

Beyond the Gene, Almost

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Beyond the Gene, Almost

Origination of Organismal Form: Beyond the Gene in Developmental and Evolutionary Biology. Gerd B. Müller and Stuart A. Newman, eds. MIT Press, Cambridge, MA, 2003. 332 pp., illus. \$45.00 (ISBN 0262134195 cloth).

Rumors concerning the demise of the evolutionary synthesis that crystallized during the 1930s and 1940s may be exaggerated, but the call for new and broader perspectives on the study of phenotypic evolution has been insistent from different quarters over the past several years (e.g., Rollo 1995, Schlichting and Pigliucci 1998, Oyama et al. 2001, Gould 2002, West-Eberhard 2003). Furthermore, there seems to be an increasing feeling—again within part of the evolutionary biology community—that tackling questions related to the evolution of complex phenotypes and developmental systems requires something more than (and different from) genomics, proteomics, metabolomics, and a number of other recently fashionable “-omics” words (e.g., Wagner 2001, Wilkins 2002, Pigliucci and Preston 2004).

But what, exactly, is in the air, and how do we make it into more than a series of criticisms of the limits of the neo-Darwinian synthesis, peppered with a few intriguing suggestions on what to do next? Neither this review nor the book I am reviewing will provide the reader with an answer to that question, but *Origination of Organismal Form* does contribute to the ongoing and increasingly vocal debate on these matters.

The focus of the book, edited by Gerd B. Müller and Stuart A. Newman, is the problem of the origination of organismal form, which the editors refer to as “the forgotten cause in evolutionary biology.” This may seem surprising to some: Hasn’t modern evolutionary theory established that genes encode organis-

mal form? Not quite, as it turns out. While genes obviously have a lot to do with why certain organisms look a certain way, and of course genes do influence development, genes by themselves do literally nothing. Organisms do not begin with a collection of genes that generates everything else; they need a set of environmental conditions, as well as the inheritance of materials and extragenetic information from the previous generation. From the point of view of causal analysis, genes may be said to be a necessary but far from sufficient condition for the development (and evolution) of organisms.

Several chapters in the book make this extremely clear, using both stringent logic and compelling examples. For instance,

the contribution by Bissell and colleagues (chapter 7) includes a discussion of the difference between tissues cultured in vitro using two-dimensional versus three-dimensional environments: While the genes are exactly the same, tissue cultures on flat petri dishes simply tend to spread over the available space, with no spontaneous aggregation that even remotely resembles their structure in vivo. But change the experimental setup so that the cells can grow within a three-dimensional matrix, and suddenly complex structures similar to the tissue of origin spontaneously emerge from the initial randomness. Steinberg’s chapter (chapter 9) investigates the preeminent role of tissue and cell affinities in generating the vertebrate body plan. Of course,

those affinities are made possible, in part, by the surface characteristics of the cells involved, which in turn depend on molecules encoded in the genetic makeup of the individual. Yet it is hard to read this and other chapters in the book and still think of the gene as in any way causally central to the whole: an important component, yes, but certainly not the main determinant. In this respect, Nijhout's discussion of the role of genes in creating gradients and diffusion reactions (chapter 10), which make pattern formation possible, is particularly lucid.

Some chapters are much more speculative, and those include a few that did not seem to me particularly insightful, or even clearly written. But there are some interesting exceptions, such as Kaneko's discussion (chapter 12) of the application of the idea of "attractors" (borrowed from chaos and complexity theory; Kauffman 1993, Ferriere and Fox 1995, Solé et al. 1999) to help us understand why organismal form seems to cluster in limited subsets of the available morphospace. Another bold but intriguing thesis is put forth by Newman (chapter 13), who speculates that the form of early organisms was much less rigid than the developmentally canalized systems we see today. This, according to the author, means that Darwinian mechanisms of selection for certain genetic systems function as a stabilizer of organismal form, rather than a generator of it (as assumed, with little if any evidence, by standard neo-Darwinism).

While some chapters of the book tend to be too detailed or heavy with jargon, there are examples in which the in-depth treatment has a clear *raison d'être*. Wagner and Chiu's contribution (chapter 15) certainly falls into the latter category: Their analysis of the genetic and epigenetic factors underlying the origin and evolution of the tetrapod limb is a superb example of how such analyses should be carried out. Wagner and Chiu make clear how both careful developmental analyses and phylogenetically informed comparative methods are necessary to untangle the evolution of development—something, incidentally, that an "omics" kind of approach by itself simply cannot muster.

As in all collections of essays from various authors, *Origination of Organismal Form* suffers from the more than occasional lack of focus (or at least significant departures from the supposed focus of the book) as well as from contributions that are below par from a qualitative perspective. The chapter by Nanjundiah (chapter 14) on phenotypic plasticity, for example, actually has little to do with that phenomenon as it is understood in the prevalent literature of the field (which, accordingly, is largely not cited by the author). Further, Nanjundiah makes some statements that betray an idiosyncratic, if not downright incorrect, understanding of the subject matter. For example, at the beginning of the chapter, we are told that developmental noise is another manifestation of the organism being "plastic"—I beg to differ: Developmental noise and phenotypic plasticity seem to have very little in common, mechanistically or phenomenologically—and that an extended sense of the term *plastic* is "capable of adapting to varying conditions." The author makes the common, yet still inexcusable, mistake of assuming that plasticity is adaptive, when in fact that is a hypothesis to be considered on a case-by-case basis.

I reserve my most severe criticism for the second chapter, authored by the eminent paleontologist Simon Conway Morris. Besides the fact that we actually learn nothing new about the Cambrian explosion of metazoans—the purported central topic of the contribution—from this chapter, Conway Morris allows himself a largely unwarranted, and certainly tasteless, postmortem attack against Stephen J. Gould. Discussing the contribution that the famous Burgess Shale fauna has made to our understanding of Cambrian life, Conway Morris says, "Although such discoveries have generated considerable controversy, this has been largely for ideological reasons, most blatantly by Stephen Jay Gould, who, in support of a strange materialist agenda, has argued that a contingently happenstance origin of humans leads to certain ethical consequences" (p. 22). Curiously, there is no citation of where Gould has allegedly written such statements. I am most certainly not a Gould worshipper (in fact, I

happen to strongly disagree with some aspects of his treatment of science and religion; Durm and Pigliucci 1999), but I find the accusation all the more strange given that Gould (1989) actually lavished ample (and amply deserved) praise on Conway Morris's own technical work on the Burgess Shale.

All in all, I recommend *Origination of Organismal Form* to anybody seriously interested in the study of the evolution of complex phenotypes. The book will provide plenty of food for thought for graduate seminars and laboratory discussion groups. Readers will need to keep their critical sense alert in order to discriminate the most useful parts, but then again, critical thinking is supposed to be standard fare in any science reading activity.

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A SHORT TRIP THROUGH THE WORLD OF ALFRED RUSSEL WALLACE

The Alfred Russel Wallace Reader: A Selection of Writings from the Field.

Jane R. Camerini, ed. Johns Hopkins University Press, Baltimore, 2001. 304 pp., illus. \$19.95 (ISBN 0801867894 paper).

Jane R. Camerini is a faculty associate in the History of Science Department at the University of Wisconsin, Madison, where she received her PhD in biocartography. She is probably best known for her informative papers on “Wallace’s Line,” the boundary between the Asian and Australian faunal regions that Alfred Russel Wallace discovered in the East Indies (which, interestingly enough, is only briefly mentioned in her book). These papers, and others on Wallace and 19th-century biogeography, well qualify her to edit this eclectic collection of Wallace’s very readable prose.

Wallace wrote not only about many aspects of biology, including evolution, but also about education, religion, morality, spiritualism, vaccination, eugenics, social values, political systems, and even Mars. Most of these subjects are covered in *The Alfred Russel Wallace Reader*, but not all. Also, because Wallace was reticent about revealing much about his personal life, there are few details about his family relationships. The volume is written “for general readers, not for historians,” so endnotes and references are kept to a minimum.

The book begins with a foreword by the well-known nature writer David Quammen, who claims that Wallace was “the greatest field biologist of the nineteenth century.” Some Darwin scholars might not agree with this, but Quammen qualifies his assertion by admitting that Darwin was “the greatest *conceptual* biologist of his era, yes, and maybe the greatest of all eras.” Although it is no surprise that Quammen’s short discussion of the two 19th-century biologists is biased toward Wallace (who is, after all, the subject of the book), his points about Wallace’s importance are well taken.

Camerini’s introductory biographical sketch of Wallace gives a short but informative overview of his life. From Wallace’s birth on 8 January 1823 into a lower-middle-class family in rural Wales to his death on 7 November 1913 at the age of 90, all the high points are touched on here and in the introductions to the other four sections of the book. It is true that you will learn more about Wallace from Peter Raby’s *Alfred Russel Wallace: A Life* (Princeton University Press, 2001), and that Charles Smith’s *Alfred Russel Wallace: An Anthology of His Shorter Writings* (Oxford University Press, 1991) discusses more of his publications, but Camerini reveals his essence in a nutshell.

The excerpts from Wallace’s writings are organized into four sections. The first section, “Wales,” includes excerpts from Wallace’s autobiography (*My Life, A Record of Events and Opinions*; Chapman and Hall, 1905). Wallace describes parish, enclosure, and railway surveying with his elder brother William in England and Wales, during which “I first began to feel the influence of nature and to wish to know more of the various flowers, shrubs, and trees I daily met with, but of which for the most part I did not even know the English names” (pp. 27–28). Thus began the training of a naturalist who had to leave school at age 14 to earn his own way through life. “The South-Wales Farmer” gives a penetrating picture of rural life in South Wales at the time, including the wonders of Welsh superstition, religion, virtues, and education. Another excerpt, “At Neath,” describes Wallace’s time in the Welsh town where he and his younger brother John wound up the affairs of the

deceased William, continued the surveying, and undertook building and architectural work, including the local Mechanic’s Institute, where Wallace later gave lectures on mechanics and physics.

The next section, “The Amazon,” relates the story of Wallace’s four years (1848–1852) in South America. The section is based on his *A Narrative of Travels on the Amazon and Rio Negro, with an Account of the Native Tribes, and Observations on the Climate, Geology, and Natural History of the Amazon Valley* (Reeve and Company, 1853). This is my favorite Wallace book because of the amount of time I’ve spent collecting in Latin America, and because I’ve been to several of the places he describes on the Rio Negro in Venezuela. Wallace went to South America with his friend Henry Walter Bates to collect natural-history specimens and to study the origin of species. The excerpts include a chapter describing Wallace’s problems with mostly unreliable local assistance and yellow fever while ascending the Rio Uaupés in Brazil. “Sinking of the *Helen*” is a letter to Wallace’s friend Richard Spruce, a botanist with whom he collected in South America, describing in vivid detail the burning and sinking of the ship that was taking Wallace and his collections back to England. “On the Monkeys of the Amazon” reprints a paper from the 1852 *Proceedings of the Zoological Society of London*, revealing its importance both to Wallace’s later ideas about geographical distribution and to the study of systematics.

“The Malay Archipelago” covers Wallace’s second great field experience, his eight years (1854–1862) in modern-day Indonesia, Malaysia, and Singapore. It includes “Collecting Birds of Paradise,” a chapter reprinted from perhaps his most well-known book, *The Malay Archipelago: The Land of the Orang-Utan and the Bird of Paradise, a Narrative of Travel with Studies of Man and Nature* (Macmillan, 1869). This chapter relates the story of the first of three expeditions that Wallace undertook to obtain specimens of these magnificent (and, for the collector, remunerative) birds of paradise. One must remember that Wallace was there to make a living, something he had been unable to accomplish in Britain. I must admit

that as a graduate student, when I read Wallace avidly, I was unable to finish *The Malay Archipelago*. What put me off was Wallace's vivid description of shooting orangutans in order to collect them and send them back to Samuel Stevens, his specimen dealer in London, for sale to rich collectors.

The other selection from Wallace's Malaysian travels, "On the Tendency of Varieties to Depart Indefinitely from the Original Type," reprints the paper that Wallace sent to Darwin in February 1858 from the East Indies. This paper forced Darwin to publish *On the Origin of Species by Means of Natural Selection* (J. Murray, 1859) and was part of their "joint paper" in *Proceedings of the Linnean Society of London* (1858), which announced natural selection to the world at large (although several of Darwin's confidants had known of his evolutionary views before this). It is interesting to note that Wallace did not think artificial selection was analogous to natural selection, as Darwin claimed in his half of the paper. Wallace later (in 1866) came to feel that Herbert Spencer's term "survival of the fittest" was preferable to "natural selection," but Darwin didn't agree. I have seen Wallace's copy of the joint paper in which he has drawn a line through every mention of natural selection by Darwin and written "survival of the fittest" in the margin. He is reported to have done the same in his copy of the *Origin*.

The last section, "The World," spans 1862 to 1913, more than 50 years of Wallace's life. "Limits of Natural Selection in Human Evolution," published in the *Quarterly Review* (1869), reprints his first mention of human evolution being guided by "a Higher Intelligence." "Spiritualism and Human Evolution," which first appeared in the *Fortnightly Review* (1908), reveals Wallace's social conscience. Mental divergence in human races, he argues, exceeds physical divergence; there are no differences, physically, intellectually, or morally, between civilized and "savage" humans; and there is no evidence that "stone age" humans "were mentally or morally inferior to ourselves." In "Impressions of the United States," a short selection from *My Life* that sum-

marizes his US visit of more than 10 months in 1886 and 1887, Wallace's anti-capitalism and hope for socialism show forth. I only wish that Camarini had included Wallace's humorous description of oversleeping and missing a train in Virginia. Finally, "Remembrances of Alfred W. Wallace by His Children William G. and Violet Wallace" describes growing up with a loving father, giving a better glimpse of his personality than any of his own writings.

Wallace's prose is a pleasure to read. Even today, one can see how he was able to make his living primarily by writing. Alfred Russel Wallace is finally receiving the recognition denied him by many biologists of the 19th and early 20th centuries. After reading these excerpts from his books and articles, you will want to go to your library and read the originals in full.

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HANDBOOK FOR SUSTAINABILITY CHANGE AGENTS

Leading Change toward Sustainability: A Change-Management Guide for Business, Government and Civil Society. Bob Doppelt. Greenleaf Publishing, Sheffield, United Kingdom, 2003. 272 pp., illus. \$30.00 (ISBN 1874719640 paper).

Leading Change toward Sustainability: A Change-Management Guide for Business, Government and Civil Society blends insights and research from science and organizational development to provide a framework for leaders and organizations to refer to when making their shift toward environmental sustainability. Whether you are just thinking about taking baby steps toward "greening" your organization or business, or you have al-

ready established written policies to formalize your efforts, this book serves as a practical guide. The author, Bob Doppelt, combines organizational development and leadership theory with what he has learned from researching and evaluating organizations, businesses, and governments that have headed down the path toward sustainability. His book is full of compelling examples that provide real-world context for the reader.

Doppelt is the director of the Program in Watershed and Community Health, a sustainability research and technical assistance organization affiliated with the University of Oregon in Eugene. Doppelt draws on experience from his programmatic work and consulting to provide real-world examples of integrating sustainability into organizations, large and small. (For example, he is currently advising and teaching at the Bainbridge Island Graduate Institute's new MBA program in sustainable business.) Qualitative and anecdotal evidence abounds demonstrating that reducing waste and conserving resources makes good sense, both economically and for the environment.

The book starts with a narrative chapter, "Tale of Two Companies," in which the author presents two divergent efforts toward sustainability change. Norm Thompson Outfitters is highlighted as having made successful inroads, while B&G Tools (not the company's real name) has faltered through the process. This introduction gives the author a comparative backdrop for discussing the key strategies for successful change in the following chapter, "What Went Wrong?" Next, Doppelt provides the reader with an informative primer on sustainability. A variety of definitions are discussed, but the author's version seems to speak to the everyday citizen: "Sustainability is about protecting our options. This requires a new economic paradigm that allows humans to live and work in ways that can be maintained for decades and generations without depleting or causing harm to our environmental, social and economic resources" (p. 40).

A number of established frameworks for sustainability are presented in chapter 3. The well-respected team of Paul

Hawken and colleagues (1993) developed the “natural capitalism” model, which involves increasing natural resource productivity, reducing waste, moving to a “service and flow” business model, and restoring the stocks and flows of natural capital. The systems science-based model called “the natural step,” founded by Swedish oncologist Karl-Henrick Robert (2002), is described as another option. This is only the beginning of many stellar Swedish citations that are presented throughout the book, making the reader feel as if the United States is still in the Dark Ages in its approach to sustainability for the planet.

There are two examples given of frameworks that build on the efficiency of environmental management. The focus of the Zero Emissions Research Initiative is to identify specific objectives for technological innovations that help bring about zero emissions or waste from manufacturing. The second example, the “zero waste” model, uses a very similar approach; proponents of this model work to achieve zero levels of toxins, discharges, or hazardous waste. An alternative framework for reaching sustainability is the “ecological footprint” designed by Mathis Wackernagel and William Rees (1996). This accounting tool enables individuals or institutions to estimate their total resource use and waste in relation to a corresponding parcel of terra firma (you can assess your own impact by using a footprint calculator at www.lead.org/leadnet/footprint/intro.htm). The last model highlighted is the “cradle-to-cradle” production model of Bill McDonough and Michael Braungart (2002). This framework draws on nature’s balanced wisdom and reminds us that waste equals food. Out of this emerges McDonough and Braungart’s mantra of “eco-effectiveness”: the goal of designing and manufacturing products and processes that replenish, rejuvenate, and give back to nature and society.

With these models as a backdrop for achieving sustainability, the author proposes his own version, a “wheel of change” toward sustainability. This is a model of organizational changes that are key to facilitating environmental sustainability, made up of seven principles

rotating on a wheel. The process of change is continuous and circular, and users can begin anywhere on the wheel. This is important because, as Doppelt says, change is messy and far from linear. Each principle has a chapter devoted to it, with examples of companies and professionals working to make changes in each area. Doppelt calls the seven stages of change “interventions,” with names such as “Change the Dominant Mindset” (establish compelling need) or “Restructure the Rules of Engagement” (create new strategies). This was where I thought I was going to be lost in the rhetoric of organizational development and change, but I was pleasantly surprised. Beyond the long-winded titles of the interventions were easy-to-understand chapters laying out the concepts for the amateur reader. Doppelt’s model draws more from organizational development and leadership theory than the other science-based frameworks discussed earlier. He makes a great attempt at synthesizing a number of threads from both science and business contexts to give the reader detailed, practical information on affecting environmental change. The weaving of the sustainability tapestry has seen many successes and failures. But this is the fabric of our future, and we need to be persistent in repairing and strengthening it in innovative ways to keep the threads intact.

The examples the author uses to illustrate his model vary widely in scope. For example, the Dutch government’s sustainability-focused National Environmental Policy Plan gives the reader an example of a countrywide effort to balance the economy and environment. The State of Oregon’s sustainability initiative gives us hope that advances in the public sector are being spearheaded in the United States. Compelling stories emerge from the private sector as well, in companies ranging from international corporations to small businesses. The author uses firsthand communications with top business leaders to share the raw challenges of trying to incorporate sustainable practices throughout a company. By the end of the book, the reader is bolstered by the successes of these companies and

begins to think, “If they can do it, I surely can!”

Overall, I found the book easy to navigate. The narrative is interspersed with simple flowcharts, bulleted lists, and diagrams. The only downside to this was that there were numerous times when it had the feel of a textbook, with the and narrative and figures repeating themselves.

This book will serve both the novice and the seasoned person who strives to be an agent of change in his or her business, institution, government, or country. My copy will not rest on my bookshelf long. The colored flags and neon highlighter marks throughout the book will serve me well as I journey on my own path toward sustainability.

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