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Not a Four-Letter Word

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reading this book, but the demands of their schedules, the lack of resources, and misguided political pressure that requires them to "teach to the test" rather than to educate students will prevent many from incorporating these excellent examples into their curricula. This is unfortunate, as it is at this educational level that the greatest need exists and the most benefit can be achieved in establishing a lifelong appreciation and understanding of science. However, teachers are constantly adapting, and one can hope that the examples in *The Evolving World* will soon be modified and used by science teachers at all grade levels for the benefit of current and future students and of the evolving world in which we all live.

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NOT A FOUR-LETTER WORD

Darwinian Reductionism: Or, How to Stop Worrying and Love Molecular Biology. Alex Rosenberg. University of Chicago Press, Chicago, 2006. 268 pp. $40.00 (ISBN 9780226727295 cloth).

Reductionism is a four-letter word, from which all manner of evils are supposed to follow—at least if you believe some of its critics. To be called a reductionist is to be slapped with a term of abuse signaling that one is a crass, unsophisticated epistemic leveler, perhaps suffering from a bad case of physics envy. It wasn't always so. During the heyday of logical empiricism in the philosophy of science (the 1940s and 1950s), "reduction" was considered the *summum bonum* of a philosophical account of natural science (which meant, in practice, physics). Since the steady rise of the philosophy of biology in the 1970s, however, reduction as a philosophical ideal has been out of favor. In *Darwinian Reductionism: Or, How to Stop Worrying and Love Molecular Biology,* Alex Rosenberg aims to restore reductionism's good name. He has his work cut out for him.

Alex Rosenberg is the R. Taylor Cole Professor of Philosophy and Biology at Duke University. His previous books in the philosophy of biology include *The Structure of Biological Science* (Cambridge University Press, 1985) and *Instrumental Biology, or The Disunity of Science* (University of Chicago Press, 1993). The fulcrum for his latest book is what he considers the "untenable dualism" characterizing much contemporary philosophy of biology. On the one hand, virtually all philosophers of biology are physicalists: They maintain that the universe consists solely of physical things (e.g., matter, forces, etc.). On the other hand, many of these same philosophers reject reductionism: "They hold that the adequacy, accuracy, correctness, completeness of biological theories and explanations need not and in most cases do not hinge on the provision of theories and explanations from physical science that show how biological phenomena are physical" (p. 4). How is this possible? Doesn't physicalism entail reductionism? In his sustained defense of reductionism in biology, Rosenberg aims to force physicalist antireductionists to come to terms with their conceptual schizophrenia and to put their philosophical houses in order.

Antireductionists, of course, have principled objections to reductionism. They insist that whereas it is true that all biological processes are physical processes, it is also true that biology has its own unique and distinctive explanatory strategies that cannot be framed without explanatory loss in the terms of molecular biology. For example, the Lotka-Volterra equations embody principles governing the behavior of predator–prey populations that describe systems entirely physical in their constitution, yet the concepts of "predator" and "prey" nowhere appear in the terminology of molecular biology. According to antireductionists, even if there is a sense in which the behavior of the physical systems in question could be explained in terms of the behavior of macromolecules, something important would be lost in such a reduction. Ecology and evolutionary biology, they would argue, are no more reducible to molecular biology than are economics and cognitive psychology. This is not to deny that such disciplines deal with purely physical systems. But it is to be skeptical about the human ability to grasp important generalizations in these domains framed solely in terms of biologically interesting molecules.

Rosenberg considers the issue of reductionism in biology to have important societal consequences: "A biological science that cannot be systematically connected to the rest of natural science gives hostages to mystery mongering or worse—creationism, 'intelligent design,' and their new-age variants."

In response, Rosenberg argues that molecular biology "completes" evolutionary biology. Why do some moths have eyespots on their wings? In order to misdirect avian predators away from more vulnerable parts of their bodies. These eyespots exist because they provided a selective advantage in the past for individuals of this species. How do the eyespots actually come about in individual moths? Through a complex developmental process involving genes—a process that could, in principle, be spelled out in a molecular biological account.

Rosenberg thus wants Darwinians to love molecular biology. But Darwinians *already* love molecular biology when it provides a proximate explanation for eyespots on moth wings, and especially when it continues to confirm, and sometimes correct, the phylogenetic conclusions arrived at by systematists attempting to reconstruct the tree of life. What's not to love? On the other hand, if "reductionism in biology turns out to be the radical thesis that ultimate [i.e., evolutionary] explanations must give way to proximate ones and that these latter will be molecular explanations" (p. 43)—that is, if reductionism entails the elimination of evolutionary explanations in favor of explanations framed entirely in terms of macromolecules—then arguably there is less for which to feel genuine affection.

Rosenberg never explicitly identifies the intended readership of *Darwinian Reductionism,* although in places (e.g., pp. 22, 57) he assumes that molecular biologists are his audience. Nonetheless, biologists will probably find the twists and turns of the subtle argumentation in support of reductionism difficult to appreciate. Likewise, most philosophers are likely to find the molecular biological details throughout the text all but impenetrable. The book will most interest those philosophers of biology who are already well versed in the issues discussed in the book. This is not a large audience.

The question that is thus bound to arise for potential nonspecialist readers is why one should be concerned with any of this. Interestingly, Rosenberg considers the issue of reductionism in biology to have important societal consequences: "A biological science that cannot be systematically connected to the rest of natural science gives hostages to mystery mongering or worse—creationism, 'intelligent design,' and their new-age variants" (p. ix). Granted, were Darwinian theory either inconsistent with or just systematically unrelated to other relevant areas of science, this would clearly represent a crisis in biology. Indeed, some of the chief arguments against Darwin's theory in the years immediately following its publication centered on its alleged inconsistency with what was then believed about the nature of inheritance and about the age of the Earth. But it is less clear that our inability to "reduce" evolutionary biology to molecular biology, in the sense that Rosenberg deems essential, is critical to rebutting the challenges posed by creationism and its intellectual bedfellows. Arguably, unreduced evolutionary biology has succeeded at this task just fine. Ironically, should Rosenberg be successful in convincing readers that evolutionary biology is grossly deficient in the absence of its successful reduction to molecular biology, he could be providing aid and comfort to just those opponents of Darwinism he appears to be most concerned to combat. And this *would* be something to worry about.

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VAVILOV'S HARVEST?

Darwin's Harvest: New Approaches to the Origins, Evolution, and Conservation of Crops. Timothy J. Motley, Nyree Zerega, and Hugh Cross, eds. Columbia University Press, New York, 2006. 390 pp., illus. $73.00 (ISBN 9780231133166 cloth).

Charles Darwin's work, including *The Variation of Animals and Plants under Domestication,* anticipated a wide range of modern evolutionary research. Darwin would indeed have been impressed with the scope of the eclectic set of papers in *Darwin's Harvest: New Approaches to the Origins, Evolution, and Conservation of Crops* (even though he might have had some trouble grasping the details, as he lacked an understanding of Mendel's crosses and statistics). However, Nikolai Vavilov's work has had a more direct connection to this volume, and it would be more properly called "Vavilov's Harvest," even though his name is more obscure and less marketable.

As recounted in Timothy Motley's opening chapter, Vavilov, who worked from 1921 to 1940 in Leningrad, laid many of the foundations of crop plant research. Among other findings, he documented the close relationship in origins between crops and some weeds (oats and rye were once weeds infesting barley and wheat, as Vavilov noted by 1926). Vavilov also developed detailed hypotheses about the biogeographic centers of crop origins. He proposed eight of these centers, although it is now argued that there are at least a couple more, as shown in this volume.

Perhaps most important, Vavilov believed that the improvement of agriculture was best achieved through the collection of thousands of crop varieties, and through their use in careful selective breeding to develop better varieties. Indeed, Vavilov pursued germplasm collections with great vigor in the 1920s. It was the selective breeding that caused him to run afoul of Trofim Lysenko, who believed (for example) that repeated exposure of wheat seeds to cold would generate cold-adapted progeny. With the support of Stalin, Lysenko replaced Vavilov as president of the Bureau of Applied Biology (now the Vavilov Institute of Plant Industry). Vavilov was later arrested on charges of espionage, and tragically died in prison in 1943.

In this volume, 36 authors contributed to 15 chapters, grouped around topics that probably would have pleased Vavilov: "Genetics and Origin of Crops: Evolution and Domestication," "Systematics and the Origin of Crops: Phylogenetic and Biogeographic Relationships," "The Descent of Man: Human History and Crop Evolution," and "Variation of Plants under Selection: Agrodiversity and Germplasm Conservation."

There are many interesting stories and insights among these chapters. The collection certainly achieves its goal of providing a broad sample of current research on a diverse group of crop plants. Still, it was never clear to me why these particular authors and chapter topics were chosen. Were these the most recently advanced or instructive cases? Why not pineapples, cocoa, or bananas? Some of the crops are of obvious importance, including wheat, corn, beans, cassava, potato, and sugarcane, but others are plants that many of us have hardly heard about and never tasted, like chayote (a cucurbit widely grown in Latin America), oca (an *Oxalis* species grown for tubers in the Andes), and breadfruit. Common themes of the chapters included the use of DNA markers and the importance (and poor funding) of germplasm resources.

The editors' own research interests seem (not surprisingly) to have influenced some of the choices of topics. At the time the book was being written, Timothy J. Motley was associate professor in the Collum Program for Molecular Systematics at the New York Botanical Garden; he has since become the J. Robert Stiffler Distinguished Professor of Botany in the Department of Biological Sciences at Old Dominion University. Motley's research has focused on plant evolution and phylogeography in Pacific islands, particularly of plants in the family that includes coffee. Nyree Zerega and Hugh Cross are Motley's former students, with interests that include the origins (and present diversity) of breadfruit and chayote, respectively. Zerega is the director of the Plant Biology and Conservation Program at Northwestern University and the Chicago Botanic Garden. At the time of publication, Cross was a postdoctoral researcher at the National Herbarium of the Netherlands, Leiden University.

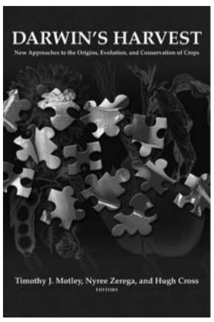
Unfortunately, as is so often the case with edited volumes, the chapters are uneven in content. Some are written as reviews that are broadly accessible to a wide audience, but others are much more like technical journal articles, complete with materials and methods, and are probably of greatest interest only to specialists. Some, such as the chapter on walnuts, seem to be mostly about phylogeny, with little real emphasis on crops (the harvest side of the title). Two appendices help to explain the biochemical and statistical techniques and terms used. The index is adequate, but could probably have usefully referenced more of the authors and details cited in the chapters.

The references cited are handily included with each chapter. It appears that most of the literature reviews were completed in 2004. I was therefore surprised that Norman Ellstrand's highly relevant 2003 book *Dangerous Liaisons? When Cultivated Plants Mate with Their Wild Relatives* was apparently not cited, especially for discussions on gene flow between modern crops and their relatives, although Ellstrand and colleagues' 1999 review article was noted. The book is generally free of formatting errors.

Maize is not only one of the world's most important crops but one whose evolution has long been among the most complicated and controversial—and arguably the most remarkable crop-breeding accomplishment of all time. Buckler and Stevens piece together not only the fascinating story of how corn was selected from teosinte by Native Americans over several thousand years but also the history of scientific research that revealed this pathway.

My favorite chapter was that of Edward S. Buckler IV and Natalie Stevens on the origins, domestication, and selection of maize. Maize is not only one of the world's most important crops but one whose evolution has long been among the most complicated and controversial—and arguably the most remarkable crop-breeding accomplishment of all time. Buckler and Stevens piece together not only the fascinating story of how corn was selected from teosinte by Native Americans over several thousand years but also the history of scientific research that revealed this pathway. The difference between teosinte, with only 6 to 12 kernels in two interleaved rows, and domesticated corn, with cobs bearing more than 20 rows of kernels, is apparently due mainly to just five regions of the maize genome, most probably started from a single domestication event in the Balsas River Valley of southern Mexico. This story is also a vindication for George Beadle and his persistence in supporting his teosinte hypothesis from 1939 to his death in 1989, only mildly distracted by a Nobel Prize in biochemical genetics and the presidency of the University of Chicago.

I was also fascinated by chapters on the evolution of the common bean and the uses of landraces of wheat to investigate the origins of European agriculture. Further, the book highlights a number of interesting conundrums in the evolution of crops, such as the origins of sweet potatoes in the Pacific and the development of sugarcane.



As broad as this book is, it could best serve as a prelude to a deeper discussion of how we can link fundamental studies of crop evolution, systematics, phylogenies, and biogeography more vigorously to crop improvement. Borrowing from the book's title, what are the detailed implications of the origins and evolution of crops to their harvest? A few of these chapters showed a path forward: Buckler and Stevens in discussing starch pathways in corn, Roberto Papa and colleagues in reviewing work (largely by Paul Gepts) that shows two independent domestications of beans and the implications for disease resistance, and Barbara Schaal and her colleagues in describing carbohydrate and beta-carotene variants in cassava (a critical crop in Africa, where average yields are only 8 metric tons per hectare, compared with a potential of 80!). A thoroughly modern synthesis of evolution into crop breeding would be a book that both Darwin and Vavilov could enjoy.

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NEW TITLES

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