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Natural selection and mechanistic regularity

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ABSTRACT

In this article, I address the question of whether natural selection operates regularly enough to qualify as a mechanism of the sort characterized by Machamer, Darden, and Craver (2000). Contrary to an influential critique by Skipper and Millstein (2005), I argue that natural selection can be seen to be regular enough to qualify as an MDC mechanism just fine—as long as we pay careful attention to some important distinctions regarding mechanistic regularity and abstraction. Specifically, I suggest that when we distinguish between process vs. product regularity, mechanism-internal vs. mechanism-external sources of irregularity, and abstract vs. concrete regularity, we can see that natural selection is only irregular in senses that are unthreatening to its status as an MDC mechanism.

1. Introduction

Nature tends to preserve those traits that afford their possessors the greater chance to survive and reproduce, and it tends to reject those that do not. The result is that species become increasingly matched to their respective environments; they become exquisitely adapted over time. In its most basic form, this is natural selection.

For natural selection to occur, Darwin argued that three, and only three, conditions must obtain. (1) There must be *variation* among members of a population (e.g., some wolf pups are born with faster running abilities than others); (2) These variations must be *heritable* (e.g., those faster wolf pups will tend to have faster offspring); and (3) There must be, what he termed, a '*struggle for existence*' (e.g., there must be more wolf pups in a given generation than can survive).[1] Given, these three preconditions, it follows that those individuals with advantageous variations will tend to survive and reproduce while those with deleterious ones will tend to die off.

As helpful as the above basic characterization of natural selection is, it leaves open the answer to a question that has long interested philosophers of biology: what kind of a thing is natural selection? How should we represent what sort of process it is?

Indeed, Darwin himself seems to have been unsure about the answer to this question. In *the Origin of Species*, he referred to natural selection in myriad ways: an "action" (1859/1964, 90, 108, 129, 133, 211), a "doctrine" (5, 95), a "means" (6, 246), a "power" (43, 109, 205, 238, 454), a "theory" (237, 245, 281, 320, 325, 338, 345, 460, 462, 472, 474, 478), a "principle" (80, 95, 116, 127, 188, 206, 239, 475), and a "process" (93, 104, 109, 179, 203, 235, 280, 350).[2] In part due to Darwin's own apparent indecision in the *Origin,* contemporary philosophers of biology have been hard at work arguing for a more precise understanding of what kind of a process natural selection actually is. Some have argued that natural selection is best understood as a *force* (Sober, 1984; Stephens, 2004, 2010); some that it is a *purely statistical trend* manifesting in natural histories (Matthen & Ariew, 2002, 2009; Walsh, 2004); some that it results from *causal processes operating at the individual level* (Glennan, 2009); some that natural selection is a *causal process, but one that necessarily operates at the population level* (Millstein, 2013), and some that it is a multi-staged *mechanism characterizable on both the individual and population level* (Barros, 2008). Each of these positions has outspoken critics.

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[1] There is debate as to whether (3) is really required for natural selection. But nothing I go on to say turns on this debate.

[2] See Havstad (2011) for the source of this research.

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In what follows, I hope to show that there are some good reasons for understanding natural selection as a mechanism of the sort characterized by Machamer, Darden, and Craver (2000) (henceforth 'MDC mechanism'). And by appealing to some important and heretofore unrecognized distinctions regarding mechanistic regularity and abstraction, natural selection can be seen to escape at least one of the serious problems set forth against it counting as such: that it fails to operate regularly enough.

I will proceed in the following steps. In Section 2, I offer some prima facie reasons for understanding natural selection as a mechanism. In Section 3, I outline one influential argument against natural selection as an MDC mechanism: that it fails to meet the regularity requirement set forth in the MDC characterization of mechanism. In Section 4, I draw three distinctions regarding mechanistic regularity and show that natural selection only fails to be regular in ways that should be seen as unthreatening to its status as an MDC mechanism. First, I distinguish between process and product regularity and argue that the Skipper and Millstein critique only shows natural selection to be product irregular not process irregular, but there are good reasons for thinking that process regularity should matter more for MDC mechanisms. Second, I distinguish between mechanism-internal and mechanism-external sources of irregularity and argue that the sources of the irregularities associated with natural selection constitute unthreatening mechanism-external sources of irregularity. And third, I distinguish between abstract and concrete regularity and show that how regularly we conceive of natural selection depends crucially on the degree of abstraction we employ to schematize it. When schematized in a highly abstract manner, I contend, natural selection can be seen to operate regularly enough for certain legitimate explanatory contexts. I conclude in Section 5 by suggesting that this debate evinces an important general point about grounding mechanistic explanations in a complex, contingent biological world.

2. Prima facie reasons for natural selection as an MDC mechanism

The search for mechanisms pervades the life sciences. Examples abound. Endocrinologists search for the mechanisms by which specialized cells, tissues, or organs transport hormones throughout the body (Mizoguchi, Kamimura, Kiuchi, & Kataoka, 2015); geneticists search for gene silencing mechanisms that play important roles in suppressing genes that are required in only certain contexts (Kim, Ma, & Cerutti, 2015); plant scientists study the mechanisms by which plants signal the presence of microbial pathogens (Wu, Shan, & He, 2014). There are thousands more examples.

Recently, much work in the philosophy of science has been devoted to understanding *what* exactly it is that scientists look for when they search for mechanisms and *how* these mechanisms are meant to function in scientific reasoning. One now widely accepted philosophical characterization of mechanism was put forward in Machamer, Darden, and Craver's oft cited paper "Thinking about Mechanisms" (Machamer et al., 2000).

> MDC: Mechanisms are entities and activities organized such that they are productive of regular changes from start or set-up to finish or termination conditions. (Machamer et al., 2000, 3)[3]

On this characterization of mechanism, the beating heart clearly qualifies as a mechanism. It is composed of entities (aorta, ventricles, arteries, and so on) and activities (beating, pumping etc.) that are organized to produce regular changes (blood circulation) from the start of an animal's life to its end. This analysis applies equally well, mechanists have argued, to the molecular mechanisms of DNA replication and protein synthesis (Darden, 2006, 2008; Craver & Darden, 2013) as it does to the processes of synaptic transmission in the brain (Andersen, 2012; Bogen, 2005; Craver, 2007) as it does to the ubiquitous maintenance of circadian rhythms in all living beings (Bechtel & Abrahamsen, 2013[4]).

It would be nice if natural selection could also be characterized as an MDC mechanism. As is now widely recognized, mechanistic explanation—at least in the life sciences—affords several important advantages over the once-received deductive-nomological (D-N) account of scientific explanation.[5] On the D-N model, scientific explanation proceeds by identifying at least one law of nature, specifying the explanandum event's precise initial conditions, and showing that, given the laws and the initial conditions, the event had to have occurred. Mechanistic explanation, on the other hand, explains a given event by describing the causal mechanism that produced it.[6] There are several advantages of the latter over the former. Mechanisms, unlike laws of nature, are comfortably understood as physically existing in the world, so are more easily investigable by empirical science. Furthermore, generalized mechanism schemas allow us to explain more than the specific explanandum instance under examination; mechanisms support generalizations and ampliative inference in scientific explanation much the same way that laws once did. However, unlike with laws-based accounts, the mechanisms underlying these generalizations and ampliative inferences need not be exceptionless, necessary, or contain universals. Mechanistic explanation also matches intuitions, originally highlighted by Salmon,[7] that giving a scientific explanation must involve laying bare the causal structure of the world: locating a puzzling phenomenon in its causal nexus. And, as a matter of coherence with current practice, biologists *actually do* engage in searching for and describing mechanisms.

Prima facie, natural selection seems amenable to a mechanistic analysis. There are several reasons for this. For one, central to the notion of mechanism is the idea that mechanisms, among other things, are *set up for something*; mechanisms are productive of some general *phenomenon*. This feature of mechanisms is highlighted in many of Stuart Glennan's early works. In his 1996 article, "Mechanism and the Nature of Causation", Glennan points out the "one cannot even identify a mechanism without saying what it is that the mechanism does" (Glennan, 1996, 52). Put another way, whatever else a mechanism is, it at least needs to have a function; it needs to be set up to do something. Here, it seems natural selection fares quite well. Quite clearly, natural selection is a system *for* something: it is that which brings about adaptation.[8]

Another central feature of mechanisms is that they support reductionist explanation. That is, one of the reasons why mechanisms are so explanatorily useful is that they can be decomposed to their component parts and operations, and by doing so, crucial

[3] Similar characterizations have been put forward by Glennan (1996, 2002) and Bechtel (2006), but MDC's characterization has received the most attention in the literature—so theirs is the one on which I focus my discussion.

[4] It should be noted that Bechtel and Abrahamsen criticize the MDC characterization for implying that mechanisms must be linear. The circadian example is cyclic, with feedback. However, more recent developments in the mechanisms literature have amended the MDC characterization to better suit feedback mechanisms (cf. Craver & Darden, 2013).

[5] Cf. Hempel (1942, 1965).

[6] See Bechtel & Abrahamsen (2005) and Craver (2007) for detailed treatments of the nature and norms of mechanistic explanation.

[7] Cf. Salmon (1984).

[8] In making this point, I do not mean to attribute any problematic teleology to natural selection. It is not that natural selection is directed towards any specific goal (e.g., to approach perfection or the like). Rather, I mean only to draw attention to the fact that natural selection has a *function* (in the Cummins [1975] sense of causal-role function). It is that which brings about adaptation.