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The Endangered Species Act at Thirty, vols. 1 and 2

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A Closer Look at the Endangered Species Act

The Endangered Species Act at Thirty, vols. 1 and 2. Dale D. Goble, J. Michael Scott, and Frank W. Davis, eds. Island Press, Washington, DC, 2006. 432 and 450 pp. $35.00, $40.00 (ISBN 9781597260084 and 9781597260558 cloth).

In this two-volume analysis of American policy governed by the Endangered Species Act (ESA), contributor Steven L. Yaffee notes that the law "has fundamentally changed natural resource decisionmaking in the United States." Few would disagree with that assessment, which is reason enough to make this review of what has been—and could have been—achieved under the ESA in its 30-year existence well worth reading.

The Endangered Species Act at Thirty, edited by Dale Goble, Michael Scott, and Frank Davis, offers a comprehensive overview of the ESA's effectiveness in saving and recovering species and habitat, and examines the interplay of the law with science, land-use planning, and politics. The first volume, *Renewing the Conservation Promise,* looks at the available data to evaluate the effectiveness of species recovery and habitat protection efforts over the past three decades, and includes an extensive discussion of how policy could be improved in the years to come. The second volume, *Conserving Biodiversity in Human-dominated Landscapes,* contains more in-depth analysis of specific areas of endangered species conservation.

Editor Dale Goble is a professor of law at the University of Idaho, Mike Scott is a professor of wildlife biology at the University of Idaho, and Frank Davis is a professor in the Donald Bren School of Environmental Science and Management at the University of California, Santa Barbara. Chapter authors include some of the most respected experts on endangered species science, American wildlife law, and biodiversity policy, many of whom have decades of experience with the ESA.

A lot has changed since President Richard Nixon signed the ESA into law with unanimous support in the Senate and opposition from only 12 members of the House of Representatives. Since that time, the ESA has been amended by Congress repeatedly, barely escaping many drastic revisions that would have undermined species protection. Individual chapters address population growth and habitat loss over the last 30 years, but a chapter providing an overview of land conversion, forest loss, resource consumption, and explosive growth in invasive species problems would have been a useful accompaniment to the background on the law's political history.

Several authors make clear their belief—with many chapters providing quantitative or qualitative evidence to support their assertions—that federal agencies charged with implementing the ESA have repeatedly missed opportunities to conserve and recover many more species.

The first two-thirds of volume 1, essentially a report card on what has been achieved since the ESA took effect, provides an excellent background on endangered species in the United States. Some chapters offer new insights and data on the ESA that are unavailable elsewhere. For example, D. Noah Greenwald and colleagues review the history of species listings, and the analysis by Robert P. Davison and colleagues provides insights into the effectiveness of the National Wildlife Refuge System in protecting threatened and endangered species. Several authors make clear their belief—with many chapters providing quantitative or qualitative evidence to support their assertions—that federal agencies charged with implementing the ESA have repeatedly missed opportunities to conserve and recover many more species. The case studies in these chapters make for interesting reading. Michael J. Bean and other authors describe the bizarre conditions and sometimes daunting procedural requirements that US Fish and Wildlife Service and National Marine Fisheries Service staff have imposed on other government and nongovernment partners attempting to initiate recovery efforts.

Many authors discuss the ESA's shortcomings as if those inadequacies were somehow specific to this one national law. There cannot be many such broad and ambitious measures that have not resulted in similar failures to achieve lofty goals. Whether such efforts addressed the War on Poverty or species protection, these disappointments provide fuel for critics' attempts to throw the baby out with the bathwater. Many chapters in volume 1 make clear the positive impact the ESA has had in helping save and recover species—so this baby is worth keeping.

I found the second volume the more thought-provoking of the two, because the content addresses the significantly different world in which the ESA now operates. The United States is home today to almost 90 million more people, with 120 million more cars. Moreover, according to the US Department of Agriculture, the amount of newly developed land has swelled by more than 35 million acres (14 million hectares) during the last 20 of those years. We truly live in a human-dominated landscape where anthropogenic effects of everything from invasive species to climate change affect almost every part of the country. Chapters in volume 2 discuss hybridization policy, ecosystem services, conservation banking, efforts to define and protect distinct populations, and a host of other significant policy issues and opportunities.

Housing and other development activities have given rise to what are probably the greatest challenges to efforts to maintain the ESA's protections in

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Congress and implement them on the ground. The chapters by David L. Sunding and Thomas A. Scott and colleagues are especially fascinating. The authors used in-depth analyses of case studies of conflicts between development and endangered species to generate insightful reflections on land-use policy. Together with Holly Doremus's review, "Science and Controversy," these three chapters alone make this volume worth acquiring. Doremus's contribution provides an excellent assessment of how science is used and politicized under the ESA.

Missing from these volumes was a soul-searching analysis of whether and how scientists have responded to America's potential loss of biodiversity by producing the information needed to find ways to preserve it. Again and again, authors note that critical data are missing on habitat, on the effect of land-use decisions, and on the basic biology of species. Shortcomings in these areas are typically attributed to a lack of funding or political will. However, with the exception of a discussion by Peter Kareiva and colleagues in volume 1 about the Nature Conservancy's efforts to prioritize, collect, and use the best information available, it is clear that scientists have not collectively established their own set of research and data collection priorities. I believe that this kind of introspection would have been an important addition to this work.

A minor weakness of this book derives from the strength of the authors, who have such expertise in the ESA that there isn't always enough context to help a casual reader grasp important details. However, many other chapters—such as the one by Mary H. Ruckelshaus and Donna Darm in volume 2 on the use of science in ESA implementation, or another by Gregory M. Parkhurst and Jason F. Shogren on incentives for private lands conservation—offer enough background and analysis for ESA novice and expert alike.

This two-volume set was informed by a conference on the same subject held in 2005. Although the conference had the explicit intent of influencing changes in US government policy, it is difficult to see where *The Endangered Species Act at Thirty* has yet achieved that specific goal. The good ideas contained in this book are scarcely reflected in Bush administration policy, and certainly not in the 2005 legislative effort in the House of Representatives to drastically reduce ESA protections for species. A 2006 bill in the US Senate, championed by Senator Michael D. Crapo (R–Idaho), does create tax incentives that implicitly reflect the recommendations of Barton H. Thompson Jr. in volume 1 for motivating private landowners to become involved in species conservation. Unfortunately, good advice often falls on deaf ears—a fact of life and politics that doesn't make the authors' numerous recommendations any less insightful or relevant to improving policy. Indeed, these volumes deserve the attention of all current and future practitioners of endangered species law, policy, and science in the United States.

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UNDERSTANDING EVOLUTION

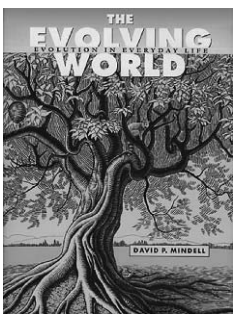
The Evolving World: Evolution in Everyday Life. David P. Mindell. Harvard University Press, Cambridge, MA, 2006. 341 pp. $24.95 (ISBN 9780674021914 cloth).

The world is changing. Every day we hear alarming reports of shifting temperature regimes, rising sea levels, diminishing glaciers, and dramatically altered species distributions and abundances. Concurrent with these large-scale events are less obvious changes in gene frequencies, some driven by selection and others by genetic drift in diminishing populations. Although doubts about the reality of global warming are waning, the debate over the outcome of genetic change in populations through time is far from over. Most Americans do not accept the fact of evolution in Earth's history, much less understand the mechanisms of evolutionary theory.

David Mindell does understand how evolution operates, as well as the implications of denying its role in comprehending our past, present, and future. In *The Evolving World: Evolution in Everyday Life,* he applies his expertise to relate the role of evolution to everyday life, an ostensibly difficult task that he skillfully accomplishes by linking evolutionary mechanisms to familiar objects and activities—for instance, by delving into the origin of the components of French toast and eggs Benedict at Sunday brunch, or the family dog, or why flu shots have to be administered every year.

Mindell has made a career of understanding evolution. He is a professor of ecology and evolutionary biology at the University of Michigan and a curator in the university's Museum of Zoology. His research focuses on molecular evolution and the evolutionary history of birds, and he has applied the results of his studies to a wide variety of topics, including conservation biology, coevolution, genome evolution, and methods of phylogenetic inference.

It is Mindell's phylogenetic approach and his understanding of evolutionary processes at multiple scales that make this book so useful and provide the reader with examples that range from the ecosystem to the genome. Although the diagrams of evolutionary relationships are essential to his arguments and serve to quickly acquaint the reader with the players, the relationships and distribution of specific characters are not the final word in his argument. Instead, Mindell discusses both patterns and the processes



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that are thought to be responsible for them, going beyond evolutionary trees to delve into the historical settings, biogeographical context, and timing of these events in the history of life. It is this depth of exploration that engages the reader, and the diversity of the subjects provides something for anyone interested in biology and other historical questions.

Mindell's presentation on the domestication of plants and animals robustly associates the workings of evolutionary mechanisms with familiar and economically important species, including dogs, horses, chickens, wheat, coffee, and cotton. Again, these examples are not limited to the position of these organisms relative to their feral brethren; the author also explores multiple derivations by different human lineages and the implications of the loss of genetic diversity, as well as other unintended effects of human selection.

biodiversity has more predictive value than estimates of taxon diversity based on traditional alpha taxonomies, and that research in disciplines as disparate as ecology, biogeography, medicine, and conservation biology is more robust when evolutionary relationships are known and taken into account. This is especially important when the research products are used in decisionmaking. Mindell's treatment of evolution and conservation addresses many of these topics, and again reflects the breadth of his research interests as he explores the complex and integrated relationships of genes, species, and ecosystems. He addresses the value of biodiversity in terms of economics as well as human health, but it is his weaving of natural history data into an evolutionary framework that underscores the new significance of these data in contemporary approaches in comparative and integrative biology.

Mindell provides an evolutionary view of pathogens. Whereas many past treatments have focused on the evolution of pathogen resistance to drugs, Mindell's phylogenetic approach presents the characteristics, biogeographical origin, and evolutionary innovations that have contributed to the virulent nature of these life-forms.

In the arena of public health, Mindell provides an evolutionary view of pathogens. Whereas many past treatments have focused on the evolution of pathogen resistance to drugs, Mindell's phylogenetic approach presents the characteristics, biogeographical origin, and evolutionary innovations that have contributed to the virulent nature of these life-forms. In addition, he outlines evolutionary strategies to minimize the success of these pathogens in humans. Emerging applications of artificial selection in biotechnology and medical research are also discussed, once again conveying the power and promise of evolutionary approaches in treating disease and alleviating human suffering.

Although the causal relationship between evolution and biodiversity is obvious, studies of biodiversity have not always taken an evolutionary approach. However, today there is little argument that an evolutionary understanding of

I am always baffled at how some individuals can attack evolution and in the next breath extol the virtues of free-market economies, when both require competition and are responsive to supply and demand for resources. The observation of this similarity is not new, and evolutionary biologists, including Michael Ghislen and Geerat Vermeij, have written on this topic. However, many others are cautious about associating evolutionary principles (even as a metaphor) with changes in human culture and institutions because of the lack of key factors such as heritability. Although he is aware of these issues, Mindell provides convincing examples of the importance of an evolutionary approach in understanding several aspects of human culture.

Examples of evolutionary change in human culture include the historical relationships of our various languages; the origin, use, and extinction of words; and the reconstruction of the history of medieval manuscripts by tracking scribes' transcription errors. All of these have been elucidated before. However, Mindell goes beyond these classic examples and documents competition among clergy, translators, and scholars for the selection of specific wording and arrangements in various versions of the Bible. He also uses cladistic methodologies to reconstruct the history of several of the world's major religions, showing both relatedness and convergence.

It is unlikely that reading this book will lead a creationist or intelligent design advocate to become an evolutionist. Belief systems have built-in feedback loops that prevent this kind of cathartic behavior. Some fence-sitters may find the numerous and well-documented examples of evolution, and the science that underlies them, persuasive; perhaps they will become more inclined to see and understand the world in a less mystical way. However, the major audiences for this book are students and their teachers, especially at the college and university level. Freshman and sophomores in nonmajor biology courses can gain an understanding of evolutionary principles from the examples of the role of evolution in domestication, while beginning premed students can learn about the role of evolution in public health, and how it continues to shape the diseases they confront and the treatments they will administer in their chosen profession. Both of these audiences also need to understand the role of evolution in biodiversity and ecological interactions as they face unprecedented environmental change that will require them to make informed decisions with their ballots and their pocketbooks.

The incorporation of Mindell's examples and arguments into college and university courses is straightforward and relatively easy. However, their usefulness in teaching evolution below that level is more problematic. If there is a shortcoming here, it is in the strictly college-level presentation of the material and the lack of supplemental material for use in grades 6–12. There is no doubt that middle and high school science and biology teachers will greatly benefit from

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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

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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

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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

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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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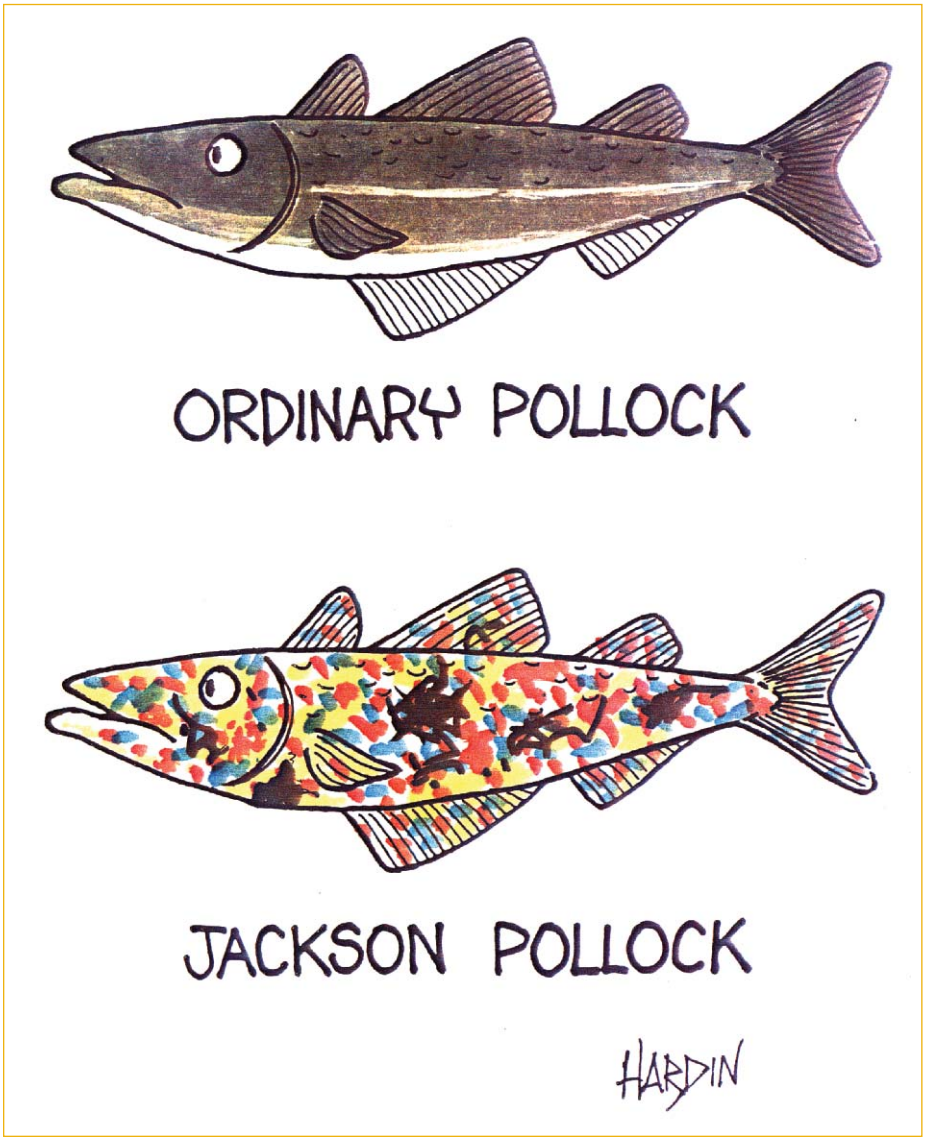
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