

Chance caught on the wing

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1 Twenty-first century natural theology

Making a convincing case for explanatory pluralism requires arguments against well-known, deeply-held, and compelling views about explanation and evolutionary biology. Richard Dawkins and Daniel Dennett are the best representatives of those views I believe to be mistaken. In well-known works such as Dawkins' *The Selfish Gene* and *The Blind Watchmaker* and Dennett's *Darwin's Dangerous Idea*, they articulate a naturalizing project, with natural selection as centerpiece: where the 19th century tradition of natural theology identifies divine design in nature, for instance, as the explanation of the eye and other complex organs, show that evolution by natural selection can be substituted. This naturalizing project is complete only when all organic phenomena are brought under the rubric of the sciences. As they see it, language, thought, beauty, and meaning, and even religious belief itself are at stake, and that, when these phenomena are shown to be the result of natural processes, humanity will at last be free from the grip of myth and irrationality.

There is second component to the view that explaining adaptation is the central explanatory aim of evolutionary biology. Dawkins and Dennett take the view that scientific explanations make essential appeal to laws of nature, a view best known through the work of philosopher of science Carl Hempel. Understood

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in the context of evolutionary biology, as Dawkins and Dennett see it, natural selection is the only process of evolution that behaves in a lawlike manner: all other things being equal, organisms better adapted to their environments are better represented in later generations than those less well adapted. The final piece of the argument is that evolutionary biologists generally agree that natural selection explains organic adaptation. This dovetails neatly with the project of naturalizing our understanding of the organic world. Natural selection is a lawlike regularity, the only such regularity in evolution, and it explains adaptation; explaining adaptation by natural selection displaces divine design; so the central explanatory task of evolutionary biology is to explain adaptation by natural selection.

Herein lies the first central motivating factor behind exploring the issue concerning the explanatory power of natural selection and the aims of evolutionary biology. In a way few scientific theories have, evolutionary biology is felt by many to be of special relevance to the relationship of humanity to the rest of the universe. In 1844, Darwin wrote to his close friend and colleague J. D. Hooker that “I am almost convinced (quite contrary to opinion I started with) that species are not (it is like confessing a murder) immutable.” This passage, framed in terms of *mutability*—“evolution” was never used—perhaps more than others, captures the essence of what is so disturbing about evolution. Darwin is often placed in a narrative, with Copernicus, of the reduction of humanity’s importance. One means by which this reduction in importance is effected by evolution is to establish humanity’s affinity with the animal world. A more deeply frightening truth that common descent confronts us with is the possibility that a biological species can change into a different, new one: transmutation.

The same term is used in the alchemical tradition for the process of turning one species of metal, e.g., lead, into another, e.g., gold: the transmutation of metals. The world as it confronts us appears to be populated straightforwardly with distinct kinds of things; and, putting aside things that develop, like seeds and infants, we do not have experience of one thing losing its essence entirely, to become a new kind of thing, with its own essence. In the case of metals, science now tells us that it can be achieved, at least in principle, by a coordinated sequence of nuclear explosions. This confirms our sense that transmutation is an exceptional process. The opposite is true of organic species, which are, each and every one, the result of change of some other species. Whatever the error or insult to humanity there is to being a kind of animal, the complicated web of instability in which our evolutionary heritage entraps us is more deeply forbidding and unsettling, because it impinges on the experience of continuity essential to both day-to-day life and long-term planning and thinking.

Dawkins and Dennett take up this issue more or less as the 19th century natural theologians did. They observe in nature chaotic interactions, processes and chance events that cannot, by themselves, explain adaptation, which requires complex organization of a kind so extraordinary that human engineers have not yet exceeded it. Either there is some other way of explaining adaptation, or else the powers of human reason must be accepted as limited in the extreme, because we cannot explain a phenomenon so clearly in need of explanation. The

argument of the natural theologians is that, because only human beings and God are known to produce objects of such complexity, one of those two must be responsible; but since we know human beings are not responsible, it is safe to conclude that God is. This is in accord with the idea of God's providence. Each organism is given the abilities to survive. In contrast, some would like to explain nature with science, and do not believe in God's providence. Natural selection is indeed such an explanation, or at least, anyone who trusts science ought to admit that natural selection does explain adaptation. The backdrop of chaos remains inexplicable, but this does not matter.

Scientific discovery, and a more nuanced understanding of the nature of explanation, weaken, in a considerable degree, the motivation for the Dawkins-Dennett view about the exclusive importance of natural selection. Although one is free to ignore phenomena other than adaptation, doing so is to ignore a wide range of the most interesting and important empirical and theoretical advances in biological science. In the 19th century, focus on explaining adaptation might have been warranted; but, since then, scientists have discovered that nonadaptive phenomena are orders of magnitude more frequent than adaptive phenomena, and that they play critical roles in a wide range of biological contexts including physiology, genetics, and the formation of morphological traits. (To be clear, "nonadaptive" is not intended to mean "maladaptive." Rather, it indicates biological traits or genes equally well-suited for their role in the organism, so that chance, rather than differences in response to the environment, is what determines their evolutionary success.)

Furthermore, there is a pragmatist line of argument in philosophy about the nature of explanation according to which explaining why an event occurred by means of reference to laws of nature is one among many explanatory strategies in science, but not the only one. Explanation-seeking why-questions have no special importance, indeed, others, such as questions about how events occurred, are often more critical. Apparently, evolutionary biology is of use to those who would like to build a world-view using materials drawn only from science. Answering explanation-seeking-why-questions serves this end. For the truly curious, this is unsatisfying, because it does not address the question, What is the relevance to evolutionary biology, considered in general, to how we see ourselves in relationship to the universe? In contrast to the astonishing adaptations such as the hand or the eye, the most conspicuous feature of nature seen through the lens of evolutionary biology is that there are so many specific forms and variations that, to use Nobelist Jacques Monod's words, result from *chance caught on the wing*. Explaining how this happened is of enormous interest, if we are to understand it.

2 Explaining nonadaptive evolution

First, there are four nonadaptive phenomena of particular importance. (1) The neutral theory of molecular evolution and its relative, the nearly-neutral theory, according to which most variation among DNA base pairs does not make any difference to the level of adaptedness of any trait resulting from that variation,

or else, on the nearly neutral theory, the variation reduces biological fitness. (2) Conditions under which new species arise often include the separation, by chance factors, of a small group that can be identified later as the incipient species. Although adaptive differences between related species can evolve after the separation, initial differences are not, in general, adaptive. (3) The shape of the tree of life—do new lineages branch away rapidly from their predecessors, by chance: does the tree of life look like an oak, each branch budding and spreading nearly-perpendicularly from the ground, or a fir tree, on which each branch is perpendicular to the tree trunk? In the latter case, chance factors are often responsible for the change in direction of long-term evolution. (4) The shifting balance theory, according to which the interplay of migration, chance, and adaptation is required to push a species toward its maximum fitness, adaptation alone not being enough.

The view that scientific explanations require laws of nature depends upon a commitment to *universalism*. According to universalism, all scientific explanations conform to a single model, and, in particular, the explanation of a given phenomenon to a given audience does not differ from an explanation of that same phenomenon to a different audience. In this way, explanations are understood on analogy with mathematical proofs. Whether the statements S prove the conclusion C does not depend upon the audience to which the proof is presented. In contrast, my view is *pragmatic*: there is a broad range of explanation-seeking questions; the appropriate question depends upon the purposes and cognitive states of the audience. “Pragmatism” is appropriate because the position is that explanations are understood as means to an end—remedying some state of ignorance in the audience.

Explanation-seeking how-questions are of special importance for explaining chance events and nonadaptive evolution. On the one hand, suppose that someone asks, about a family with three daughters, why the three children are female. Assuming that the normal processes of conception were used, this is highly improbable: there is a 12.5% chance. This is not an especially satisfying explanation why there are three girls; most certainly, there is no law of nature describing circumstances under which three girls ought to be expected. On the other hand, consider the question, how did there come to be three daughters? This question asks for the description of a process: a sequence of causally relevant events by which the event of interest occurred. There is an answer to this question that adverts to the normal processes of conception and that mentions the father’s contribution, in each case, of an “X” chromosome, which results in a female child. Because such explanations describe a process, I term them *process explanations*. Events and processes such as those mentioned above, each of which is a chance event or process, can, I claim, be explained using the strategy of process explanation, that is, by answering an explanation-seeking how question.

3 Literature & ontology of evolution

Relevant scientific literature must be identified, in order to become clearer on how scientists understand these chance phenomena. The problem is acute. At present, discussion of chance in evolutionary biology among philosophers of science centers around a few paradigm cases. The mathematical techniques used to describe chance processes are esoteric, some having been invented solely for the purpose of doing so; and much of the discussion of chance in evolution proceeds in mathematical terms. Although they are pervasive in nature and form a theme in evolutionary biology, chance processes do not form a unified set of phenomena. As indicated above, they occur in a range of contexts in different disciplines. To make matters worse, practitioners of what I term 20th century natural theology (above) parade before their audience an array of striking examples of adaptation, used to illustrate the power and subtlety of natural selection.

The enterprising researcher might, as I have, search the extensive set of databases online in which works about evolutionary biology are indexed. Unfortunately, this yields nothing of value. The literature is not indexed for the user interested in evolutionary biology, but is rather indexed to be of use to clinicians in medicine and medical researchers. There are few relevant subject keywords. Searching the full text of abstracts or the articles themselves produces far too many results to be of use. An ambitious solution to this problem, which I am pursuing as a part of my research program, is to create a new indexing system designed for use by evolutionary biologists and scholars in the history and philosophy of science studying it: an ontology of evolutionary processes.

An indexing system such as the Library of Congress Subject Headings (LCSH) works by associating a keyword with a bibliographic record. Users search the library catalog, discovering works of interest by finding relevant keywords in the subject field of bibliographic records. Some bibliographic records are indexed with keywords related to the user's initial keyword, but that were previously unknown to the user. The user explores the literature by searching for works on these related keywords. An ontology works in a similar fashion, but is far more effective. An ontology is an abstract logical entity that models phenomena of a part of the universe of interest to the researcher. Instead of keywords naming subjects or topics, as in the LCSH, but by describing entities and their relationships. The ontology is, in effect, an abstract replica of some part of the universe. For instance, an ontology of the academic labor force would include the terms *instructor* and *student*, and the relationship *instructor I is the instructor of S*. The ontology of evolution works in a similar manner, describing evolving entities (including processes) and their relationships. Because it describes the entities and relationships *as they are*, building ontologies is, in effect, a description of being itself, in the Aristotelian sense of *ontology*.

How does the ontology of evolutionary processes help someone who wants to find literature on a particular topic, such as chance events? Here is where recent mass-digitization projects can be brought into play in an exciting way. The Biodiversity Heritage Library is a consortium of libraries of natural history committed to digitizing as much of their library holdings as possible, given

constraints of copyright. At present, some 40 million pages in roughly 100,000 volumes have been digitized. This literature extends far enough into the past to include texts of the late 19th century origins of evolutionary biology and its precursors in England and Europe, all of which are of interest to my project. In addition to displaying each page as it appears, the content of each page is stored digitally in a text file that can be read by machine. Other digitization efforts such as JSTOR and digital texts published commercially can also be read by machine. This vast text-base can be explored with the benefit of an ontology using the following procedure.

1. Expert readers read a sample of paradigm texts. Passages, in the ideal case, sentences or paragraph, are indexed with terms from the ontology. In this case, my colleagues and I are the expert readers.
2. By means of natural language processing, the machine reader indexes the entire text-base.
3. A sampling of the results of the machine reader's indexing is evaluated by the expert readers; where the machine has made a mistake, the indexing is corrected.
4. The previous three steps are repeated, increasing the accuracy of the machine reader each time, until it is as good as the human reader.

Using a method such as this, my research program requires the creation of a database with bibliographic records with links to particular passages, but only about evolutionary biology. In this way, literature relevant to chance events and processes can be identified; once in hand, they will form the subject of interpretation in accord with the methodological principles of history and philosophy of science.

4 The evolutionary sublime

Taking a macroscopic perspective, what difference does it make for our view of ourselves and our place in the universe, if the importance of chance events and processes is highlighted? My tentative answer to this question is that our experience of nature and our evolution starting with the earliest forms of life is an aesthetic experience: the sublime. There is a variety of accounts of the sublime; consider a gloss on Kant's view. According to Kant, we experience the sublime in the presence of the vast scales we can only experience in nature, for instance, thunderclaps and lightning strikes; mountains, or the view of a valley far below and violent storms and surf. The experience is connected with the recognition that human reason has a kind of integrity that cannot be affected by nature. Human beings can rise above their animal nature, because they have the power to reason, which is universal, and applies across any natural phenomena. My view is that it is not human reason that generates the sublime experience of the idea and fact of our evolution. Rather, what generates the sublime experience is

the recognition that, despite the odds, humanity has persisted, due just as much to chance as to any deliberate contrivance on our part or any adaptation on the part of our ancestors.

5 The challenges

There are two central strategies employed against the claim that the principle of natural selection is the sole explanatory principle in evolutionary biology, each strategy corresponding to one or the other of the two lines of argument in favor of the Dawkins-Dennett exclusivity claim. First, the exclusivity claim is warranted only insofar as explaining organic adaptation is taken to be the chief aim of evolutionary biology. In the 19th century, explaining adaptation provided a route to belief; in the 21st, explaining adaptation is a central part of naturalizing humanity and nature. The observation that there are chance processes and events that are studied by evolutionary biologists suggests that there is more to be learned about the natural world and our place in it. In order to identify the relevant literature, an ontology of evolutionary processes and a bibliography of the literature of evolution are created. Second, the strategy of process explanation stands against the claim that invoking selection is the only way to explain events and processes in evolution. Carrying out this attack on the exclusivity thesis requires that the research aims presented below be attained. Means to these aims, planned or in progress, are listed in the outline below, labeled with lower-case letters.

Research aim 1 Identify research traditions in the evolutionary sciences not aimed at studying adaptation, and that are aimed at explaining chance processes or events using the strategy of process explanation.

1. Develop a comprehensive bibliographic database of works about evolutionary biology, “EvoLit.”
2. Create an ontology for evolutionary biology, that is, a formal model of the subjects treated in the literature.
3. Exploit techniques in the new discipline of Digital Humanities to search digitized copies of the texts listed in EvoLit for relevant literature.

Research aim 2 Articulate a robust philosophical foundation for process explanation by establishing pragmatism about explanation, against universalism.

1. Motivate the problem by showing that current arguments in favor of pragmatism are mistaken.
2. Identify the arguments in support of Hempelian universalism.
3. Argue conclusively that, from a methodological point of view, process explanation is a well-warranted strategy.
4. Illuminate the history of the study of nonadaptive phenomena (see above) by determining the importance of nonadaptive phenomena that are explained with process explanations.

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Research aim 3 Assess the question, What does evolutionary biology tell us about our place in the universe?

1. Explore the aesthetic dimension of how we come to terms with the element of chance in our history as a species.