reasons for thinking this also imply that there is no path back from culture to a world in which behavior is governed directly by natural selection. It was this strongly autonomous view of culture that in my view turned the modest retreat proposed by E. O. Wilson's "sociobiology" into a full-scale crisis in evolutionary biology in the 1970s.

To describe the Baldwin effect in ways that made it analogous to, or even a "special kind of," genetic assimilation was, then, bad news for the Baldwin effect. Simpson's choice of the term "effect," whether intentionally or not, could not have been better calculated to expose the general idea that learning guides evolution to obloquy. The term "effect" is associated with a theory-neutral phenomena that is waiting to be explained by this or that theory. Genetic assimilation is an effect in this sense. But the Baldwin effect is not. No straightforward, theoretically neutral case of the Baldwin effect has ever been reported or agreed on. Rather, the Baldwin effect is a hypothesis that might be used to explain this or that phenomenon, such as the mix of learning and instinct in bird song, foot calluses, or lactose tolerance. Even then, however, Baldwinian explanations are no better than the theoretical background that licenses them. They were favored by the version of Darwinism assumed by Weismann, Baldwin, and Lloyd Morgan. They were at a considerable disadvantage, however, in a conceptual environment dominated by Simpson, Dobzhansky, Mayr.

This disadvantage can be seen clearly in the fact that, much to Waddington's annoyance, repeated comparisons of the Baldwin effect to genetic assimilation in the 1950s and 1960s were soon casting a shadow over the genetic assimilation itself. While no one doubted that it happened sometimes, it was generally treated as at most a peripheral, and not very important, mechanism of possible evolutionary change. Dobzhansky was even more dismissive. He called it a "tour de force," but one "achieved by manipulation of the external rather than the genetic environment" (Dobzhansky 1970: 211). Dismissing genetic assimilation in this way also meant driving a stake through the heart of the Baldwin effect. Comparison between genetic assimilation and "alleged Lamarckian inheritance is superficial," Dobzhansky proclaimed (Dobzhansky 1970: 211). This reading became the dominant one because the makers of the Modern Synthesis, having marginalized developmental biology from the outset, could not see why Waddington had fancied the comparison between the Baldwin effect

and genetic assimilation in the first place. In large part, that is because ontogenetic processes were off their screen; what Dobzhansky and Mayr saw was only natural selection operating on adult phenotypes in populations. It was quite otherwise for Waddington. While he admitted that genetic assimilation is the manifestation of preexisting genetic variation, Waddington's point was that whether and when variation is triggered depends on the crucial role of formed and forming tissues in "transferring competence" during the embryological process. Because Dobzhansky, Mayr, and Simpson considered the values of only two variables, genotypes and phenotypes, rather than attending to the role of embryology, which Waddington took to be the most proximate causal factor, they were inclined, according to Scott Gilbert, to put Waddington on the side of the Lamarckians and so to call his Darwinian credentials into question (Gilbert 1991: 205, n. 53).

4 Two Contemporary Baldwin Boosters

In view of the growing hostility of Simpson, Mayr, and Dobzhansky that I have recounted, it is odd that the Baldwin effect, or evolutionary scenarios that choose to go by that name, should have come into vogue again. For his part, Deacon acknowledges the tension; he speaks of either "Darwinian *or* Baldwinian" explanations (Deacon 1997: 328). Dennett, on the other hand, claims that the Baldwin effect is "a no longer controversial wrinkle in orthodox Darwinism" (Dennett, chap. 4, this volume). This conflict requires some explanation, especially in view of the fact that it is Deacon, I will suggest, whose version of the Baldwin effect is closer to the spirit of the mid-century Modern Synthesis than Dennett's. Dennett's approach reflects the influence of post-Synthesis versions of Darwinism in which game-theory and genetic algorithms are deployed in conjunction with selfish genes to trace the evolution of optimimally adapted functional modules, including, perhaps, a "module" for language.

In *The Symbolic Species*, Deacon invokes the Baldwin effect in the course of trying to explain the same things that Dennett wants to explain: the rapid evolution of brain, language, and representationally mediated intentional activity. The details of his case are not relevant in the present context, except to note that Deacon thinks that the acquisition of even a minimal capacity for using symbols creates a niche in which very strong selection pressures were brought to bear against members of human populations who failed to acquire this capacity. Rather than being a mere side effect of an enlarged brain, protolinguistic capacities may well have helped (in a coevolutionary way) cause the brain's expansion, as well as other species-specific adaptations, such as changes in the position of the larynx that permit enhanced vocalization.

In developing this argument, Deacon prepares the way by putting a Baldwinian spin on two well-known stories: lactose tolerance among herding populations, and selection in favor of heterozygotes that confer some protection against malaria. Deacon is aware that orthodox neo-Darwinian stories are available for both phenomena. In human populations that follow herds, alleles that allow infants to digest milk are not shut down immediately after weaning, as is normally the case, but instead remain operative at increasingly deferred points in the life cycle. The Modern Synthesis can easily interpret this by saying that members of the relevant subpopulations deferred shutting down genes for breaking down lactose *before* they became radically dependent on milk products, not (or at least dominantly) the other way around. The case of sickle-cell anemia and resistance to malaria has an even more canonical explanation. It is a virtual paradigm of Dobzhansky's theory of balancing selection, not of the Baldwin effect. The benefit conferred by having an allele that sickles blood cells, thereby conferring some degree of resistance to malaria, far outweighs the resulting illness in circumstances where the alternative is death, and so spreads rapidly through the population. (The cost-benefit ratio changes, of course, when these populations migrate to, or in this case were transported to, malaria-free environments.) Nonetheless, Deacon puts a decidedly Baldwinian accent on these cases by stressing the initiating and sustaining, and hence *causally primary,* role of cooperating human agents in creating and maintaining the environmental conditions down which cascades of gene frequency changes by means of natural selection can, and, in his opinion, must have proceeded to support the new dependence on an environment shaped by human activity. This is what Deacon calls "niche construction." "Whether Darwinian or Baldwinian," he writes, "the evolution of genetically based adaptations is a function of the long-term invariance of conditions that affect reproductive success" (Deacon 1997: 328). Accordingly, Deacon writes that

> It is no coincidence that the human populations with the highest percentage of lactose-tolerant adults are those where animals have been herded for the longest time, and those with the least lactose tolerance are those where herding was introduced most recently or not at all. (Deacon 1997: 323)

and that the

> sickle cell trait spread quite rapidly in Africa in recent prehistory because of human activity. . . . Probably the critical historical event that catapulted malaria to an epidemic disease was the introduction of agriculture and animal husbandry into Africa between five and ten thousand years ago. This culturally transmitted practice modified the tropical environment to create the perfect breeding ground for mosquitoes. . . . The human population was thrust into a context in which powerful selection favored reproduction of any mutation that conferred some resistance to malaria. (Deacon 1997: 323)

Deacon calls these cases "Baldwinian *rather than* Darwinian" in part because he explicitly dissents from the insistence of the lions of the mid-century Synthesis that adaptive natural selection always favors phenotypic flexibility (Deacon 1997: 323). About that they were just wrong. In some cases, he argues, it makes sense to lose phenotypic flexibility in order to ensure environmental stability and adaptedness to that stable environment. Soon enough the disadvantage conferred on members of a population that cannot more or less effortlessly acquire the behavior in question will be felt. An environment in which maintaining a learned behavior has become a matter of life and death survival for the population in question (shades of fly-swatter selection) will thus incur "costs in terms of learning times, costs for failing to learn, or learning incorrectly, and costs for simply being inefficient" (Deacon 1997: 326). In these conditions, Deacon argues, "any predisposition that even remotely contributes to producing a more reliable and efficient response will be positively selected" (Deacon 1997: 326). Deacon sees this dynamic at work in the progressive autonomization of language acquisition abilities.

In recent work, Deacon has had new thoughts, some of which he shares in the present volume (Deacon, chap. 5, this volume). His stress on the agency of organisms, especially of organisms that possess culture, in constructing environments that in turn exert their own selection pressures remains a central theme in his work. But Deacon has become increasingly insistent that the learned traits in question—herding in the case of lactose-tolerance, slash-and-burn agriculture in the case of sickle-cell anemia, and language-acquisition coincident upon an enlarged brain—are not genetically assimilated. They require learning, and plenty of it. Nonetheless, to the extent that the new behavior becomes absolutely necessary for survival and reproduction in a cultural niche, gene frequencies do change radically in favor of all manner of *supportive* adaptations that render the learned behavior more easily and universally acquired. There are no genes for herding cows, or for planting crops—or, indeed, for a "language instinct," at least of the sort postulated by Steven Pinker (Deacon 1997: 328). Nonetheless, as populations become dependent on herding, even at the cost of some digestive distress, regulatory genes that defer the shutting down of lactose-digesting metabolic pathways spread quickly and thoroughly through the population. So do genes that confer protection against malaria. An even more telling case is the dependence of modern humans on agriculture to supply ascorbic acid. Although ascorbic acid is obligatory, selection pressures that would unmask buried metabolic pathways that supply this vital nutrient metabolically are screened off by the construction and maintainance of cultural practices that ensure it by other means. Still, peripheral genetic adaptations that support the relevant learned behaviors, such as the proclivity to attend visually to yellow and orange oval shapes against a green background, do spread quickly and pervasively through the population. So too with the traits that support language acquisition.

Since writing *The Symbolic Species*, Deacon has resisted thinking of his account of language-acquisition as straightforwardly Baldwinian. The Baldwin effect refers, in his view, to the unmasking of previously hidden genetic variation under conditions in which strong selection pressures, and collapsed norms of reaction, are in play (Deacon, chap. 5, this volume). That is essentially Simpson's mid-century interpretation, to which Deacon cleaves. By this standard, language acquisition, which on Deacon's view deflects natural selection from fixing a trait genetically by favoring supportive adaptations, is a kind of Baldwinism in reverse. Nothing is in the genome that doesn't have to be. But what is there supports an obligatory dependence on learning by way of supportive genetic adaptations that often go to fixation. Accordingly, language acquisition is even further from genetic assimilation, which the makers of the Modern Synthesis conflated with the Baldwin effect simply because from the perspective of their conceptual scheme both seemed to have in common a certain "pseudo-Lamarckism" (Deacon, chap. 5, this volume). Having teased these concepts apart, however, we might profitably recall from our earlier discussion that Simpson's and Mayr's reconstruction of the Baldwin effect involved recasting it in something other than its original conceptual framework. This being so, Deacon's "reverse Baldwinism" might actually be closer, ceteris paribus, to Baldwin's and Lloyd Morgan's original concept of the relation between organic selection and evolutionary change than it would seem from a mid-century perspective. Baldwin and Lloyd Morgan too required strong selection pressures, sometimes at the cost of death; a collapse of norms of reaction; a conception of organisms as agents that are able to construct and maintain their own environments; and the (anti-Spencerian) notion that germ-line modifications support and reinforce, rather than actually replace, phenotypic plasticity.

These reflections reveal a certain continuity between Deacon and the Modern Synthesis. This impression is reinforced by noting that Dobzhansky's heir, Richard Lewontin, has also stressed the causal primary of niche construction, not only in the human case, but in the case of most organisms (Lewontin 1983; 1992: 32)—although, unlike Deacon, Lewontin will not retreat an inch from the view that natural selection has produced in humans full cultural autonomy and phenotypic plasticity, as his implacable hostility to sociobiology, evolutionary psychology, and to what he regards as the fatuous promises of the Human Genome Project shows (Lewontin 1992). In the matter of evolving genetic adaptations that help make certain kinds of learning obligate, moreover, Deacon appeals to the vastly enlarged supply of genetic variation that gene-reduplication and exon-shuffling have made available. But the insistence on new sources of genetic variability that can be maintained in human populations has since the 1940s been the hallmark of Dobzhansky's version of Darwinism. Here too Deacon reveals his continuity with received theory. It is also possible, however, that Deacon's "reverse Baldwinism," which increasingly stresses the interaction between cultural and genetic evolution, might resonate with something like Developmental Systems theory, which does not countenance privileging genes as developmental resources, but instead treats niche construction by human activity, Waddington-style embryology, and genes as mutually reinforcing, and presumptively causally equal, developmental resources (Griffiths, chap. 10, this volume). These developments will appear non-Darwinian only if the term Darwinism is exclusively reserved for the optimization thinking that has become increasingly well known in recent decades. (See Weber and Depew and 2001.)

In contrast to Deacon, who takes note of his differences with the Modern Synthesis because he shares a good deal of its conceptual background, Dennett tends to downplay the discontinuity between the orthodox Synthesis and his version of Darwinism, at least when it comes to the legitimacy of the Baldwin effect. In *Darwin's Dangerous Idea,* Dennett admits that the Baldwin effect has "typically been shunned by overcautious thinkers, because they thought it smacked of the Lamarckian heresy" (Dennett 1995: 80). We can guess that he means Simpson, Mayr, and Dobzhansky. After the work of Hinton, Nowlan, and Maynard Smith, however, Dennett argues that the Baldwin effect should be considered "no longer a controversial wrinkle in orthodox Darwinism" (Dennett, chap. 4, this volume). He appears to conclude that it was a merely contingent fact—lack of access to computational machines, programs, and models—rather than conceptual disagreement that led people like Simpson, Dobzhansky, and Mayr to fail to understand that the Baldwin effect can be part of the "orthodox" Synthesis itself. (In a similar way, Dennett argues that Darwin himself failed to grasp fully the nature and consequences of what Dennett still takes to be *his,* namely Darwin's, Dangerous Idea [Dennett 1995].)

It is no doubt true that Dennett would like to recruit the authority of Modern Synthesis for his version of genetic Darwinism. Nonetheless, the differences between his version and the Modern Synthesis are fairly large. Dennett turns to the Baldwin effect as a way of accounting for the rapid coevolution of the physiological, mental, linguistic, and behavioral characteristics that mark off our quite young species from other hominids, and perhaps hominids from primates. Dennett has Baldwin, as reconstructed by Richards, holding that a "species will evolve faster because of its greater capacity to discover design improvements in the neighborhood" through a process of behavioral trial and error (Dennett 1995: 79). ("Design improvements" is Dennett's concept, not Richards's or Baldwin's.) As Dennett makes clear in his contribution to this volume, however, it is not just evolutionary tempo that is in question, but the need to ensure that natural selection moves in a concerted direction as it explores fitness landscapes in what Dennett calls the "design space" that lead toward big brains, behavioral plasticity, and speech (Dennett, chap. 4). Dennett's scenario for the

Baldwin effect relies on the lucky hard-wiring of the neural system of an individual (or perhaps small group of individuals) who happens to perform a "Good Trick," which, if it were to spread in a population, would solve a significant, pressing adaptive problem. "With this Good Trick," Dennett writes, "comes a minimal capacity to 'recognize' (in scare quotes) a tiny bit of progress, to 'learn' something by blind trial and error" (Dennett 1995: 78–79). The required spread through the population is assured by reinforcing the behavior in offspring and other members of the population. Dennett then relies on Hinton and Nowlan, as glossed by Maynard Smith, to show that such learned and relearned tricks will be favored by reiterated bouts of natural selection moving in the direction pointed by learning. The assumption must be that these selection pressures are very strong, that they move in a concerted direction, and that subsequent gene frequency changes both optimize and autonomize the behaviors in question.

Whether this scenario, or the mechanism on which it rests, is the same as that proposed by Deacon is a matter of dispute. The issue is explored in a subtle three-way exchange among Godfrey-Smith, Dennett, and Deacon in this volume (Godfrey-Smith, Dennett, and Deacon, chap. 6, this volume). On the descriptive surface, however, it is for Dennett a neurological, or perhaps even a genetic, variant rather than wide norms of reaction that is causally responsible for the initial behavior; and learning is seen as capable of marking off evolutionary vectors not because a shared environment brought into existence by the spread of the novel behavior exerts a new selection pressure on the population as a whole, but because competition among individual members of society for the reproductive benefits brought by the Good Trick is very stiff. This individualist picture accords well with Dennett's own theoretical framework, according to which natural selection itself is a negative feedback process, an "algorithm" for generating and testing variations (Dennett 1995). It accords less well than Dennett might like to admit, however, with the way in which the Baldwin effect was reconstructed by Simpson and other mid-century figures.

Construing natural selection as an algorithm encourages the reader to think of natural selection itself, and not just the adaptations it brings forth, as operating in a concerted, end-oriented, optimizing way, and so justifies Dennett's confidence that the results of genetic algorithms can be read directly into nature's ways. So concerted is the effect of a Good Trick that, according to Dennett, it confers on those who possess it a tiny bit of "look ahead" not only into what is immediately necessary for task at hand, but into the direction of evolution (at least in their lineage) itself. This claim, if interpreted in this way, may well echo Baldwin's and Lloyd Morgan's view that evolution marches in the direction marked off by organic adaptations, or, roughly, learned behaviors. If interpreted charitably, it might be a good account of adaptive dynamics. Nonetheless, the conceptual scheme that permits the first uncharitable interpretation is not, as we have seen, one that could be countenanced by the orthodox Modern Synthesis. While wide arrays of genetic variation in populations allow novel, potentially imitable behaviors to occur in populations of social animals, and in addition confer on populations the genetic plasticity that allows them to remain adapted to changing environments, this very stress on genetic variety and phenotypic plasticity—a conception that is at the core of the fully articulated Modern Synthesis—blocks any sort of "look ahead" that foreshadows, either at the phenotypic or genotypic levels, the direction of evolution itself (Downes, chap. 2, this volume). It was for just this reason that the Baldwin effect was placed under suspicion by the Modern Synthesis. It is also why Deacon, in his second thoughts, has retreated from thinking of the role of learning in evolution as straightforwardly Baldwinian. If the Baldwin effect, under this redescription, does not fall under suspicion in Dennett's work, it is perhaps because his version of genetic Darwinism, while it might very well be superior, differs from that of the Modern Synthesis.

5 An Encouraging Conclusion

In this essay, I have argued for two theses. The first is that there is no theory-neutral empirical phenomenon that can be named "the Baldwin effect." The second is that the term "Baldwin effect" cannot name even a theoretical concept that maintains fixity of reference between Baldwin's version of Darwinism, Simpson's version, and either Dennett's or Deacon's, which themselves diverge. The moral I wish to draw from these claims, however, is a cautionary, and perhaps even an encouraging, one. Just as there was considerable conceptual slippage between the so-called Baldwin effect in its first and second reconstructions, so too there might very well be slippage between the fate of Baldwinism in a new, post-Synthesis framework and how it appeared to Simpson and the other framers of the Modern Synthesis. The very fact that Deacon's version of the Baldwinian idea calls into question what it takes to be arbitrary dogmas of Modern Synthesis—its prohibition on collapsed norms of reaction, for example, or its a priori insistence that gene frequency changes must always precede phenotypic heritability—reinforces the observation that the Modern Synthesis is being buffeted by many challenges, and may, taken as a totality, be a thing of the past. So too does Dennett's refiguring of natural selection, in the age of computation, as a cybernetic process. Admittedly, there is some irony in the circumstance that, if I am right, Deacon's version of the Baldwin effect remains closer to the central principles of orthodoxy than Dennett's. For it is Dennett who professes himself to be drawing out implications of the tradition, while, in dissenting from subsidiary, but influential, hypotheses that were presumably insisted upon by the makers of the Modern Synthesis, Deacon downplays the degree of continuity between his theory and the fundamental principles of orthodoxy. The main lesson, however, is this. The fact that we may be entering into a post-Synthesis period need not be an objection to creative appropriations of the Baldwinian idea by Deacon, Dennett, or anyone else. If the history of Darwinism generally, and of the Baldwin effect specifically, is any guide, we should be wary of dismissing hypotheses just because they do not fit with received interpretive schemes. For it is possible that new appropriations of the general Baldwinian idea may go hand in hand with the emergence, if sometimes obscurely and *in statu nascendi*, of theoretical frameworks that may in the end prove more empirically satisfactory than their predecessors.[6]

Notes

1. It would be possible to argue that Baldwin discovered the principle of operant conditioning. Since Baldwin habitually claimed priority for new ideas in biological psychology, he would have been gratified by this attribution. This is a point made by Paul Griffiths (chap. 10, this volume).

2. Weismann's argument first became known in the English-speaking world in 1889 with a translation of his *Essays upon Heredity and Kindred Biological Problems* (Weismann 1893). They became far more widely known to the reading public, however, and charged with political meaning, only with the appearance in 1893 of an article in *Contemporary Review* entitled "The All-sufficiency of Natural Selection: A Reply to Herbert Spencer" (Weismann 1893).

3. James, who had been attracted to it in his youth, rejected Spencerism, and despised Social Darwinism. In an 1878 letter to his boss, Harvard president Charles Norton Eliot, he had written, "My quarrel with Spencer is not that he makes much of the environment, but that he makes nothing of the glaring and patent fact of subjective interests which cooperate with the environment in molding intelligence" (James to Eliot, November 22, 1878; quoted in Richards 1987: 426–427). James's fidelity to Darwinism is evident in the support he gives Weismann in the final pages of the second edition of his *Principles of Psychology* (James 1890: 678–680). In the same place, however, James reiterated his belief that it would be helpful "if habits could bear fruit outside individual life, and if the modification so painfully acquired by parents' nervous systems could be found ready made at birth in those of the young" (James 1890: 680–681). Alas, James was unclear how this might happen under the exclusive regime of hard inheritance—the very point on which Baldwin and Lloyd Morgan profess to give an answer. Thus James could do little more comfort himself in the final sentenced of his revised masterpiece with the thought that "the actual course of psychogenesis" may be forever occluded as "the slowly gathering twilight closes into utter night" (James 1890: 689).

Dewey's early Darwinism shows signs of having profited from Baldwin's 1895 book, from the press battle in *Science* and the *American Naturalist* that followed in 1896, and perhaps from Lloyd Morgan's lecture tour, which brought him to Illinois. Dewey's earliest recorded thoughts about natural selection stress Baldwin's notion that behavior is shaped by a process of organic selection. He alludes in a review written in 1896 to

> those having competent knowledge of details have good reason [for claiming that] not only is one form of life as a whole selected at the expense of other forms [for a population], but one mode of action in the same individual is constantly selected . . . by the success or failure of special acts—the counterpart, I suppose of physiological selection so called. We do not need to go here into the vexed question of the inheritance of acquired characters. We know that through what we call public stimulated and encouraged, while other types are as constantly objected to. . . . What difference in principle exists between this mediation of the acts of the individual by society and what is ordinarily called natural selection I am unable to see. (Dewey, *Early Works* 5:50)

Dewey's insouciant solution to the problem that vexed James, Baldwin, and Lloyd Morgan is to redefine organic selection as itself a form of natural selection, and to think of Baldwin's ontogenetic adaptations simplicter in the case of humans, because the social environment, and social heredity of humans, constitute, in his view, their species-specific biotic environment. That is why Dewey wrote at the same time, "The unwritten chapter in natural selection is the evolution of environments" (Dewey 1971: 5: 52). This bracketing of what Dewey calls "extreme Weismannism" (Dewey 1971: 4: 212) provides, I suspect, the foundations of his "instrumentalist" brand of pragmatism, and of the opinions about "the influence of Darwinism on philosophy" that he set down in his 1910 essay of the same name (see Godfrey-Smith 1996). I suspect that Dewey neither changed his view nor defended it in subsequent decades, but merely assumed it in all of his work.

4. I am not entirely sure how to reconcile this conception of natural selection with Lloyd Morgan's earlier proposal, cited by Richards (1987): 390, to distinguish between natural selection and "natural elimination," and to identify something close to Baldwin's ontogenetic adaptation as natural selection—the same proposal made by Dewey, except that it seems to be a general claim rather than a special claim about humans.

5. Schmalhausen recognizes that "development is determined not only by the genotype but by environment factors. Therefore, the genotypic expression of both normal organisms and mutants is different in diverse environments" (Schmalhausen 1949: 4). Schmalhausen's term "norms of reaction" names the width of such responses. Schmalhausen does not, however, think that all norms of reaction are either adaptive or adaptations. They include "adaptive modifications of the organism to different environments" (7), but also include "nonadaptive modifications . . . which have not yet attained an historical basis." Indeed, Schmalhausen claims that "all really new reactions are never adaptive" (8). These are, he says, "very unstable," in contrast to "adaptive modifications," which are stable precisely because they have fairly wide norms of reactions, and thus can adjust to all environmental changes that are not so random and capricious that they could never become historical, or adaptive, responses. This has become a fundamental principle of contemporary genetic Darwinism, especially through the work of Dobzhansky (Dobzhansky 1970) and Lewontin (Lewontin 1974). Along the way, however, the term seems to have become ever more restricted to norms of reaction that are adaptations. Schmalhausen's openness on this point may well have influenced Waddington's and even Simpson's comparison of the Baldwin effect with genetic assimilation. For genetic assimilation is sometimes indeed nonadaptive. I owe this point to Allan Love.

6. I am grateful to audiences at Bennington College, the Center for Philosophy of Science, University of Pittsburgh, and the University of Iowa for many good suggestions. An earlier, much different version of the argument in this paper appeared in *Cybernetics and Human Knowing* 7 (2000) 7–20. I am grateful to Soren Brier for comments on that version. I am also grateful to Terry Deacon for helpful comments on the present version.

References

Ackly, D. and M. Littman. (1992). Interaction between learning and evolution. In C. G. Langston, C. Taylor, J. D. Farmer, and S. Rasmussen (eds.), *Artificial Life II*, pp. 487–509. Redwood City, Calif.: Addison-Wesley.

Baldwin, J. M. (1895). *Mental Development in the Child and the Race*. New York: Macmillan.

Baldwin, J. M. (1896a). Heredity and instinct. *Science* 3 (March 20–April 10): 438–441, 558–561.

Baldwin, J. M. (1896b). Physical and social heredity. *American Naturalist* 30 (May) 353, 422–428.

Baldwin, J. M. (1896c). A new factor in evolution. *American Naturalist* 30 (June) 354, 422, 441–451, 536–553.

Baldwin, J. M. (1902). *Development and Evolution.* New York: Macmillan.

Brandon, R. N. (1996). Phenotypic plasticity, cultural transmission, and human sociobiology. In R. N. Brandon, *Concepts and Methods in Evolutionary Biology.* Cambridge: Cambridge University Press.

Cope, E. D. (1896). *Primary Factors in Organic Evolution.* Chicago: Open Court.

Deacon, T. (1997). *The Symbolic Species.* New York: W. W. Norton.

Dennett, D. (1991). *Consciousness Explained.* Boston: Little, Brown.

Dennett, D. (1995). *Darwin's Dangerous Idea.* New York: Simon and Schuster.

Depew, D. J. and B. H. Weber (1995). *Darwinism Evolving: Systems Dynamics and the Genealogy of Natural Selection.* Cambridge, Mass.: Bradford Books/MIT Press.

Dewey, J. (1971). *Early Works,* vols. 4, 5. Edited by Jo Ann Boydston. Carbondale: Southern Illinois University.

Dobzhansky, T. (1970). *Genetics of the Evolutionary Process.* New York. Columbia University Press.

Hinton, G. E. and S. J. Nowlan (1987). How learning can guide evolution. *Complex Systems* 1: 495–502. Reprinted in R. K. Belew and M. Mitchell (eds.), *Adaptive Individuals in Evolving Populations,* pp. 447–453 (Reading, Mass: Addison-Wesley, 1996).

Huxley, J. (1942). *Evolution: The Modern Synthesis.* London: Allen and Unwin.

Gilbert, S. (1991). *A Conceptual History of Modern Embryology.* Baltimore, Md.: Johns Hopkins University Press.

Godfrey-Smith, P. (1996). *Complexity and the Function of Mind.* Cambridge: Cambridge University Press.

James, W. (1890). *The Principles of Psychology,* revised edition. New York: Henry Holt.

Lakatos, I. (1970). Falsification and the methodology of scientific research programmes. In I. Lakatos and A. Musgrave (eds.), *Criticism and the Growth of Knowledge,* pp. 91–195. Cambridge: Cambridge University Press.

Laudan, L. (1977). *Progress and Its Problems: Toward a Theory of Scientific Growth.* Berkeley and Los Angeles: University of California Press.

Lewontin, R. (1974). *The Genetic Basis of Evolutionary Change.* New York: Columbia University Press.

Lewontin, R. (1983). Gene, organisms and environment. In D. S. Bendall (ed.), *Evolution from Molecules to Men,* pp. 273–285. Cambridge: Cambridge University Press.

Lewontin, R. (1992). *Biology as Ideology.* New York: Harper/Perennial.

Lloyd Morgan, C. (1896a). *Habit and Instinct.* London: Arnold.

Lloyd Morgan, C. (1896b). Of modification and variation. *Science* 4 (99) (November 20): 733–739.

Maynard Smith, J. (1987). Natural selection: when learning guides evolution. *Nature* 329: 761–762. Reprinted in R. K. Belew and M. Mitchell (eds.), *Adaptive Individuals in Evolving Populations,* pp. 455–457 (Reading, Mass: Addison Wesley, 1996).

Mayr, E. (1963). *Animal Species and Evolution.* Cambridge, Mass: Harvard University Press.

Osborn, H. F. (1896). A mode of evolution requiring neither natural selection nor the inheritance of acquired characteristics. *Transactions of the New York Academy of Science* 15: 141–148.

Richards, R. J. (1987). *Darwin and the Emergence of Evolutionary Theories of Mind and Behavior.* Chicago: The University of Chicago Press.

Schmalhausen, I. I. (1949). *Factors of Evolution.* Translated I. Dorick, ed. T. Dobzhansky. Philadelphia: Blackison Press.

Simpson, G. G. (1953). The Baldwin effect. *Evolution* 7: 110–117.

Waddington, C. H. (1953). "The Baldwin effect," "genetic assimilation," and homeostasis. *Evolution* 7: 386–387.

Waddington, C. H. (1962). *New Patterns in Genetics and Development.* New York: Columbia University Press.

Watkins, J. (1999). A note on the Baldwin effect. *British Journal for the Philosophy of Science* 50: 417–423.

Weber, B. H. and D. Depew (2001). Developmental systems, Darwinian evolution, and the unity of science. In S. Oyama, P. Griffiths, and R. Gray (eds), *Cycles of Contingency,* pp. 239–253. Cambridge, Mass.: MIT Press/Bradford Books.

Weismann, F. (1891). *Essays on Heredity and Kindred Problems.* Edited by E. Poulton et al. Oxford: Clarendon Press.

Weismann, F. (1893). The all-sufficiency of natural selection: A reply to Herbert Spencer. *Contemporary Review* 64: 309–338, 596–610.