone, with liquid water, following a regular circular or close to circular orbit, with plenty of organic material. Let's also assume that this planet has no plate tectonics and is extremely stable environmentally. It never undergoes major temperature or atmospheric changes, it has little or no seismic activity, and is somehow highly protected from meteor or asteroid impacts. Finally, we can assume that the origin of some primitive organized life form occurs, perhaps as a result of basic principles of energy dissipation[38] or chemically driven reactions.[39]

We might find living cells with a host of metabolic chemistry going on in this world, including energy conversion reactions and synthetic reactions enclosed in a naturally occurring lipid vesicle or cell. We can even think that such a cell might grow in size as more chemical species are added to the cell by ingestion or metabolism. These cells might split in two at a certain point. It is even possible to imagine that some complex macromolecules such as polypeptides might be found in them. Once such a cell was formed, it might survive for a very long period, and if it did divide, the population might grow until checked by limited chemical resources.[40]

Would such a life form further evolve on such a planet? Why should it? Natural selection is very weak when the environment does not change. It is likely that evolution would not happen at all. And in fact, these living cells could be devoid of genes—they could have no DNA, no RNA, no genetic molecules of any kind. If there is no need for evolution, there is no need for genes. The metabolizing cells would just live and metabolize until they died. If they all died, nothing much would happen until another accidental start of life occurred. It is possible to imagine a world like that lasting for billions of years, with no change, no evolution, and no life other than a series of chemical reactions going on in a vesicle. Here is a somewhat different but related speculation from the Committee on the Limits of Organic Life in Planetary Systems:

> The only alternative to evolution for producing diversity would be to have environmental conditions that continuously create different life forms or similar life forms with random and frequent "mistakes" in the synthesis of chemical templates

> used for replication or metabolism. Such mistakes would be equivalent to mutations and could lead to traits that gave some selective advantage in an existing community or in exploiting new habitats. That random process could lead to life forms that undergo a form of evolution without a master information macromolecule, such as DNA or RNA. It is difficult to imagine such life forms as able to "evolve" into complex structures unless other mechanisms, such as symbiosis or cell-cell fusion, are available.[41]

Perhaps life and evolution are not as tightly linked as we think—although on an unstable, constantly changing planet like ours, they must be. The point is that evolution is very special. It is not guaranteed to occur whenever life gets started, and it is, in fact, a much more elaborate and difficult phenomenon to visualize than the appearance of purely metabolic chemical life.

The Molecular Biology of Evolution

We know a great deal of the mechanisms of evolution in modern terrestrial life. Evolution could potentially occur through alternative mechanisms that do not involve a genetic code (as is postulated for RNA world), but for the kind of efficient and adaptive evolution we see around us, a DNA-based code seems ideal.

However, DNA itself does not actually do anything; it is only the repository for information. The information lies in the sequence of the bases in DNA, much like the information in this sentence lies in the sequence of the letters in each word and phrase. The DNA chemical language is read and translated by other chemicals in a process that is now well understood. There is nothing about this process that is outside of the laws of chemistry and physics, but it is a remarkable process, even compared to all of the other complex biochemical processes that occur in every living cell.

In all cellular life forms on Earth, the information in the DNA is copied into RNA with the same sequence as the DNA. This RNA serves as a message (it is called "messenger RNA") and is then used to create the proteins. There is a code by which every group of three bases of DNA and RNA (called a "codon") is translated into a specific amino acid. Thus the base sequence GGG codes for the amino acid Glycine, AAG codes for Lysine, et cetera.

The information contained in the DNA sequence is translated into the correct protein sequence by an exceedingly complex machinery that involves the messenger RNA (mRNA), ribosomes (another form of RNA), and two adapter molecules: an RNA type called transfer RNA (tRNA) and a protein enzyme called aminoacyl-tRNA synthetase (aaRS). There are also many cofactors and proofreading enzymes required for the process to work properly.

The three kinds of RNA involved in this process are fascinatingly different from each other, and very ancient. The mRNA is a long polymer, resembling a miniature single strand of DNA; the ribosomal RNAs are large enzyme-looking structures with bumps and grooves and binding sites; and the tRNA is a small, folded-up molecule with a whole series of different shapes. It is the tRNA that contains a three-base sequence (the "anticodon") that binds to the correct codon on the mRNA.

Each aaRS has a binding site for an amino acid, and another for the tRNA specific for that amino acid. The tRNA is recognized by a part of its shape called the "paracodon." When the amino acid and its tRNA are both bound to the enzyme, the aaRS changes its shape and brings the two molecules together, forming an amino acid-tRNA conjugate.

This conjugate then goes to the ribosome, and the anticodon on the tRNA binds to the codon on the mRNA that is specific for the amino acid now bound to its tRNA. This is the chemical basis for the genetic code. The mRNA and its bound tRNA (with the amino acid attached to it) are bound to a special site on the ribosome. Another amino acid-tRNA conjugate binds to the next codon on the mRNA and lands on the ribosome right next to the first one. The ribosome then links the two adjacent amino acids together in a peptide bond to begin the synthesis of the long protein ("polypeptide") chain. The mRNA then moves along the ribosome, displacing the first tRNA; the second tRNA moves into the first position, and another tRNA (with its amino acid attached) binds to its codon and is added to the growing protein chain. This process then repeats for between several dozen to several hundred times, until the protein with exactly the right amino acid sequence (as determined by the DNA nucleotide sequence) is complete.

So, we have a set of tRNAs that have amino acid-specific codons (from one to six different ones for the different amino acids), which also have a shape that fits into a specific aminoacyl-tRNA synthetase, which also has a binding site for the corresponding correct amino acid. This, in itself, is remarkable. But no less so is the process by which the messenger RNA moves along the ribosome while the protein chain is grown. And then, of course, there is the question of the genetic code built into the chemical translation system that converts the seemingly random sequence of the DNA bases into usable information for creation of all the properties of the cell.

Chemical reactions, including synthetic biochemical reactions and reactions that convert energy from sunlight or chemical bonds into useful work for the cell, are all reducible to blind chemical principles. The law of mass action should be considered the underlying principle of most of cellular biochemistry. This is not to say that cellular biochemistry is simple—far from it. The control processes and interactions between metabolic cycles are orders of magnitude more complex than any human-engineered system. But there is no denying their reducibility to simple chemistry.

However, when we speak of the genotype-to-phenotype conversion system (as I refer to the DNA-directed protein synthesis process), we have left the world of organic chemistry behind. Of course, the detailed mechanisms of each enzymatic reaction still follow chemical rules. But the underlying feature of this system is not based on chemistry but on purpose. The existence of a genetic code is the very embodiment of inherent teleology. The code exists as a means to an end, and the end informs the code. The genetic code and the cellular machinery of protein synthesis are inherently purpose driven, which is manifested by the technical name for this process: "translation." Any translation, whether it is from one language to another, or from an obscure code to a meaningful statement, or from an observation to a conclusion, is inherently teleological. Translations do not occur spontaneously, accidentally, or by random chance. The translator has a purpose: namely, to convert some information into something else.

This does not imply that the biochemical cellular translation system was designed or created. That could be true or not, but it is not relevant to the issue of purpose. The proponents of intelligent design (ID) like to say that there is no similar phenomenon in nonliving nature, and they are right on that point.[42] Unlike ID, however, I do not find this to be scientific evidence of a designer. I do think that the genetic code and the translation system is the basis for the existence of teleology in all of life.

We may eventually have a good theory to explain how the translation system might have evolved through some kind of non-Darwinian selection, but regardless of how it happened, it remains a fact that the conversion of genotype information to phenotypic characteristics is a highly teleological process. There is a purpose to having such a system working in biological organisms, and that purpose is to allow for evolution. As McGrath has written, "Yet what if some kind of teleology is discerned within, not imposed upon, the biological process? What if an evolutionary teleology is an *a posteriori*, rather than an *a priori*, concept?"[43]

It does not work to argue that the mechanism for evolution evolved initially for some other purpose, and was selected for because of that alternative purpose ("exaptation"). This is a valid response to ID arguments for design that appeal to purportedly irreducibly complex features such as the eye or photosynthesis. It does not apply here because I am not arguing *for* design. The point is that however the system developed or evolved, even if teleology was not part of its evolution, teleology appears *a posteriori* with the functioning of the genotype-phenotype linkage, and is then a fixed part of all life forever. Another way to approach this idea is to think of biological inherent teleology as emerging from the adaptive interactions of the complex molecular biology surrounding the genetic code and directed protein synthesis.

What makes the translation system especially teleological, as compared to other complex cellular biochemical pathways such as photosynthesis or the metabolic Krebs cycle, or even the action of a single enzyme in the vast space of cellular chemistry? After all, no living creature, not even one of us humans, consciously communicates any willful commands to the ribosomes to make a particular protein, and there is no Aristotelian final causation of the function of the genetic code. If I am not arguing for a conscious will in the creation of this system, then where does the concept of purpose come from? Cells do not see the future and do not decide to change based on what is needed.

And that is the point. Cells do not *need* to see the future, because evolution provides a way to deal with any novel circumstances or challenges in the absence of sight, thought, will, or any form of consciousness. Evolution by natural selection is the cellular biological alternative to survival by conscious struggle. And the biochemical mechanism that allows and promotes evolution by natural selection is the linkage between an inherited genotype and an environmentally mediated selection of phenotype, a chemical linkage that is provided uniquely by the protein synthesis/translation process. Primitive protocells with metabolic cycles and catalysts such as ribozymes or polypeptides are not equipped with any such system. However it arrived, the modern universal translation system was the very first purpose-driven chemical system on the planet. It provides the nonconscious will to survive in all of terrestrial life through evolution. That is its purpose.

Mayr did not include this idea in his discussions of teleology and teleonomy in biology, and I have not seen it in other philosophical treatments of the subject. However, some writers have provided evidence consistent with the existence of an evolutionary direction beyond that resulting from purposeless accident. Simon Conway Morris's work on the ubiquitous phenomenon of evolutionary convergence could be seen as supporting the argument for inherent biological purpose.[44] Many of the findings of new evolutionary mechanisms, such as natural genetic engineering, epigenetics, and complex patterns of gene regulation,[45] are also consistent with a potentially goal-driven biological mechanism that has yet to be clearly identified or articulated. I am suggesting that the translation system is that mechanism. My purpose in proposing the idea is not to argue for its veracity, but to raise its possibility as an explanatory principle in an evolutionary process as a basis for further discussion and enquiry.

If it is indeed true that there exists a strong teleological system at the heart of every living cell, it is no wonder that evolution can proceed along its "blind" path, guided only by natural selection, and at the same time produce creatures who show every sign of being ruled by some form of purpose. As evolution produces more and more complex organisms, we arrive at the stage where purpose takes the form of a willful human decision to write an essay about teleology in evolution for the purpose of expressing ideas for others to read and think about.

If we believe (as I do) in a creator God who endowed human beings with a purpose for existence, and that we do act as purposeful agents, then humans are the final demonstration of the existence of biological purpose. For that we must thank evolution—for which, in turn, we must thank the genetic code and the system that can translate that code from the chemistry of nucleic acids to the chemistry of proteins. We might also thank God for the creation that made all this possible, but that is an option for a different discussion. What *can* be said here, however, is that if this view of the evolutionary mechanism as the ultimate source of teleology in life is correct, there is an interesting conclusion one could draw that is relevant to the theological debate on evolution. God's tool to accomplish this was none other than the natural process of Darwinian evolution, and biological evolution is actually a strong pointer to the power of God's creative majesty.

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Notes

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[2] Sy Garte, "New Ideas in Evolutionary Biology: From NDMS to EES," *Perspectives on Science and Christian Faith* 68, no. 1 (2016): 3–11.

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[8] Allen W. Johnson and Timothy Earle, *The Evolution of Human Societies: From Foraging Group to Agrarian State* (Stanford, CA: Stanford University Press, 1987).

[9] Darwin, *On the Origin of Species by Natural Selection*.

[10] Arthur, *The Nature of Technology*.

[11] This was Darwin's conclusion, which displaced Lamarck's vision of phenotypic inheritance. It should be acknowledged, however, that with the emergence of epigenetics as

a potential alternative evolutionary mechanism for variation (see Garte, "New Ideas in Evolutionary Biology"), some aspects of Lamarckian thinking related to environmental influences on genomes have been given renewed consideration. However, for purposes of this discussion, I will focus on a strictly Darwinian approach to genotype and phenotype.

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