# BOOK REVIEWS

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## EVOLUTION

***The Cambrian Explosion: The Construction of Animal Biodiversity.*** By Douglas H. Erwin and James W. Valentine. 2013. Roberts and Company. (ISBN 9781936221035). 406 pp. Hardcover. $60.00.

*The Cambrian Explosion* reviews the current state of research on the earliest forms of metazoan life. Chapters on geological and environmental "contexts" set the stage for thorough treatment of the fossil record, especially from Ediacaran and Cambrian formations known throughout the world. These are followed by more detailed examinations of the evolution of the earliest metazoan ecosystems and earliest metazoan genomes. The penultimate chapter covers current theories regarding ancestral lineages and relationships connecting Cambrian, Ediacaran, and earlier phyla. Finally, the authors present their best integration of all the evidence to tell the story of a critical and exciting time in our planet's history, roughly from 640 mya to 500 mya.

Erwin is Curator of Paleozoic Invertebrates at the Department of Paleobiology of the National Museum of Natural History (Smithsonian), and Valentine is Professor Emeritus in the Department of Integrative Biology, UC Berkeley. Although these two are true specialists in Cambrian paleontology, they have nonetheless written with great clarity. One gets the impression that it was a personal and professional challenge to see whether they could summarize, for a wide readership, just where things stand in their field. The exposition is calm, logical, and not jargon bedeviled. The illustrations are profuse, wisely placed, and clear.

Although the phrase "Cambrian Explosion" is never likely to disappear, it's too catchy and convenient, there's ample evidence that tens of millions of years were involved. Erwin and Valentine delineate many, many long, intertwining threads that detail the best ideas of what was happening over this period on a planet that would be quite unrecognizable to us. The continents, of course, were completely differently distributed, but even more unfamiliar to us would have been a world where niches themselves were alien and rapidly evolving. The evidence that genomes and genomic architecture were changing rapidly, partly in response to each other, giving rise to the establishment of disparate phyla early in the history of metazoan life, matches the excitement of new fossil discoveries.

Understanding of the Cambrian animals is exploding because of the integration of paleontology, comparative anatomy, developmental biology, and comparative genomics. This integration is leading to the following picture of the late Proterozoic: "The relative importance of changes in protein-coding genes to the evolution of *cis*-regulatory elements began to change at this time because morphological changes were increasingly underpinned by the evolution of *cis*-regulatory networks. The morphological differences between different early bilaterians increased faster than differences in gene composition" (p. 326). And, as good scientists, the authors report about this same period: "We do not, however, have fossils to tell us how disparate the body plans of these preexplosion bilaterian clades were; indeed, it is not clear that paleontologists have even appropriate search images for fossils of this interval" (p. 325).

"It is to the explosion, and not to the origin of phylum-level clades, that we are indebted for the body plans of living phyla, those familiar morphological themes that are still with us.... Those body plans have – so far, at least – proven robust to very severe environmental perturbations over geological time. An important caveat to our reading of the explosion is that we have learned about it by peering through newly opened taphonomic windows that have surely made the explosion appear to be more abrupt than was actually the case" (p. 328).

To close this masterful account, the authors choose their words carefully, epitomizing the processes of science: "Complex patterns of causality, the importance of contingency, and the interaction of many different processes are the norm. Clearly, the biosphere has promoted its own evolutionary trajectory, and the Cambrian explosion was a once-in-an-era happening; it could hardly have been more complicated and could hardly be more tantalizing. In addition, there can hardly be more of a challenge to paleobiologists, evolutionary biologists and many other scientists than to describe and interpret the confluence of history and process responsible for events during that remote and critical time in life's history" (p. 342).


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## INTELLIGENT DESIGN

***Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design.*** By Stephen C. Meyer. 2013. HarperCollins. (ISBN 9780062071477). 498 pp. Hardcover. $28.00.

*Darwin's Doubt* claims to review research on the earliest forms of metazoan life. Part One presents a history of discovery and interpretation of the Cambrian animals through both paleontology and genetics; Part Two, research on protein evolution, evo-devo, and epigenetics; Part Three, ideas



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of "self-organization." The final four chapters purport to demonstrate how Intelligent Design provides the ultimate explanation of all these phenomena.

Meyer, Director of the Center for Science and Culture at the Discovery Institute, emphasizes that our understanding of the Cambrian explosion remains incomplete. He recapitulates the arguments from his earlier book, *Signature in the Cell*, and from his Discovery Institute colleagues Michael Behe, William Dembski, Jonathan Wells, and Douglas Axe, who all maintain that there have never been a sufficient number of cell divisions, nor a sufficient number of years in the history of the universe for unguided processes to bring about animal forms. *Darwin's Doubt* thoroughly reviews the arguments of the Intelligent Design movement and, thus, could save a person the trouble of reading all their previous publications.

Reporting on the discovery that developmental gene regulatory networks are highly conserved and not tolerant of mutations, Meyer asserts that this must have always been the case, thereby preventing the development of varied animal body plans: "The system of gene regulation that controls animal-body-plan development is exquisitely integrated, so that significant alterations in these gene regulatory networks inevitably damage or destroy the developing animal. But given this, how could a new animal body plan, and the new dGRNs necessary to produce it, ever evolve gradually via mutation and selection from a preexisting body plan and set of dGRN's?" (p. 269). The idea that in early metazoan populations such networks, and the interplay among them, might have evolved spectacular diversity before they became so highly integrated is dismissed, even though this idea is central to current research.

Meyer moves to the crux of his argument on page 337: "Neither neo-Darwinian nor a host of more recent proposals [he includes a list] have succeeded in explaining the origin of the novel animal forms that arose in the Cambrian period. Yet all these evolutionary theories have two things in common: they rely on strictly material processes, and they also have failed to identify a cause capable of generating the information necessary to produce new forms of life…. Is it possible that intelligent design – the purposeful action of a conscious and rational agent – might have played a role in the Cambrian explosion?"

The reliance on "strictly material processes" that Meyer finds limiting is the basis of modern (since the 17th century) science. His concern for "generating the information necessary" reflects the Intelligent Design movement's premise that anything really complex requires a blueprint, despite the fact that modern biology has shown that this is not true: DNA is not a blueprint and organisms are not constructed like machines.

In addressing how a designer actually manipulated atoms and molecules to create brand-new life forms, all Meyer claims is that "intelligent agents can act suddenly or discretely in accord with their powers of rational choice or volition, even if they do not always do so…. If body plans arose as the result of an intelligent agent actualizing an immaterial plan or idea, then an extensive series of material precursors to the first animals need not exist in the fossil record…. Mental plans or concepts need not leave a material trace" (p. 375). To quote Nick Matzke, formerly of the National Center for Science Education, this explains the appearance of the first animals and their body plans by saying, in effect, "POOF!"

The author and his institute claim that *Darwin's Doubt* is an important contribution to modern biological science. There are major clues that it isn't. HarperCollins chose to publish this under their HarperOne imprint, and HarperOne describes itself thus: *The most important books across the full spectrum of religion, spirituality, and personal growth*…. A more important clue is found in the last chapter, entitled *What's at Stake*. In science, what would be at stake would be a better understanding of the Cambrian fossil record and the processes of life and evolution. But Meyer instead tells us: "Modern life suspends many of us, so we feel, high over a chasm of despair. It provokes feelings of dizzying anxiety – in a word, vertigo. The evidence of a purposeful design behind life, on the other hand, offers the prospect of significance, wholeness, and hope." A heavy burden for a trilobite to bear!

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*for the confusion this book causes about the evidence and the science of studying the evidence. It rates *four frogs* as a review of the thinking of the Intelligent Design movement.

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## TEACHING & THE NATURE OF SCIENCE

***Teaching the Nature of Science: Perspectives & Resources.*** By Douglas Allchin. 2013. SHiPS Education Press. (ISBN 9780989252409). 310 pp. $40.00.

In his recent book *Teaching the Nature of Science: Perspectives & Resources*, Douglas Allchin presents a compelling pedagogical approach for using episodes from the history of science toward improving students' understanding of aspects of the nature of science (NOS). The text admirably synthesizes Allchin's expertise in both the philosophy and history of science, including his understanding of recent research in education that strives to both capture and improve students' NOS conceptions.

Allchin admits in the opening pages that the majority of the text can be found elsewhere as separate works, and while this is the case, two notable features of this book make it particularly worthwhile. First, Allchin has admirably synthesized the separate works and included additional chapters to create a rather comprehensive argument for why and how teachers should use history of science *as a tool* toward helping students learn NOS. Second, while the individual chapters stand alone in helping the reader to understand some facet of how to use the history of science in this way, throughout each there are frequent explicit references to the themes contained in other chapters. Allchin is careful to help the reader see how one or more themes from earlier chapters connect with one another, and this technique indeed synthesizes his points well.

The text is divided into two large sections, with the first half of the book designed to help the reader understand some of the philosophical emphases, both historical and recent in education reform designed to improve students' NOS understanding. In this first section, Allchin draws attention to the increasing emphasis placed on having students learn the nature of science, though he is critical of both research in science education and pedagogical efforts that tend to treat NOS "tenets" as decontextual conceptions that students should learn. Allchin develops his "whole science" model as embodying the notion that NOS should be learned within the confines of an engaging and realistic context and further that the history of science, when properly framed, can be an important tool toward fostering students to learn NOS explicitly, reflectively