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Confirmation and explaining how possible

Patrick Forber

Philosophy Department, Tufts University, Miner Hall, Medford, MA 02155, USA

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ABSTRACT

Confirmation in evolutionary biology depends on what biologists take to be the genuine rivals. Investigating what constrains the scope of *biological possibility* provides part of the story: explaining how possible helps determine what counts as a genuine rival and thus informs confirmation. To clarify the criteria for genuine rivalry I distinguish between *global* and *local* constraints on biological possibility, and offer an account of how-possibly explanation. To sharpen the connection between confirmation and explaining how possible I discuss the view that formal inquiry can provide a kind of confirmation-theoretic support for evolutionary models, and offer an example of how-possibly explanation interacting with testing practice.

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1. Introduction

The climate fluctuates and the availability of food resources changes. The beak of a Galapagos finch species evolves. A correlation between the environmental change and the evolutionary change can be evidence for natural selection. The data count as evidence by supporting the natural selection hypothesis over other rivals, such as hypotheses that invoke drift or constraint. If we take seriously this contrastive nature of confirmation, as Salmon (1990) and Sober (1990) argue we should, then evidential relations depend on a contrast class or testing set. Yet what rival hypotheses should biologists include in (or exclude from) the testing set? I aim to investigate what guides this kind of decision by analyzing minimal explanatory conditions that constrain the scope of *biological possibility*.

To gain traction on the problem, I will use the distinction between *how-possibly* and *how-actually* explanations, introduced by Dray (1957) and applied to evolutionary biology primarily by Brandon (1990). Prima facie, how-possibly explanations provide a guide to what counts as biologically possible. Yet there is a crucial ambiguity regarding the sorts of constraints introduced by explaining how possible (Sect. 2). There are broad *global* constraints, informed by formal inquiry into models of evolution, about what sorts of

evolutionary processes may occur and the potential patterns these processes can produce. There are also narrower *local* constraints, informed by empirical inquiry into real biological systems, about whether evolutionary processes can produce specific outcomes, such as the camera eye, wings, or a change in finch beak size. I shall offer an account of how-possibly explanation in evolutionary biology that respects the difference between global and local constraints, and helps vindicate the practice of constraining the focus of inquiry to relatively few rivals (Sect. 3). I then connect my account to previous discussions on how-possibly explanation (Sect. 4). Finally, I make two points in support of the connection between confirmation and explaining how possible. First, distinguishing global from local constraints clarifies the claim that formal analyses of abstract evolutionary models provide a kind of confirmation-theoretic support for those models (Sect. 5). Second, some historical controversies are usefully interpreted as expanding the scope of biological possibility by defending novel global how-possibly explanations. The origin of the neutral theory of molecular evolution provides an illustrative example of this (Sect. 6). How-possibly explanations thus inform confirmation by showing that some hypotheses, whether general proposals about evolutionary processes or specific models of some target system, meet the minimal conditions to be considered a genuine rival.

E-mail address: patrick.forber@tufts.edu

2. Global versus local

One way to understand what counts as a biological possibility appeals to the distinction between *how-possibly* and *how-actually* explanations, due originally to Dray (1957). This is a familiar distinction, but it turns out to hide an ambiguity. So I will first lay out the standard view, then locate the ambiguity in question.

How-actually explanations aim to explain how or why some event actually occurs; these are the sorts of explanations usually considered in the explanation literature (Salmon, 1989; Woodward, 2009). In the context of evolutionary biology a how-actually explanation picks out the biological possibility that, given suitable evidence, we take to explain the target outcome or pattern. Kettlewell (1955, 1956) gives a how-actually explanation for the evolution of melanism in *Biston betularia*—the melanic phenotype confers a greater degree of camouflage that helps individuals avoid predators better than the non-melanic phenotype.¹ Brandon (1990) discusses the evolution of heavy metal tolerance in *Arabidopsis* to facilitate their growth on toxic mine tailings as another good example of a how-actually explanation in evolutionary biology. Both examples provide an explanation for how evolution unfolded in biological populations to produce the target traits, melanism and heavy metal tolerance. Also, these explanations are ostensibly well confirmed hypotheses about how natural selection *actually* produced specific evolutionary outcomes in real populations of organisms.

In contrast, how-possibly explanations aim to explain how some event could possibly occur. As Dray puts it, the function of a how-possibly explanation 'is to rebut the presumption that what happened was impossible, or at any rate extremely unlikely given the circumstances' (Dray, 1993, p. 27). This formulation deserves some clarification. First, a how-actually explanation would, of course, rebut such a presumption as well. A how-possibly explanation does so without providing the complete actual explanation. Second, Dray complicates the picture by adding that how-possibly explanations can show that some event is not 'extremely unlikely'. An unlikely event is still possible. Dray may be closer to scientific practice since scientists often exclude the very improbable from the set of genuine rivals. However, if *contingency* characterizes much of the evolutionary process, as Gould (1989) and Beatty (1995, 1997) argue, then such improbable events may play an important role and so should not be neglected. To be precise, we should correct Dray and count 'extremely unlikely' events as possible. The relative importance of contingency in the evolutionary process is an open question and interacts with explanation in a different way. It affects the *counterfactual resiliency* of our how-actually explanations for evolutionary phenomena, and thus whether we can give a *robust process* or *actual sequence* explanation of some target phenomenon (Jackson & Pettit, 1992; Sterelny, 1996). Counterfactual resiliency simply does not apply to how-possibly explanations, for an event is possible if it occurs in one possible state of affairs or many. Subtleties aside, Dray's notion of explaining how possible plays a vital role in evolutionary biology, as many have argued (Lewontin, 1985, 2000; O'Hara, 1988; Resnik, 1991; Plutynski, 2004, 2005).

Before moving on, let me set aside some issues about possibility and explanation. What is biologically possible depends on the way the world is, on what physical or biological laws hold, if any. If one takes Van Fraassen's (1977) perspective then biological possibility is a subset of logical or verbal possibility constrained by the biolog-

ical and physical laws. Yet the metaphysical nature of possibility, the proper account of laws in science, and even the existence of biological laws are all controversial issues. I will set these problems aside in order to investigate how biologists both develop and deploy their background theoretical framework to constrain what counts as a biological possibility. What really matters is what practitioners *take to be* possible given their background theoretical framework. Levi (1988) provides a clear way to approach this: explaining how possible involves determining whether some event is possible *relative* to a suitably constrained set of background information. While what is biologically possible is determined by the causal structure of the world, what biologists take to be possible depends on their accepted theoretical framework, and this can change as the framework changes (see Sect. 6). The overall theory of explanation for biology, and whether how-possibly explanations count as genuine explanations on this theory, are not resolved either.² I will take a pluralist perspective on explanation in science and, based on arguments made by Lewontin and others, treat how-possibly explanations as worthy of philosophical investigation. They help us answer a crucial question: *what are the biological possibilities?*

There are, however, *two* distinct ways to take this question about biological possibility. The first way takes the question to address the nature of evolutionary processes, focusing on the power and limits of selection, drift, and constraint operating in ideal populations. Can weakly adaptive traits evolve by natural selection in small populations? Can random drift produce a constant rate of molecular change in DNA and proteins? This sort of question concerns the scope of abstract, *global* biological possibility space, for it investigates the capabilities of general evolutionary models. The second way takes the question to address whether evolution can produce target outcomes in real populations. Dawkins (1986) and Nilsson and Pelger (1994) offer explanations of this kind for how the vertebrate camera eye may have evolved. Can natural selection for coping with informationally demanding foraging problems explain the evolution of human cognition? Can constraint explain the pattern of allometry observed across biological lineages? Can random drift explain the rate of protein evolution in Cytochrome C? This sort of question concerns the scope of concrete, *local* biological possibility space, for it guides speculation on how an evolutionary process can produce target traits and patterns.

The global question uncovers a formal kind of constraint, whereas the local question uncovers an applied kind of constraint. Abstract or mathematical investigation into how process models of evolution operate in *idealized* populations to produce potential evolutionary outcomes constrains the scope of global possibility, whereas concrete or empirical speculation on how those evolutionary processes can operate in *real* populations to produce specific target outcomes constrains the scope of local possibility. The mathematical or formal structure of models determines the global possibilities. In addition to the models, the background biology of a target population determines the local possibilities for that system. Local possibility space is a subset of global possibility space—global possibilities must be consistent with information about the accepted set of formal evolutionary models, whereas local possibilities must be consistent with that information plus information about some real biological system. Call the first body of information the *global information set*. For simplicity I will assume that there is one global information set shared across the field. Call the second body of information, enriched by specific biological de-

¹ There is some debate about the results of Kettlewell's studies (Hagen, 1999; Rudge, 1999). Nevertheless, if the studies were to provide the results claimed using the proper control groups then these studies would give a how-actually natural selection explanation.

² Reiner (1993), for example, argues that how-possibly explanations should not count as true explanations because they merely resolve puzzlement and are incomplete.

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