

simply unjustified. The history of science, cognitive psychology, and social factors all constrain philosophy of science just as they constrain science itself. It is time for naturalized philosophers of science to give up their dogmas.

## REFERENCES

- Brown, H. I. (1988), "Normative Epistemology and Naturalized Epistemology", *Inquiry* 31: 53-78.
- Campbell, D. T. (1974), "Evolutionary Epistemology", in P. A. Schilpp, (ed.), *The Philosophy of Karl Popper*, vol. 1. La Salle: Open Court, pp. 413-463.
- Dupré, J. (1983), "The Disunity of Science", *Mind* 92: 321-346.
- Fine, A. (1986), *The Shaky Game: Einstein, Realism, and the Quantum Theory*. Chicago: University of Chicago Press.
- Fuller, S. (1988), *Social Epistemology*. Bloomington: Indiana University Press.
- Fuller, S.; De Mey, M.; Shinn, T. and Woolgar, S. (eds.) (1989), *The Cognitive Turn: Sociological and Psychological Perspectives on Science*. (Sociological Sciences Yearbook, 1989) Dordrecht: Kluwer.
- Galison, P. L. (1987), *How Experiments End*. Chicago: University of Chicago Press.
- . (1988), "History, Philosophy, and the Central Metaphor", *Science in Context* 2: 197-212.
- . (1989), "Multiple Constraints, Simultaneous Solutions", *PSA 1988*, vol. 2. East Lansing: Philosophy of Science Association, pp. 157-163.
- Giere, R. N. (1988), *Explaining Science: A Cognitive Approach*. Chicago: University of Chicago Press.
- . (1989), "The Units of Analysis in Science Studies", in Fuller et al. (eds.), pp. 3-12.
- Goldman, A. I. (1986), *Epistemology and Cognition*. Cambridge, MA: Harvard University Press.
- Hacking, I. (1983), *Representing and Intervening*. Cambridge, England: Cambridge University Press.
- Laudan, L. (1984), *Science and Values: An Essay on the Aims of Science and Their Role in Scientific Debate*. Berkeley and Los Angeles: University of California Press.
- . (1987), "Progress or Rationality? The Prospects for Normative Naturalism", *American Philosophical Quarterly* 24: 19-31.
- . (1990), "Normative Naturalism", *Philosophy of Science* 57: 44-59.
- Maffie, J. (1990), "Recent Work on Naturalized Epistemology", *American Philosophical Quarterly* 27: 281-293.
- Nickles, T. (1987), "From Natural Philosophy to Metaphilosophy of Science", in P. Achinstein and R. Kargon (eds.), *Kelvin's Baltimore Lectures and Modern Theoretical Physics: Historical and Philosophical Perspectives*. Cambridge, MA: MIT Press, pp. 507-541.
- . (1989), "Integrating the Science Studies Disciplines", in Fuller et al. (eds.), pp. 225-256.
- Quine, W. V. (1953), "Two Dogmas of Empiricism", in *From a Logical Point of View*. New York: Harper & Row, pp. 20-46.
- . (1969), "Epistemology Naturalized", in *Ontological Relativity and Other Essays*. New York: Columbia University Press, pp. 69-90.
- Shapere, D. (1984), *Reason and the Search for Knowledge*. Dordrecht: Reidel.
- Stump, D. (1991), "Fallibilism, Naturalism and the Traditional Requirements for Knowledge", *Studies in History and Philosophy of Science* 22: 451-469.
- . (1989), "Representation, Cognition and Self: What Hope for an Integration of Psychology and Sociology?", in Fuller et al. (eds.), pp. 201-224.

## DISCUSSION:

DARWIN'S ARGUMENT IN THE *ORIGIN*\*

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Various claims have been made, recently, that Darwin's argumentation in the *Origin* instantiates and so supports some general philosophical proposal about scientific theorizing, for example, the "semantic view". But these claims are grounded in various incorrect analyses of that argumentation. A summary is given here of an analysis defended at greater length in several papers by the present author. The historical and philosophical advantages of this analysis are explained briefly. Darwin's argument comprises three distinct evidential cases on behalf of natural selection, cases, that is, for its *existence*, its *adequacy* and its *responsibility*. Theorizing, today, about evolution by natural selection involves a similar structure of evidential and explanatory concerns.

There are now in the literature several sustained attempts to show that Darwin's argumentation in the *Origin of Species* ([1859] 1964) fits and so vindicates some general philosophical proposal concerning scientific theorizing. There is, however, no consensus about that argumentation nor about the philosophical proposals. Most notably, Ruse (1975) has written on Darwin and the "received view" of the logical empiricists, Thagard (1978) on Darwin and inference to the best explanation, Lloyd (1983) on Darwin and the "semantic view", and Kitcher (1985) on Darwin and explanatory unification.

Recker (1987) has examined these writings and concluded that they all fail in fitting Darwin exactly to their favored general proposal. Hodge (1989) reached the same conclusion. Even more recently, Sintonen (1990), disagreeing with Recker, has claimed that a certain version of the semantic view does fit and is vindicated by the *Origin*, while Wilson (1992) has presented Darwin's theory as having the logical structure and observational evidence of a paradigm in Kuhn's sense.

The purpose of the present discussion is to explain why Sintonen's claim cannot be accepted, and, much more broadly, to indicate some conditions that any such claim must meet if it is to be historically accurate and philosophically cogent.

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Ultimately, the reason why Sintonen's claim must be declined is that it is grounded in a mistaken analysis of Darwin's argumentation in the *Origin*. Recker had urged—also mistakenly as it turns out (Hodge 1989)—that throughout the *Origin* Darwin is always arguing for the causal efficacy of natural selection, but that Darwin deploys three distinct argumentational strategies on behalf of this single causal efficacy thesis. Sintonen (see, especially, 1990, 689), disagreeing, holds, instead, that Darwin has two arguments: a short one to establish the *existence* of natural selection, and a much longer one to establish its *explanatory sufficiency* for a wide range of phenomena.

Although Sintonen gets closer to a correct analysis of Darwin's argumentation than Recker, his two-argument analysis is still incorrect. His mistake has arisen, as did Recker's, mostly from not seeing how Darwin conformed the structure of his argumentation to the *vera causa* (true cause) ideal. Both Recker and Sintonen give extensive discussions of this ideal as it was discussed by such authors as Herschel, Whewell and Mill in the 1830s and 1840s, but neither has seen (nor has Wilson) that in conforming his argumentation to that ideal, Darwin knowingly constructed *three* distinct, evidential cases, three component arguments, on behalf of natural selection: first, a case for its *existence* as a causal process going on in the world; second, a case for its *adequacy*, its competence to produce, adapt and diversify species; and, third, a case for its *responsibility*, for, that is, its having produced the species now living and the extinct species found as fossils. So, in sum, natural selection exists, it can have that sort and size of effect, and it has indeed formed the species that have originated so far.

The drift of these three arguments—or, better, evidential cases within Darwin's "one long argument"—can be recalled briefly. The first and second arguments are contained in the first eight chapters of the *Origin*, in its first edition. As for *existence*, species in the wild are subject to changes in conditions of life, and domesticated species show that any animals and plants exposed to changed conditions vary heritably. There is hereditary variation in the wild, then. There is also a struggle for life, for there is superfecundity and this entails a struggle for food, space and other limited requirements for life. In this struggle for life, there is a differential survival and reproduction of hereditary variants, for some hereditary differences affect chances of survival and reproduction. There exists in nature, therefore, a process of selective breeding, a process analogous to the selective breeding practiced by farmers and gardeners. As for *adequacy*, artificial selective breeding is known to be sufficient, competent, or adequate to produce, within a species, distinct races—of dogs, for example—adapted to distinct human ends. These races do not count, according to customary criteria, as distinct species. But natural selection

has vastly longer to work and is much more comprehensive and discriminating. So, it can then produce races that would count as species, for they would be more permanently and more perfectly adapted and divergent in their organization, and hence infertile with one another, true breeding in their characteristics and without intermediate varieties. (There is more to Darwin's adequacy case, obviously, but this is the primary line of reasoning.)

The third argument is contained in the next five chapters (the ninth, that is, through the thirteenth). As for *responsibility*, the theory that natural selection has been the main agency responsible for bringing into being the living and extinct species is more probable, and so is to be preferred over any rival theory because it is better than any other at explaining several kinds or classes of facts about those species: biogeographical facts, embryological facts and so on.

Since I have set out elsewhere (Hodge 1977, 1987, 1989, 1991a and 1991b) the textual grounds and other advantages of this three-case, or three-component argument, explication of the one long argument of the *Origin*, and since I have indicated there, too, what can be learned from the growing, specialist literature on such topics in the history of the philosophy of science as the *vera causa* ideal, let me allude here only to some leading reasons for seeing this explication as historically instructive and philosophically suggestive.

As the papers just cited attempt to show, Darwin's argumentation is in keeping with Herschel's and Lyell's endorsement of this ideal as an appropriate ideal for geological science; his argumentation is, therefore, not in keeping with Whewell's rejection of the appropriateness of this ideal for that or any other science, nor, therefore, with Whewell's proposed replacement for this ideal in natural science, generally—namely, the conciliation of inductions. More remotely, then, Darwin's commitment to this ideal is in descent from Reid's elaboration of what he took to be the implications of Newton's dicta about true and sufficient causes.

So much here for history. Philosophically, it is surely worth asking whether current theorizing about evolution by natural selection still takes the same form that Darwin gave his theorizing in 1859. For, as one of those papers (Hodge 1987) just cited urges, despite mathematical, Mendelian and molecular developments in this century, much the same structure of enquiry persists. There are questions about the definition of natural selection, and, beyond those definitional questions, there are empirical questions about its occurrence and prevalence (i.e., existence), about its consequences and capacities (i.e., what it suffices to effect), and about its past achievements (i.e., for what it has been responsible). These three clusters of empirical questions descend directly from the old *vera causa* evidential and explanatory concerns.

It would seem, therefore, that if the analysis of Darwin's argumentation hinted at here is correct, then it imposes constraints on two genres of task. First, anyone seeking to throw light on Darwin's argumentation—whether by means of semanticist, Kuhnian, or any other type of general philosophical proposal—must show how light is thrown on the three-case, or three-component-argument, structuring of that argumentation (see Hull 1989, 319). Second, anyone seeking to capture the form taken by current theorizing about evolution should be able to show how a similar structuring of evidential and explanatory concerns continues to be involved in establishing the empirical status of the theory of evolution by natural selection when this is construed, as it surely has to be, as a probabilistic causal theory.

## REFERENCES

- Darwin, C. ([1859] 1964), *On the Origin of Species*. Cambridge, MA: Harvard University Press.
- Hodge, M. (1977), "The Structure and Strategy of Darwin's 'Long Argument'", *British Journal for the History of Science* 10: 237–246.
- . (1987), "Natural Selection as a Causal, Empirical and Probabilistic Theory", in L. Krüger (ed.), *The Probabilistic Revolution*, vol. 2. Cambridge, MA: MIT Press, pp. 233–270.
- . (1989), "Darwin's Theory and Darwin's Argument", in M. Ruse (ed.), *What the Philosophy of Biology Is: Essays Dedicated to David Hull*. Dordrecht: Kluwer, pp. 163–182.
- . (1991a), "Discussion Note: Darwin, Whewell, and Natural Selection", *Biology and Philosophy* 6:457–460.
- . (1991b), "The History of the Earth, Life and Man: Whewell and Palaeontological Science", in M. Fisch and S. Schaffer (eds.), *William Whewell: A Composite Portrait*. Oxford: Oxford University Press, pp. 255–288.
- Hull, D. (1989), "A Function for Actual Examples in Philosophy of Science", in M. Ruse (ed.), *What the Philosophy of Biology Is: Essays Dedicated to David Hull*. Dordrecht: Kluwer, pp. 309–321.
- Kitcher, P. (1985), "Darwin's Achievement", in N. Rescher (ed.), *Reason and Rationality in Natural Science*. Lanham, MD: University Press of America, pp. 127–189.
- Lloyd, E. (1983), "The Nature of Darwin's Support for the Theory of Natural Selection", *Philosophy of Science* 50: 112–129.
- Recker, D. (1987), "Causal Efficacy: The Structure of Darwin's Argument Strategy in the *Origin of Species*", *Philosophy of Science* 54: 147–175.
- Ruse, M. (1975), "Charles Darwin's Theory of Evolution: An Analysis", *Journal of the History of Biology* 8: 219–241.
- Sintonen, M. (1990), "Discussion: Darwin's Long and Short Arguments", *Philosophy of Science* 57: 677–689.
- Thagard, P. (1978), "The Best Explanation: Criteria for Theory Choice", *The Journal of Philosophy* 75: 76–92.
- Wilson, F. (1992), *Empiricism and Darwin's Science*. Dordrecht: Kluwer. In press.

## DISCUSSION:

### AIMS AND ACHIEVEMENTS OF THE REDUCTIONIST APPROACH IN BIOCHEMISTRY/MOLECULAR BIOLOGY/CELL BIOLOGY: A RESPONSE TO KINCAID\*

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Kincaid argues that molecular biology provides little support for the reductionist program, that biochemistry does not reveal common mechanisms, indeed that biochemical theory obstructs discovery. These assertions clash with biologists' stated advocacy of reductionist programs and their claims about the consequent unity of experimental biology. This striking disagreement goes beyond differences in meaning granted to the terms. More significant is Kincaid's misunderstanding of what biochemists do, for a closer look at scientific practice—and one of Kincaid's examples—reveals substantial progress toward explaining biological function with biochemical models. With the molecular detail emerge unifying generalizations as well as further aspects of the functional processes.

The textbook *Molecular Cell Biology* begins, "We asserted in the preface to the first edition of this book that the reductionist approach and the new techniques of molecular biology would soon unify all experimental biology. Now, four years later, perhaps the only surprise is the speed and completeness with which biologists from fields formerly considered distant have embraced the new experimental approaches" (Darnell et al. 1990, vii). Yet Kincaid (1990, 575, 587) writes, "[M]olecular biology provides little support for the reductionist program. . . . Nonetheless, reductive research strategies still find significant sympathy among practicing biologists, especially molecular biologists. . . . So it is worth explaining how the failure of reductive explanations bears on scientific practice".

How can one account for this contrast in viewpoints between the biologists' pride in proclaimed success and the philosopher's complaint that it cannot and should not be done? Part of the answer, of course, may lie in alternative meanings attached to "reductionism". A deeper and larger issue is the proper recognition of what biologists actually strive to do, and what the consequences of that doing currently are. Only a serious

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