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BOOK REVIEW

A Permian Murder Mystery

Extinction: How Life on Earth Nearly Ended 250 Million Years Ago, by Douglas H. Erwin. Princeton, Princeton University Press, 2006. pp. vii + 296. S/b $22.95

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During the largest mass extinction in history, 82% of all genera disappeared at the end of the Permian, and at first it seems that *Extinction*, by Douglas H. Erwin, will be exploring natural history's greatest whodunit. Erwin even spends his first chapters setting up the suspects: was it Dr. Anoxia in the Oceanic Deepwater with the Shift in Stable Carbon Isotopes or was it Col. Prolonged Volcanism in the Siberian Traps with the Sulfurous Gases? Unfortunately, by the end of this murder mystery, every suspect has a convincing alibi, there have been many red herrings, and the reader is left considering the possibility that—as in *Murder on the Orient Express*—every suspect had some part in the dirty deed. But amid all this confusion about these competing theories, Erwin is able to guide the reader to a conclusion that, while not something a reader of murder mysteries might expect, is just as satisfying.

Erwin starts his book by talking about the barren Early Triassic rocks in the Guadalupe Mountains of west Texas. It is one of several enjoyable asides he takes during the course of the book, each one telling of the interesting people and places he encounters as he scours the globe for Permo-triassic outcrops. These are the stretches of his book that are most accessible to the lay reader. His descriptions of his work in the unique Meishan quarry in China and his tales of the extraordinary fossil hunting Rubidge family in South Africa give the book a personal touch that helps meld the more technical sections into a narrative.

Yet the most important parts of Erwin's book are not concerned with the modern task of reconstructing the evidence but on the evidence itself, which he lays out in a series of chapters each dealing with a different piece of data from the mass extinction. These portions are where he talks most about the effect of this truly massive extinction on the flora and fauna of the Paleozoic and just how the more modern phyla ended up superseding the dominant species of the Permian. Each piece of evidence is weighed against the possible suspects he set up in the beginning, and the possible conclusions are evaluated. His stories about how the evidence was collected by scientists working at various locations around the world occasionally appear, breaking up the more technical passages and also giving the reader a break from the jargon that may intimidate non-scientists.

In one sense, the book can be viewed as increasing in complexity and technical content throughout. Erwin assumes that his readers are growing more proficient in scientific vocabulary and more familiar with the various concepts of the book as he goes forward. This assumption is generally acceptable, though he occasionally gets a little carried away with just how far his readers have come. For example, though it takes Erwin 164 pages to mention $\delta^{13}C$ (rather than referring more generally to the "shift in carbon isotopes" or "changes in the carbon cycle"), he quickly thereafter leaps into discussion of other proxies for Paleozoic climate change and some of the finer points of carbon cycle analysis. To readers without a background in geochemistry and stratigraphy, some of these passages may become a little dense, but Erwin generally balances these passages with less technical discussions of phenomena such as asteroid impacts and various methane hydrates. No matter how deep the book may get, Erwin manages to explain these daunting subjects with patience and detail. Students (or adults!) with a memory of their high school science classes will find themselves prepared to grasp all the concepts he discusses, though some passages may necessitate a second reading.

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The most baffling part of the book is likely to be the extensive degree to which Erwin is able to debunk each and all of the theories he presents as possible causes for this mass extinction. Readers might not be satisfied with a murder mystery that ends with all possible suspects cleared of any wrongdoing and the case left as unsolved, but in this situation we may indeed have no choice. Erwin is very careful to note that the quarter of a billion years between the End-Permian extinction and today do much to erase what evidence we may have and that no theory of mass extinction (even the well-known asteroid impact that ended the Mesozoic Era) is immune from criticism and wholly accepted by the entire scientific community. Yet it seems that extinction central to his book of the same name will be forever shrouded in uncertainty. There will always be different interpretations of and severe limitations on the data gathered, and in the end, it will be unlikely that we can pin down a single cause for such an event.

Erwin himself even invokes the idea that multiple causes may be to blame, which he refers to as the *Murder on the Orient Express* hypothesis. But just in case his readers are too quick to accept this possibility as the most plausible, he quickly points out that if proving one cause is difficult, proving many may border on the impossible. There does come a point when it seems that there is no remaining theory to explain the mass extinction. No detective story would end on such a note, but it is instructive for a science story to strike such a tone.

Too often, science teachers forget that the interesting parts of science are the unknowns, the things that no one has discovered yet. It is very easy to lose sight of this because so little of the curriculum is dedicated to the things we do not know about, and getting to the forefront of scientific knowledge can be daunting if one's students do not possess degrees in science fields. *Extinction*, therefore, offers teachers of evolution a marvelous opportunity. Classroom discussions of certain passages, talk of the pros and cons of the various theories that try to explain the disappearance of so many organisms at one time, and systematic debunking of each possibility can leave students with the wonderful realization that there is much that has yet to be discovered.

Teachers of evolutionary theory will also find the last portion of *Extinction* to be useful. Once the crime of mass extinction has been committed, even though none of the suspects are convicted, Erwin lays out the end results of the event in terms of the recovery and, in some cases reappearance, of marine and terrestrial organisms following the cataclysm. The mysterious Lazarus taxa, as well as the concepts of niches, body plans, and the limitations on evolutionary innovation, are all discussed in detail in this section. Plenty of material could be used in classroom discussions and to provoke questions about the mechanisms of evolution and the lasting effects of mass extinction.

Overall, *Extinction* is an engaging and entertaining read. For teachers who need a good primer on the Permotriassic extinction or on mass extinctions in general, it is an invaluable resource. Even those readers who may have more knowledge of the time period would find the depth of the discussion and the extensive list of references to be useful. The mystery might remain unsolved, but the thrill of the chase is Erwin's focus here, and he gives it the excitement it deserves.