

lution of communication. After all, a full account of the evolution of language should include not just establishing signaling systems but also the origin (or invention) of the signals. This requires modifying the original game so that the players must first invent signals and then learn how to use them. To address this, Skyrms proposes a model that is able to represent an evolving signaling game as the agents (represented as a variation of simple reinforcement learners) invent new signals during the course of interaction. Introducing this possibility of invention allows the agents to avoid the evolutionary traps of suboptimal signaling. More impressively, Skyrms finds that individuals in this model can begin with no signals and invent a signaling system from scratch that almost always enables near perfect communication.

The book ends with a set of chapters exploring the connections between signaling and networks of individuals. There are a number of interesting models examined including signal-mediated teamwork, dialogue, and dynamic networks of signaling. The results here are primarily exploratory but are very intriguing.

In summary, Skyrms succeeds in showing that effective signaling systems can arise from very simple processes such as basic reinforcement learning or natural selection. But in doing so, he opens new avenues for research and raises many interesting questions. I think one of the most important contributions of *Signals* is in demonstrating the capabilities of a new research program. Overall, Skyrms's *Signals* is a thought-provoking introduction to an area of research that is rapidly developing and promises to reshape the way we think about a number of issues in philosophy of language and epistemology.

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Elliott Sober, *Did Darwin Write the Origin Backwards? Philosophical Essays on Darwin's Theory*. Amherst, NY: Prometheus (2011), 230 pp., \$21.00.

Elliott Sober's latest book, *Did Darwin Write the Origin Backwards? Philosophical Essays on Darwin's Theory*, arrives as a result of Sober's winning the Prometheus Prize, awarded by the American Philosophical Association and Prometheus Press. The award is intended "to honor a distinguished philosopher in recognition of his or her lifetime contribution to expanding the frontiers of research in philosophy and science," and we certainly agree that the selection of Sober for this prize fulfills this charge.

The book comes in five chapters. The first is the title chapter for the book, which considers whether Darwin's argument in the *Origin* is, in fact, presented backward. The second chapter is an extended treatment

of the history of the problem of group selection, focusing significantly on Darwin's thoughts on the subject. The third chapter is an exploration of the development of sex ratio theory, beginning with Arbuthnot and Bernoulli's work in demographics and proceeding through Darwin to Hamilton. The fourth chapter is an extended treatment of methodological naturalism. The fifth chapter, the postscript, contains three separate short essays: a further discussion of the "cladistic parsimony" arguments raised in the first chapter, some work on the units of selection problem, and a discussion of the interpretation of probability in evolutionary theory.

Before continuing, it is important to note the relationship between these book chapters and much of Sober's other work. Since it is a response to the commission of the prize essay, this book reads much like Sober's "greatest hits." The first chapter is a revised and extended version of Sober's (2009a) article from the Darwin Year issue of the *Proceedings of the National Academy of Sciences*. A provocative piece when published, this article was followed by an extensive scholarly discussion at the National Humanities Center's "On the Human" forum (Sober 2010a). The second chapter, on the development of group selection, is new material, but it is familiar ground for Sober, perhaps most of all from his work with D. S. Wilson (Sober and Wilson 1998). The third chapter, on sex ratio theory, is an expanded version of another article on similar themes (Sober 2007). The new material in chapter 4, on methodological naturalism, constitutes a return for Sober to another familiar topic (see, e.g., Sober 2008b, 2009b, 2011a). The postscript combines Sober's work on evolutionary probabilities (2010b), parsimony arguments (2008a, 2008b), and levels of selection (2011b).

The title of the book would lead one to think that, in its eponymous first chapter, Sober will provide us with insight into the development of the structure of the *Origin*—showing, perhaps via historical analysis, why it moves from artificial selection to natural selection to arguments for evolution and common descent. Such a story would be rich in the details of Darwin's correspondence, of his perception of the *Origin's* intended audience, and so on. But this is not the story that Sober gives us. Instead, Sober is concerned with evidence: What is the evidential basis grounding natural selection and common descent? Sober's conclusion is that the *Origin* is evidentially inverted. That is, the evidence for evolution comes after the mechanism proposed to account for this evidence. From this perspective, Sober concludes that Darwin ought to have presented all of the available evidence for evolution and only then presented his mechanism explaining it. It is this logical sense in which Sober argues that the *Origin* was written backward.

Notably, this is consistent with the claim that, rhetorically, the *Origin* was in fact structured optimally rather than backward. Sober does note

the connection between Darwin's argument and Herschel's work on *verae causae* (32–33), drawing on the extensive work of Hodge (1977, 1983, 1992). It is, however, difficult to escape the feeling that the issue of “right order” is, at its base, a historical question—and a question that the Darwin studies community has done an adept job of answering over the last 40 years.

Chapter 2, which discusses Darwin and group selection, exhibits a disconnect between the logical arguments surrounding this biological problem and contemporary biological evidence. Sober relies on hypothetical examples to demonstrate that group selection is theoretically possible. However, in the absence of more recent experimental evidence, to tie Darwin's views on group selection to a critique of philosophical ideas prevalent in the 1960s is an odd temporal juxtaposition and leaves us to question the value of interpreting his works within this particular context. It appears that this essay is historical in nature, but, by leaving out helpful historical details in favor of thought experiments, we are left wondering why this particular period of time (and not the present) serves as the appropriate backdrop for Darwin's ideas.

A different issue regarding history arises in the discussion of sex ratio in chapter 3. Sober nicely tracks the sex ratio literature available up to the time of Darwin and shows how sex ratio data were used to justify the existence of intelligent design. His explanation of the logic and hypothesis testing required to offer support for intelligently designed sex ratios provides historical insight into why Darwin attempted to address sex ratios but then backed off in his later writing. Sober then follows some of the progression of the post-Darwin literature, but, similar to chapter 2, the lack of recent citations leaves the reader with the impression that sex ratios have been empirically underexplored. For example, Hamiltonian sex ratios have been supported by experiments even in single-celled malaria parasites (Reece, Drew, and Gardner 2008), highlighting the strength of Hamilton's theory. Reference to this broad area of recent biological work would have helped cement Sober's argument that sex ratios can serve as a “test case” for the proof of evolution contra creationism (115–19).

In chapter 4, Sober's formulation of methodological naturalism (MN) is unorthodox, phrased as a moral imperative regarding what science should not do, namely, “make claims about the existence and properties of a supernatural deity” (121). Sober then concludes that evolutionary theory does not rule out the intervention of God in nature because there remains room in the theory for “hidden variables” underlying evolutionary probabilities—be they of the supernatural or the naturalistic variety (134). The relevance of this conclusion about hidden variables to MN is not obvious: as he has formulated that thesis, it is not a claim about what

the data do or do not rule out but rather a normative constraint on the practice of science. It should not surprise us that he concludes with a “modest” (149) defense of MN. But this defense seems both pragmatic and glib: “The modest defense I would offer of methodological naturalism is simply this: *If it isn't broken, don't fix it*” (148).

Chapter 5 offers three quite nice shorter pieces drawn from Sober's current work. The section on probabilities, in particular, is a welcome contribution to the literature and is perhaps Sober's most forceful case yet offered for his interpretation of the probabilities at work in evolutionary theory.

Given the broad scope of the book, Sober's challenge was to knit these disparate topics into a coherent narrative. True to the book's title, he intended a focus on Darwin to serve as this common thread—and the book certainly succeeds in offering us a deeper appreciation of Darwin and his work. It is at this point, however, that we believe Sober's greatest fault lies. His attempt at unifying this material makes acute the problem of the work's audience. The book reaches a level of sophistication beyond most undergraduates—few of whom will have the patience for the mathematics of group selection or sex ratios—and yet its discussion is too disjointed to serve as research material for interested graduate students and professionals, especially since, as we have noted, Sober has tackled these issues elsewhere.

For the generalist philosopher or those unfamiliar with philosophy of biology in general, this volume can provide a worthy introduction to Sober's work. We also see an avenue for the book outside the academic philosophy of biology, in education or the public sphere surrounding debates over evolution. This book, for these audiences, would provide an example of subtle yet principled thought on several topics in evolutionary biology—many of them linked, unfortunately, in being perceived by intelligent design advocates as points of weakness in evolutionary theory. In this context, Sober handily shows that these perceptions of weakness are unjustified.

All in all, Sober's book is both a welcome contribution and a well-written overview of his wealth of philosophical work. Our concerns with packaging and audience are, to some degree, par for the course when writing a collection of this sort, and we have no doubt that this book exemplifies precisely the quality of both philosophical and scientific scholarship for which Sober has justly been honored.

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