Creating the animal planet

The Crucible of Creation – The Burgess Shale and the Rise of Animals

by Simon Conway Morris

Oxford University Press, 1998.
£19.99 hbk (xxiii + 242 pages)
ISBN 0 19 850256 7

The Garden of Ediacara – Discovering the First Complex of Life

by Mark A.S. McMenamin

Columbia University Press, 1998.
£23.95/$29.95 hbk (xii + 295 pages)
ISBN 0 231 10558 4

One of the most dramatic macroevolutionary problems is the origin of multicellular animals and the major animal body plans. The millions of animal species fall into 35 or so phyla, such as arthropods, mollusks, nematodes, echinoderms and chordates, each exhibiting a distinct body plan. Beginning with Ernst Haeckel in the late 19th century, zoologists looked for ancestors among the embryos characteristic of particular groups of phyla. A marvelous speculative evolutionary zoology arose that was populated by alliterative but fictive ancestors. However, paleontology, which should have been the ideal window into metazoan origins, was stymied. A profusion of complex animals all appeared with embarrassing suddenness in the fossil record in the early Cambrian, 545–535 million years ago: the so-called 'Cambrian explosion'. No amount of rock-pounding by frustrated paleontologists produced any indubitably older animal fossils.

The quandary of metazoan origins, which slept fitfully for much of the 20th century, has reawakened. New cladistic and molecular approaches to phylogeny made possible a re-evaluation of relationships among phyla. Although the old groupings of protostome and deuterostome superphyla still hold, some striking reinterpretations of relationships among phyla have emerged[1]. The Haeckelian embryos-as-proxies-for-ancestors have been replaced by application of developmental genetics and commonalities in gene regulatory systems, which are now scanned for clues about how disparate body plans might have arisen. And paleontology has found its voice through new discoveries and novel interpretation of early metazoan fossils.

Metazoan origins pose three questions: When did metazoans arise? What were the patterns of their evolutionary radiation? What mechanisms underlie the appearance of fundamental body plans? The discovery of phosphatic microfossils that possibly represent Precambrian metazoan embryos suggests that new kinds of fossil finds will play a growing role[2]. However, interpretations of metazoan origins have largely focused on two faunas. The better known is the mid-Cambrian Burgess Shale of Canada, and similar soft-bodied metazoans from Chengjiang, China and Sirius Passet, Greenland. The Burgess Shale animals were discovered early in the 20th century, but only recently interpreted in detail by Harry Whittington[3] and his students. The other fauna is the enigmatic Late Precambrian (about 570 Mya) Ediacara fauna first discovered in Australia. This fauna represents a strange world of large frond-like creatures, discs, and other forms[4,5], whose interpretation has ranged from syncytial fungal grade organisms to real animals. Recent discoveries favor the metazoan interpretation.

Simon Conway Morris is one of the chief interpreters of the Burgess Shale animals and the Cambrian explosion. *The Crucible of Creation* is an exciting read, because he makes every effort, including a visit to the Cambrian seas via time machine, to bring the Burgess Shale fossils into focus as living organisms. Conway Morris also inserts himself into the book as a working scientist, giving the reader a feel for his research as a student dissecting a thoroughly mysterious fossil animal, or hunting unknown Cambrian metazoans in Greenland. He shows that one of those fossils may surprisingly link two body plans, brachiopods and annelids. The book has a deeper message about the meaning of evolution as well. Some extrapolations of rates of gene evolution place the origins of animals as long ago as 1 billion years ago, but Conway Morris argues that even so, the Cambrian explosion represents a real evolutionary event in both body and behavior. The trigger for the rapid expansion of metazoan size, complexity and hard parts is not known, but he suggests that once a certain level of complexity was attained, less dramatic genetic changes driven by ecological demands, such as predation, might have had startling effects. Both the animals and the forces that produced them are consistent with processes observable in the living world.

Conway Morris also differs sharply about the meaning of the Burgess Shale drawn by Gould in *Wonderful Life*[6]. First, he concludes that the strangeness in body design of Cambrian animals stressed by Gould is an artifact of human interpretation, and that they fall into recognizable phyla. Conway Morris also disagrees about the grand pattern of the evolution of life. Gould claimed that evolution is contingent, and that re-running the tape of life would most likely have produced a different zoological world than ours. Conway Morris attacks contingency and Gould's purely materialist outlook on evolution, and instead argues that observable convergence shows that creatures like those that actually evolved, and that even human consciousness, were inevitable – a different world view, a different lesson from the same fossils.

Mark McMenamin's *The Garden of Ediacara* focuses on the lost Late Precambrian biosphere that preceded the Cambrian explosion by some million years. McMenamin's garden refers to his hypothesis that the ediacarans were large, flat translucent creatures that harbored photosynthetic symbionts, and lived quiet lives on the sunny sea floor. His book is a thought-provoking personal exploration of what the ediacaran fossils represent. McMenamin provides an up-to-date introduction to the fossils – what he calls a 'sand menagerie' – before taking the reader into some of his own field expeditions in Mexico and Africa. These anecdotes, like those recounted by Conway Morris, provide an engaging view of both the scientific questions and the doings of paleontologists.

McMenamin refuses to be bound by conventional explanations of the ediacaran fauna, and has expanded the range of biological possibilities. His major conceptual insight envisions these flat and often frond-like creatures as optimal hosts for photosynthetic symbionts. This kind of symbiosis is common today in many cnidarians, such as corals, and McMenamin makes a strong case for the dominance of this biology in a pre-predator world. He also struggles with the possible relationships of the Ediacara fauna to subsequent animals. His most creative interpretation is to explain the unique growth patterns of these organisms by proposing their potential cell cleavage patterns during growth. There is a good deal of controversy still. As noted by Conway Morris, Ediacara forms did survive into the Cambrian, suggesting that the ediacaran fauna may have been less weird, and had continuity with subsequent animal evolution.

Rudolf A. Raff

Molecular Biology Institute and Dept of Biology,
Indiana University, Bloomington,
IN 47405, USA (rraff@bio.indiana.edu)

References

1 Aguinaldo, A.M.A. *et al.* (1997) *Nature* 387, 489–493
2 Xiao, S., Zhang, Y. and Knoll, A.H. (1998) *Nature* 391, 553–558
3 Whittington, H.B. (1985) *The Burgess Shale*, Yale University Press
4 Fedonkin, M.A. (1992) in *Origin and Early Evolution of the Metazoa* (Lipps, J.H. and Signor, P.W., eds), pp. 87–129, Plenum Press
5 Jenkins, R.F. (1992) in *Origin and Early Evolution of the Metazoa* (Lipps, J.H. and Signor, P.W., eds), pp. 131–176, Plenum Press
6 Gould, S.J. (1991) *Wonderful Life*, Penguin Science