

Revisiting the Eclipse of Darwinism

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Abstract. The article sums up a number of points made by the author concerning the response to Darwinism in the late nineteenth and early twentieth centuries, and repeats the claim that a proper understanding of the theory's impact must take account of the extent to which what are now regarded as the key aspects of Darwin's thinking were evaded by his immediate followers. Potential challenges to this position are described and responded to.

Keywords: anti-Darwinism, Darwinism, eclipse of Darwinism

Having written books with titles such as *The Eclipse of Darwinism* and *The Non-Darwinian Revolution*, I could hardly resist the offer to produce an overview of my current thinking on the status of the Darwinian revolution. My ideas have certainly developed over the years, but in a reasonably consistent manner. Each book has, in a sense, created the question that had to be answered in the next. The initial purpose was only to document the temporary explosion of interest in non-Darwinian ideas of evolutionism in the late nineteenth century. But once it became apparent that even some ostensible supporters of Darwinism adopted positions that would never be included under that name today, it became necessary to rethink the relationship between early and modern Darwinism, and to reassess why Darwin's work was taken so seriously when it was first published. *The Non-Darwinian Revolution* built upon the insights of *The Eclipse of Darwinism* to present what was, at the time, a fairly radical reinterpretation of the impact of evolutionism on nineteenth century ideas about nature, human nature, and society. Later books such as *Life's Splendid Drama* have extended the argument further by showing how several areas of science were fruitfully transformed by an evolutionism that was at first far less radical than modern Darwinism. More recent work on science and religion in the early twentieth century has also influenced my thinking about the impact of Darwinism.

It has helped me to understand why historians were for so long misled by the myth which portrayed the late nineteenth century as a period dominated by a radically materialistic evolutionism. This paper outlines how my ideas about the Darwinian revolution have developed, and then considers various challenges which have been offered to this interpretation.

Darwinism in Theory and in Practice

I came to the study of the Darwinian Revolution in the mid-1960s via a course offered at Cambridge by Robert M. Young.¹ Although I left Cambridge too soon to be strongly influenced by Bob's Marxist approach, I was at least alerted to the social implications of scientific ideas, and my first serious study was directed toward the emergence of the idea of the progressive development of life on earth in nineteenth-century paleontology. After what turned out to be a temporary foray into the eighteenth century, this first project was ultimately turned into a book, *Fossils and Progress*.² One reason why I had been advised to write a Ph.D. thesis on the eighteenth century was that so many others were working on the early-mid nineteenth century at the time. As it happened, parts of my book closely paralleled work done independently by Dov Ospovat.³ What turned out to be the most exciting aspect of the book in opening up new avenues for research was, however, the last chapter on the post-Darwinian era. Although originally almost an afterthought, this alerted me to the fact that there were paleontologists such as Edward Drinker Cope and Alpheus Hyatt who were evolutionists, but open exponents of an anti-Darwinian interpretation of how the process operated. Further research soon revealed that these individuals were but the tip of an iceberg of non-and anti-Darwinian thinking moored firmly across the flood-tide of evolutionism. The result was, of course, another book, *The Eclipse of Darwinism*.⁴

The field was at first dominated by the work of scholars such as John C. Greene, Loren Eiseley and Gavin De Beer. In part because of the

¹ Young's work was immensely important in altering us to the ideological dimensions of scientific debates, see his collected papers, Young, 1985. In the end, though, I think many scholars felt that he painted with so broad a brush that important distinctions were obscured. My own article on Malthus and Darwin (Bowler, 1976a) was, of course, a belated response to Bob's work.

² Bowler, 1976b.

³ Ospovat, 1976.

⁴ Bowler, 1983.

centenary of the publication of the *Origin of Species* in 1959, these studies focused on the line of development leading from Darwin to the twentieth-century Darwinian synthesis as the key to the emergence of modern evolutionism. The initial controversies over the adequacy of the selection theory were noted, but presented as temporary objections soon overcome. Darwin's "failure" to anticipate Mendelian genetics was seen as the most obvious source of these initial difficulties, and once that missing piece had been inserted into the jigsaw puzzle, the modern Darwinian worldview soon emerged in all its glory.⁵ John Greene's penultimate chapter "The Triumph of Chance and Change" presented Darwin's essentially materialist theory as the climax of a long tradition of challenging the argument from design, thereby minimizing any need to see major conceptual developments in the following decades.⁶ When Ernst Mayr subsequently endorsed this Darwin-centered historiography, he did at least acknowledge the role played by neo-Lamarckism (after all, he had been a Lamarckian himself to begin with), but he treated anti-Darwinian evolutionism very much as a side-branch to the main line of development, something to be admitted, but not worthy of being explored in detail.⁷ Greene and Mayr have disagreed extensively, of course, about the moral impact of Darwin's ideas,⁸ but they share the view that his work not only encapsulated the anti-teleological position, but also placed it immediately center-stage in both science and culture. Exploration of the eclipse of Darwinism had, however, convinced me that it was far too important an episode to be dismissed so casually. In the end, I came to believe that a full appreciation of the role played by non-Darwinian thinking in the late nineteenth and early twentieth centuries required a wholesale reappraisal of the initial impact of Darwinism, a view expressed in a short book intended for a broad readership: *The Non-Darwinian Revolution*.⁹

My argument was that if the theory of natural selection had not been widely endorsed by the post-Darwinian generation of evolutionists, then we needed to think very carefully about how and why the *Origin of Species* had had such an impact. It was not the intention to deny that it did have a major impact – one referee had suggested that the book should be called *The Darwinian Non-Revolution*. But I wanted to argue that the transition to an evolutionary perspective was much less dramatic that it would have been if (as in the traditional view) Darwin's

⁵ This position is most obvious in Eiseley, 1958 but is also implicit in De Beer, 1963.

⁶ Greene, 1959, chapter 9.

⁷ Mayr, 1982.

⁸ See Greene, 1999.

⁹ Bowler, 1988.

supporters had all been advocating a non-progressionist, non-teleological vision of evolution along the lines favored by twentieth-century Darwinians. Darwin was a catalyst whose theory shocked everyone into action, but was far too radical to be accepted in the form which Darwin himself intended and in which it was later taken up. The *Origin* was hijacked by the prevailing enthusiasm for a progressive and purposeful developmental trend in nature, with even the idea of struggle being taken over and seen as either a Lamarckian stimulus to self-improvement, or as a purely negative process for weeding out evolution's less-successful efforts. On this model, the emergence of modern Darwinism required a second revolution to destroy the developmental worldview, which in science was associated with the emergence of Mendelian genetics (hence the rather tongue-in-cheek title of another book, *The Mendelian Revolution*)¹⁰. Here the metaphor of Darwin as a catalyst breaks down, because his more radical insights – associated not just with natural selection, but also with the theory of branching evolution driven largely by the demands of local adaptation – turned out to be central for this second revolution. Ideas that had been seen merely as a challenge by the first generation of developmental evolutionists were now exploited to the full. Put together, the two episodes mark a truly revolutionary transition in science and more generally in the way we think about the world.

My argument drew on several lines of evidence, many of which have been substantiated by later work. It was already clear that there was some interest in a progressionist form of evolutionism emerging before the *Origin* was published. Jon Hodge demonstrated the very non-Darwinian foundations of the transformism promoted in Robert Chambers' *Vestiges of Creation* in 1844.¹¹ Subsequent studies by Jim Secord and Adrian Desmond have uncovered the immensely important role played by Chambers, and by earlier radical Lamarckians, in promoting this vision of nature as a counterpart to calls for political reform.¹² Secord, in fact, goes much further than I had dared by suggesting that Darwin's role was really much less important, initiating only the final conversion of the majority to open acceptance of the progressionist worldview. The very lukewarm attitude of many early Darwinians toward the selection theory was also becoming apparent. Michael Bartholomew and others showed how little enthusiasm T. H. Huxley had for the mechanism, and his preference for saltationism.¹³ My own work had exposed Herbert

¹⁰ Bowler, 1989.

¹¹ Hodge, 1972.

¹² Secord, 2001 and Desmond, 1989.

¹³ Bartholomew, 1975.

Spencer's enthusiasm for Lamarckism and his role in the subsequent eclipse of Darwinism, and I think this point has gradually been recognized by most students of 'social Darwinism.' Jim Moore's study of Darwinism and religion showed the extent to which acceptance of evolutionism depended, in most cases, on the creation of an interpretation which preserved a role for some sort of teleology via the idea of progress.¹⁴

The role played by the recapitulation theory in both science and ideology had already been brought out by Stephen Jay Gould. Recapitulation was routinely used to endorse Lamarckism and the idea that evolution consisted in the addition of stages to a linear pattern of development. Gould noted the role of recapitulation in the Darwinism promoted by Ernst Haeckel, and (unlike Bob Richards, whose views are discussed below) he acknowledged that this factor distanced Haeckel from the position adopted both by Darwin and by the later neo-Darwinians. Gould's study also brought out how recapitulationism was used by the American neo-Lamarckians to promote a vision in which multiple lines of evolution were driven in preordained directions. My own later work on phylogenetic research in the late nineteenth century showed how the idea of parallelism was used to subvert the Darwinian emphasis on both the theory of common descent and the role of adaptation.¹⁵ Finally, I think most historians dealing with the emergence of Mendelism are now prepared to acknowledge the role played by the saltationist model of evolution in stimulating the thought of early geneticists such as William Bateson and Thomas Hunt Morgan. This point is crucial for establishing the case that the whole non-Darwinian episode cannot be dismissed as a mere sideline to the main development of modern evolutionism. Whatever you think about the science of the neo-Lamarckians and orthogeneticists, the fact that genetics emerged in part from an anti-adaptationist, saltationist approach to evolution shows that non-Darwinian modes of thinking had something crucial to contribute.

In short, a great deal of work by other historians has lent support to the basic interpretative framework I put together what now seems a frighteningly long time ago. I am reasonably confident that much of what I argued for has now become taken for granted both by historians of science and by students of nineteenth-century thought and culture. No one with any serious knowledge of the field now thinks that Darwin introduced the idea of evolution to a public and a scientific community

¹⁴ Moore, 1979.

¹⁵ Bowler, 1996.

that was unaware of the idea of progressive evolution. No one thinks that the first generation of Darwinists were simple forerunners of the later neo-Darwinians, and everyone is thus aware that we cannot explain the initial enthusiasm for “Darwinism” by invoking the power of arguments that only became widely accepted after the 1930s. Whatever Darwin’s own intentions (and that remains a contentious point), his theory was sucked into a wave of enthusiasm for progressionist evolutionism that had already begun to swell long before he published and reached its climax in the later nineteenth century. But his book forced waverers, especially within the elite scientific community, to think again about the idea of evolution and to accept that it was a theory that could be addressed by the methods of science.

By spearheading a highly visible conversion of the scientists to evolutionism, Darwin’s theory and his name thus took on iconic significance that created the impression of a *Darwinian* revolution. To a significant extent, however, this involved reading his book in a selective manner. Morphologists, paleontologists and naturalists studying geographical distribution were inspired to attempt the reconstruction of genealogies and migrations, even though Darwin himself had cautioned that the evidence would not bear the weight of the interpretations that would have to be put on it. My book *Life’s Splendid Drama* was written to provide a comprehensive overview for non-specialists of this initial attempt to exploit the idea of evolution within science. From these phylogenetic studies emerged much of the support for non-Darwinian mechanisms such as Lamarckism, orthogenesis and saltationism. In their more extreme form, though, these ideas led to a complete rejection of some of the key ideas of Darwinism. The “eclipse” occurred as more and more biologists rejected the emphasis on function and adaptation, highlighting instead mechanisms that stressed the role of formal or structural constraints on development. The “Mendelian revolution” followed when a byproduct of the more extreme form of saltationism (the idea of unit characters) was united with a tradition of thinking about the problems of heredity which can certainly be traced back to Darwin, although it had remained in the background during the heyday of phylogenetic research.

Outside science, a whole generation of thinkers adopted a model of social evolution which portrayed it as an advance through a linear hierarchy of stages toward the modern situation.¹⁶ They also adopted the metaphor of struggle as the motor of progress without thinking very much about Darwin’s focus on adaptation and divergence through

¹⁶ Bowler, 1993.

geographical radiation. Here again, Darwin served as a focus for an idea that was emerging into the public consciousness, although the metaphor of struggle took on a life of its own which allowed it to be invoked at the individual, the national and the racial levels, generating a whole range of social Darwinisms through into the early twentieth century. Historians of the mid-twentieth century have to grapple with the apparent paradox that the emergence of what we now call Darwinism as the dominant theory of evolution within scientific biology coincided with the demise of the original version of Darwinism as a cultural icon.

Problems and Objections

If the above summary sounds overconfident, I am only too willing to admit that there are still tensions among historians over some of the issues (it would be pretty boring nowadays if it had all been resolved so easily). But in some respects, the challenges offered to the interpretation I have sketched in here arise from the basic arguments being taken further than I myself would want to push them. This tendency emerges at three levels. The first level centers around challenges to the role played by Darwin himself in the revolution. The second relates to the overall significance of the first generation of post-Darwinian scientists who attempted to reconstruct the history of life on earth. And the third arises from the modern emphasis on the practice of science and asks whether evolutionism had any real impact on the way biologists actually did their work.

I have never regarded myself as a serious Darwin scholar, and in principle the reinterpretation of the Darwinian revolution I have urged would not suffer if it were argued that Darwin was a figurehead with little real impact on the direction of science. In a sense, that comes close to my own suggestion that Darwin was only a catalyst in the transformation toward developmental evolutionism. But the reason I prefer the term “catalyst” rather than “figurehead” is that I think Darwin did have important insights to offer, insights whose power was only dimly perceived (except by those who felt truly threatened by them) when first published, but which helped to transform our ideas of evolution when fully appreciated in the twentieth century. I am thus reluctant to accept Jim Secord’s suggestion that Darwin merely completed the job that Chambers had begun with *Vestiges*. Chambers couldn’t carry the scientific community with him because it was obvious that he didn’t have a theory that could be used as the basis of serious research. Darwin’s selection theory equally clearly did have the capacity to be tested both

directly and indirectly, and it thus drove home the message that evolutionism could become part of scientific thinking even to those who were not convinced that it was an adequate explanation of the process. Those who ignored Darwin's warning and set out to reconstruct the history of life on earth nevertheless had to realize that handwaving about ideal types or the goal of creation was no longer enough. In principle, at least, one had to construct explanations which hypothesized real ancestors living in particular times and places, and evolutionary trends which had either an adaptive purpose or (for the anti-Darwinians) some clearly defined orthogenetic trend. More importantly in the long run, Darwin's mechanism also focused attention onto problems of inheritance, variation and speciation which, while not solved within the developmental paradigm, nagged away in the background until they became central to the transformation of ideas about heredity and the variability of populations at the turn of the century.

This leads me to what I can only see as a more extreme version of the attempt to minimize Darwin's role, Robert J. Richards' efforts to incorporate him fully into the Romantic tradition.¹⁷ For Bob, Darwin becomes a clone of Ernst Haeckel; both are recapitulationists and transcendentalists, and Haeckel has as complete an understanding of the selection mechanism as Darwin himself. This would be wonderful evidence for the validity of the thesis that nineteenth-century Darwinism was completely different from its modern counterpart. But I cannot bring myself to believe that Darwin's interest in embryos as clues to ancestry is the same as Haeckel's enthusiasm for what Jon Hodge has called the "Lamarckian-recapitulationist motor of progress."¹⁸ Richards is right to accuse earlier writers on Darwin, myself included, of ignoring the evidence for Darwin's commitment to the idea of progress. But you can believe in progress without seeing it as the unfolding of a predetermined pattern, and I cannot help feeling that there was far more of the latter sentiment in Haeckel's thinking. We should bear in mind that it was precisely that "Lamarckian motor" which became the inspiration for that most anti-Darwinian of evolutionary philosophies, the neo-Lamarckism of Cope and Hyatt. Darwin may have derived some inspiration from German thought, but he was also enmeshed in the Paleyan tradition of natural theology, the utilitarian ideology of *laissez-faire*, the Lyellian philosophy of uniformitarianism (with its links to biogeography), the breeders' concerns for the practicalities of

¹⁷ Richards, 1991 and 2002.

¹⁸ Jon Hodge, comments at the conference on "Transformism, Evolutionism and Creationism," Wellcome Trust Centre for the History of Medicine, London, 6 December 2003.

heredity and the field naturalists worries about the relationship between species and varieties. Haeckel was much more of a pure morphologist, with a morphologist's tendency to see development as the unfolding of formal patterns. One of his last products was the art nouveau designs of the *Kunstformen der Natur* of 1904,¹⁹ while Darwin's last book was on the behavior of earthworms – do we need any clearer evidence of the gulf between their visions of nature?

In the end I remain convinced that Darwin did come up with a new approach to evolution which made his vision of progress far more open-ended and unstructured than Haeckel's. He certainly saw the emergence of humans from an ape ancestry as an example of progress (with the “lower” races struck somewhere back down the scale), but he was also the only evolutionist in the nineteenth century who predicted that they key breakthrough separating the earliest hominids from the ape family was not the acquisition of higher mental powers but the adoption of an upright posture as a means of adapting to the open plains.²⁰ It was precisely the unpredictability of the sequence of events in Darwin's universe which made the worldview which we now call “Darwinism” so unacceptable to the late nineteenth-century mind. The opponents of Darwinism saw this point more clearly than its supporters, because the latter simply evaded the more disturbing implications of the selection theory, while using it as a stick to beat those who wanted to keep the question of organic origins outside the realm of science altogether. It was only the advent of Bergson's philosophy of “creative evolution” in the early twentieth century that made this element of unpredictability more palatable – and then it was at first seen as anti-Darwinian, so strongly had the previous generation associated evolutionism with the unfolding of a goal-directed plan or pattern. Historians are not supposed to speak of thinkers being “ahead of their time,” but I remain convinced that Darwin did anticipate ideas that were only properly unpacked in the following century. And I am also prepared to accept that the unsettling influence of his theory's underlying concerns sustained an interest in the problems of variation and heredity which played a role in the process by which the developmentalist model was eventually undermined through the creation of modern Darwinism.

The second level at which I see a threat emerging to my view of the Darwinian Revolution can be seen most clearly in Michael Ruse's recent historical works.²¹ At one level, this objection is merely a revival of the older claim that the “eclipse of Darwinism” was only a sideshow in the

¹⁹ See the plates and commentaries in Haeckel, 1998.

²⁰ See Bowler, 1986, pp. 66–67 and 157–158.

²¹ Especially Ruse, 1996.

development of evolutionary science. But Ruse goes beyond this by seeing evolutionism itself as a movement which has piggybacked its way into science by exploiting enthusiasm for the idea of progress. Real scientists such as T. H. Huxley ignored the theory in their detailed work and used it only as a rhetorical device in their calls for more public support for professional science. To the extent that Ruse concedes the existence of a tradition of phylogenetic research in the late nineteenth century, he dismisses it as second-rate science soon swept away by the advent of experimentalism, genetics and modern Darwinism. I am quite happy to support Michael's link between evolutionism and progressionism, but I think he is driven far too much by hindsight when he dismisses the people discussed in my *Life's Splendid Drama* in so cavalier a manner. We shall never understand the effect of evolution on late nineteenth-century culture unless we appreciate the fascination excited both inside and outside science by the prospect of reconstructing the ascent of life on earth. Nor were phylogenetic questions irrelevant – they are still addressed to day, and to blame a previous generation for not being able to realize that the methods then available might not be able to resolve the issues is hardly a fair judgment. I have argued that there were major developments during this period in the way paleontologists addressed the study of the history of life on earth, developments which paved the way for a recognition of the less structured vision of evolution that became characteristic of modern Darwinism. The era of the “eclipse” should not be written off so easily, even within the history of science.

This in turn leads me to the third level of objections to the interpretation of the Darwinian revolution I favor. To some extent this level is implicit in Ruse's position when he argues that even leading public advocates of Darwinism such as T. H. Huxley did not incorporate evolutionism into their actual scientific work. Our modern emphasis on how science is actually done, and on the social framework of research programs, had led to a significant downgrading in the level of importance ascribed to mere theory. In the new historiography, what matters in scientific innovation is the creation of new specialist disciplines, with the associated apparatus of university departments, societies and journals. Supporters of this approach naturally turn a jaundiced eye on some of the great theoretical revolutions, dismissing them as an artifice of an older historiography which saw the history of science as merely a sub-department of the history of ideas.²² On such a model, the influence

²²See for instance Maienschein, 1991, especially p. 299. For more on this point see Bowler, 1996, pp. 18–25.

of Darwinism on nineteenth-century science was minimal, whatever its impact on wider thought. There was no attempt to create an autonomous discipline of evolutionary biology, and the morphological research tradition continued almost unaffected by the switch from idealized archetypes to common ancestors as the source of homologies. The real revolution came at the end of the century, with the “revolt against morphology” which founded a host of new experimental research programs, including the new study of heredity soon known as genetics.

As already indicated, I think this interpretation throws the baby out with the bathwater. We do need to look far more carefully at the practice of science, but we need to look with eyes that are not completely blinkered by the modern obsession with the social apparatus of the scientific community. Evolutionism did not lead to the creation of new academic disciplines, but I believe that it did transform existing ones in significant ways. And, more importantly, the theory allowed bridges to be built between existing disciplines, bridges that opened up new territories and new modes of exploration. Huxley *did* incorporate evolutionism into his scientific work, especially where he extended his expertise as a morphologist into the study of fossils. The next generation of biologists brought together morphology, paleontology and biogeography to apply a whole new explanatory narrative to the history of life on earth. There may have been failures where morphological methods were unable to resolve key issues, but there were also success, as for instance with the combination of morphological and paleontological work on the origin of the mammals. By the early twentieth century, the story of life’s history had begun to include dramatic episodes of environmental traumas, mass extinctions and the rapid radiations of new types, in addition to and indeed instead of the abstract connections and trends of the first generation of phylogenetic research. The whole point of *Life’s Splendid Drama* was to show that real science was being done under the umbrella of evolutionism, science which transformed our vision of the history of life and eventually brought it far closer to the modern, more “Darwinian” perspective. The revolt against morphology took place in those areas of science where an experimental perspective could be brought to bear, and it may have overshadowed the older disciplines which had been transformed by evolutionism. But it did not replace them, and they are still active today – and still the source of considerable popular interest.

Darwinism was also important for the reasons that led Bob Young to it in the 1960s and which inspired a later generation of historians to explore the broader social context within which science is done. Bob

himself probably has little enthusiasm for the fine-grained studies of this wider context done by writers such as Desmond and Secord, because they tend to undermine some of the broader links between scientific theories and ideologies which he focused on. But our recognition of the need to explore such links is a legacy of the innovative approach that he inspired, and at this level it remains necessary to recognize that the various manifestations of evolutionism, both Darwinian and non-Darwinian, had immense influence on various aspects of late nineteenth-century thought. If focusing too specifically on scientific disciplines blinds us to these broader applications, the search for a social dynamic within science undermines the objective of trying to situate science itself within its cultural context.

My conclusion is, then, that there was a Darwinian revolution in the nineteenth century, even if its impact was not as dramatic as had once been imagined. As my recent work on science and religion in the early twentieth century has suggested, the image of a late nineteenth century dominated by a rabidly materialistic Darwinism was a product of the next generation's desperate efforts to argue that Bergsonian creative evolution was something really new.²³ It *was* new in the sense that it presented progress as an unpredictable groping upwards, rather than the mechanical product of a goal-directed trend. Bergson provided the philosophical equivalent of the new, more flexible model of the history of life being developed by early twentieth-century paleontologists and biogeographers. But his followers were so anxious to present their viewpoint as something new that they exaggerated the extent to which the Darwinian selection theory had dominated late-nineteenth-century thought. We lived for a long time with their image of a Darwinian revolution in which something like twentieth-century neo-Darwinism was thought to have traumatized the science and culture of the Victorian era. Recognizing that the first generation of evolutionists had been far less radical than this interpretation implies has certainly softened our image of the original Darwinian revolution and has forced us to recognize a complex series of developments leading from the original to the modern form of Darwinism. But these historiographical developments should not be allowed to blind us to the fact that evolutionism did have a major impact on late nineteenth-century science and culture. Nor should they lead us to ignore the radical nature of some aspects of Darwin's own thoughts, blending him completely into the mainstream of nineteenth-century developmentalism. I, for one, am still prepared to accept the claims of those

²³ Bowler, 2001 and 2004.

modern thinkers who maintain that Darwin opened up a Pandora's box, offering us a vision of nature which radically undermines a host of long-cherished beliefs. I just think it took a couple of generations for those implications to be properly appreciated.

References

- Bartholomew, Michael. 1975. "Huxley's Defence of Darwinism," *Annals of Science*. 32: 525–535.
- Bowler, Peter J. 1976a. "Malthus, Darwin and the Concept of Struggle." *Journal of the History of Ideas* 37: 631–650.
- . 1976b. *Fossils and Progress: Paleontology and the Idea of Progressive Evolution in the Nineteenth Century*. New York: Science History Publications.
- . 1983. *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decades around 1900*. Baltimore: Johns Hopkins University Press.
- . 1986. *Theories of Human Evolution: A Century of Debate, 1845–1945*. Baltimore: Johns Hopkins University Press and Oxford: Basil Blackwell.
- . 1988. *The Non-Darwinian Revolution: Reinterpreting a Historical Myth*. Baltimore: Johns Hopkins University Press.
- . 1989. *The Mendelian Revolution: The Emergence of Hereditarian Concepts in Modern Science and Society*. London: Athlone and Baltimore: Johns Hopkins University Press.
- . 1993. *Biology and Social Thought, 1850–1914*. Berkeley: Office for the History of Science and Technology, University of California.
- . 1996. *Life's Splendid Drama: Evolutionary Biology and the Reconstruction of Life's Ancestry, 1860–1940*. Chicago: University of Chicago Press.
- . 2001. *Reconciling Science and Religion: The Debates in Early Twentieth-Century Britain*. Chicago: University of Chicago Press.
- . 2004. "The Specter of Darwinism: The Popular Image of Darwinism in Early Twentieth-Century Britain." Abigail Lustig, Robert J. Richards and Michael Ruse (eds.), *Darwinian Heresies*, Cambridge: Cambridge University Press, pp. 48–68.
- De Beer, Gavin. 1963. *Charles Darwin*. London: Nelson.
- Desmond, Adrian. 1989. *The Politics of Evolution: Morphology, Medicine and Reform in Radical London*. Chicago: University of Chicago Press.
- Eiseley, Loren. 1958. *Darwin's Century: Evolution and the Men Who Discovered It*. New York: Doubleday.
- Greene, John C. 1959. *The Death of Adam: Evolution and its Impact on Western Thought*. Ames: Iowa State University Press.
- . 1999. *Debating Darwin: Adventures of a Scholar*. Claremont, CA: Regina Books.
- Haeckel, Ernst. 1998. *Art Forms in Nature: The Prints of Ernst Haeckel*. Munich: Prestel.
- Hodge, M.J.S. 1972. "The Universal Gestation of Nature: Chambers' *Vestiges* and *Explanations*." *Journal of the History of Biology* 5: 127–152.
- Maienschein, Jane. 1991. *Transforming Traditions in American Biology, 1880–1915*. Baltimore: Johns Hopkins University Press.
- Mayr, Ernst. 1982. *The Growth of Biological Thought: Diversity, Evolution and Inheritance*. Cambridge, Mass.: Harvard University Press.

- Moore, James R. 1979. *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwinism in Britain and America, 1870–1900*. Cambridge: Cambridge University Press.
- Ospovat, Dov. 1976. “The Influence of Karl Ernst von Baer’s Embryology, 1828–1859: A Reappraisal in Light of Richard Owen and William B. Carpenter’s ‘Paleontological Application of von Baer’s Law.’” *Journal of the History of Biology* 9: 1–28.
- Richards, Robert J. 1991. *The Meaning of Evolution: The Morphological Construction and Ideological Reconstruction of Darwin’s Theory*. Chicago: University of Chicago Press.
- . 2002. *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe*. Chicago: University of Chicago Press.
- Ruse, Michael. 1996. *Monad to Man: The Concept of Progress in Evolutionary Biology*. Cambridge, Mass.: Harvard University Press.
- Secord, James A. 2001. *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of Vestiges of the Natural History of Creation*. Chicago: University of Chicago Press.
- Young, Robert M. 1985. *Darwin’s Metaphor: Nature’s Place in Victorian Culture*. Cambridge: Cambridge University Press.