PALEONTOLOGY

Rise and Demise of Ghostly Animals

Shuhai Xiao

Between 1908 and 1914, German geologists P. Range and H. Schneiderhöhn discovered some enigmatic fossils—including *Rangea schneiderhoehni*, later named after them—in southern Namibia. Similar organisms have since been found at more than 30 localities and on most continents. These fossils are collectively known as the Ediacaran biota, after a site in South Australia. The geological age of the Ediacaran fossils is now well established as 575–542 million years ago, an interval immediately before the Cambrian radiation of animals. However, the evolutionary relationship between Ediacaran taxa and Cambrian animals remains ambiguous. Thus, the implications of Ediacara fossils for the Cambrian radiation are intensely debated among a small group of paleontologists. Two recent books authored and edited by Mikhail Fedonkin (Russian Academy of Sciences), Patricia Vickers-Rich (Monash University, Australia), and their colleagues offer new insights into the ongoing debates and unveil the Ediacara controversies to a much wider audience.

In *The Rise of Animals*, veteran researchers, some of whom have spent their entire career unraveling Ediacaran puzzles, lead a guided tour of most of the best-known Ediacaran localities. Telling numerous stories about the fossil hunters, they chronicle decades of Ediacaran research in Newfoundland, Namibia, Australia, Russia, and other, often remote, parts of the world. Along the way, Fedonkin and his fellow authors discuss the preservation, ecology, and phylogenetic affinity of the Ediacaran fossils.

Most Ediacaran fossils are preserved as casts and molds in clastic rocks; sometimes they are only ghostly impressions on the surface of coarse-grained sandstones. The organisms have been traditionally placed in extant animal phyla, including cnidarians, annelids, and arthropods. As such, they represent forerunners of Cambrian animals and support the idea of a short phylogenetic fuse to the Cambrian explosion.

However, Adolf Seilacher, a University of Tübingen paleontologist, argues that most Ediacaran organisms could not have functioned as free-living animals. He interprets them instead as having had bodies of stitched tubes (similar to an inflated air mattress) that were organized concentrically, radially, serially, or fractally. This unique construction of the body forms the basis for his recognition of a new kingdom, Vendobionta (*1*). Although Seilacher admits that there were bona fide animals in the Ediacaran biota, he argues that those animals lived in the shadows of vendobionts that are not closely related to extant metazoans. He believes that the vendobionts were giant protists resembling modern xenophyophoran foraminifers (*2*).

Many paleontologists disagree with Seilacher, and Fedonkin and colleagues defend the traditional interpretation. A case for affinity with more-recent animals has been made for such vendobionts as *Dickinsonia* and *Yorgia*, which left resting traces that are taken as evidence for animal-like mobility. But current hypotheses about how such resting traces were made and how these vendobionts fed find few analogues among modern animals. Other examples of possible animals include *Ausia*, which has been suggested as a possible urochordate. The authors also follow the traditional interpretation of many other Ediacara fossils as animals, although such vendobionts as rangeomorphs, with a fractal body construction, have bodyplans and lifestyles that seem to have been distinct from those of modern animals. Thus, vendobionts remain phylogenetic ghosts whose placement in the tree of life is elusive. Paleontologists continue to debate whether vendobionts are monophyletic and, if they are, whether they fit within the crown of the animal tree, lie along the stem leading to that crown, or rest somewhere else in the eukaryote tree.

The Rise of Animals
Evolution and Diversification of the Kingdom Animalia

by Mikhail A. Fedonkin, James G. Gehling, Kathleen Grey, Guy M. Narbonne, and Patricia Vickers-Rich

Johns Hopkins University Press, Baltimore, MD, 2008. 343 pp. $75. ISBN 9780801886799.

The Rise and Fall of the Ediacaran Biota

Patricia Vickers-Rich and Patricia Komarower, Eds.

The Geological Society, Bath, UK, 2007. 464 pp. $190, £95. ISBN 9781862392335. Special Publication 286.

The Rise and Fall of the Ediacaran Biota comprises a collection of papers that was developed from two interdisciplinary symposia (2004 and 2006) held for the International Geological Correlation Project 493. The wide range of topics encompasses tectonics, paleomagnetism, and evolutionary developmental biology, but the bulk of the book focuses on Ediacaran fossils and contemporaneous life forms. Like most edited volumes, the individual chapters are of uneven breadth and depth

I am most impressed by the thorough analysis of *Kimberella* provided by Fedonkin and his co-authors. Fedonkin regards *Kimberella* as the crown jewel of the Ediacaran biota, whereas Seilacher considers it as a promising newcomer that lived during the vendobiont dynasty—although both agree that it was indeed an animal. Fedonkin's careful examination of a large collection of *Kimberella* specimens has revealed many anatomical structures, including a proboscis-like structure at the presumed anterior end, a dorsal shield, and a ventral foot. These structures clearly establish *Kimberella* as a bilaterian animal whose development involved programmed anterior-posterior and dorsal-ventral differentiation.

Equally intriguing is Jerzy Dzik's analysis of trace fossils, which provides a fresh perspective on animal activities prior to the Cambrian. His plausible and provocative take

CREDIT: JAMES G. GEHLING

Contemplating evolutionary relationships? A stumpy-tail lizard (*Tiliqua rugosa*) gazing at an ancient Ediacaran fossil (*Parvancorina minchami*) in Australia.

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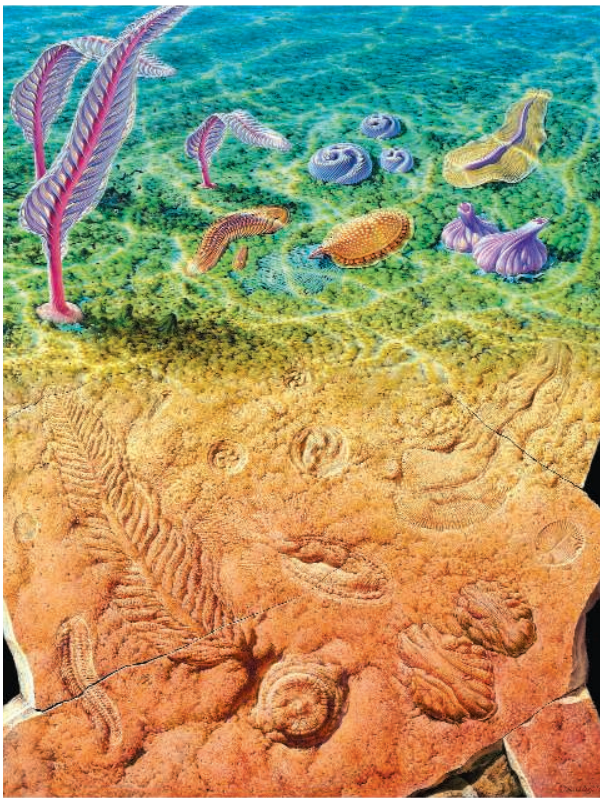

Ghostly animals. For Australia Post's "Creatures of the Slime" stamp issue (2005), Peter Trusler depicted six Ediacaran organisms (clockwise from top left): *Charniodiscus*, *Tribrachidium*, *Dickinsonia*, *Inaria*, *Kimberella*, and *Spriggina*.

CREDIT: PETER TRUSLER/REPRODUCED WITH PERMISSION OF THE AUSTRALIAN POSTAL CORPORATION (ORIGINAL HELD IN THE NATIONAL PHILATELIC COLLECTION)

on early burrows is that they represent refugia from early predators rather than feeding traces (the exploitation of organic carbon in the sediments). Testing his interpretation will require independent evidence for early predators.

Also fascinating are the new observations and innovative morphometric analyses of vendobionts by Marc Laflamme, Richard Jenkins, Jonathan Antcliffe, and their colleagues as well as Erik Sperling *et al.*'s stimulating hypothesis that the early diversification of sponges may have triggered a major disturbance in the global carbon cycle. With regard to the demise of the Ediacaran biota, Breandan MacGabhann's careful examination of purported Ediacaran fossils from Cambrian rocks accentuates the extinction of Ediacaran organisms before the Cambrian explosion, although the cause of this extinction is unresolved.

To solve the puzzle of Ediacaran fossils, paleontologists have to become more receptive to unorthodox thinking. They also need to broaden their field searches to seek fossils in such sediments as black shales, cherts, and bituminous limestones. These unconventional preservational windows may offer novel perspectives on Ediacaran fossils. In addition, future analyses should focus on the evolutionary patterns and processes of the rise and demise of the Ediacaran biota. These two books would have been richer had these aspects of Ediacaran research been explored in greater depth. Nonetheless, the beautifully produced books will serve as valuable references. Particularly useful is the atlas in *The Rise of Animals*, which includes illustrations of many important Ediacaran fossils that previously had been shown only in poor figures published in obscure journals.

The two books by Fedonkin, Vickers-Rich, and colleagues arrive while Ediacaran researchers celebrate the 100th anniversary of Range and Schneiderhöhn's discovery. It is perhaps coincidental that their findings in Namibia were made at about the same time as Charles Doolittle Walcott's unearthing of the Middle Cambrian Burgess Shale fauna in the Canadian Rockies. Like the Ediacaran fossils, many Burgess Shale fossils have also been phylogenetic ghosts, variously interpreted as members of extant animal phyla, stems leading to such phyla, or representatives of extinct phyla. Unlike the Ediacaran organisms, however, Burgess Shale animals are known to a much larger audience, largely thanks to Stephen Jay Gould's popular book *Wonderful Life* (*3*). *The Rise of Animals* offers a much-needed avenue to communicate to the general public the past decade's exciting discoveries of Ediacaran fossils. *The Rise and Fall of the Ediacaran Biota* will reward any scientist interested in the topic. I certainly recommend that both books be placed next to Gould's on your bookshelf.

References

1. A. Seilacher, *Lethaia* **22**, 229 (1989).
2. A. Seilacher, D. Grazhdankin, A. Legouta, *Paleontol. Res.* **7**, 43 (2003).
3. S. J. Gould, *Wonderful Life: The Burgess Shale and the Meaning of History* (Norton, New York, 1989).

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NEUROSCIENCE

The Female Equally with the Male I Sing

Evan Balaban

Differences between men and women have occupied people's thoughts for a very long time. Our creation myths feature them prominently; our religions and governments try to use them to define our potentialities; and our intellectual traditions are rife with rancorous debates about why sex differences exist, what they mean, and what power they should be accorded over our lives. Notions about what is "natural" for, and therefore what is naturally different about, men and women have always played a major part in this discourse.

The first post-Darwin analysis of human sex differences in mental abilities by an evolutionary scientist—written at a time when higher education for women was a subject of intense debate—argued that brain size was an adaptive, sexually dimorphic characteristic and that women's physically smaller brains doomed them to an inferior mental status (*1*). A contemporary commentary in the *British Medical Journal* (*2*) tepidly disagreed with the conclusion of inferiority and mildly ridiculed its presumed scientific basis, endorsing instead a "separate but equal" distribution of abilities whereby men and women emphasize different specialties. Discussions over the ensuing 120 years have largely replicated such arguments, simultaneously blurring the distinction between biological characteristics that cause sex differences and those that are consequences of them. Should the average wages paid to men and women and the difference in the occurrence of attention deficit hyperactivity disorder (both are higher in males in the United States) be thought of as secondary sexual characteristics? And are these inevitable consequences of our biology?

The current profusion of popular books on

Sex Differences in the Brain
From Genes to Behavior

Jill B. Becker, Karen J. Berkley, Nori Geary, Elizabeth Hampson, James P. Herman, and Elizabeth A. Young, Eds.

Oxford University Press, New York, 2008.
504 pp. $98.50, £54.
ISBN 9780195311587.

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