Book Review

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The fossil record of development

Embryos in Deep Time: The Rock Record of Biological Development by Marcelo Sánchez, University of California Press, 2012. US$39.95, hbk (265 pp.) ISBN 978-0-520-27193-7

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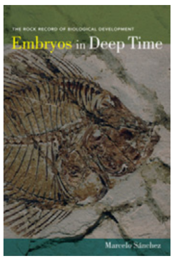

Evolutionary developmental biology, or 'evo-devo', is the study of how development has evolved and how modifications of development affect evolutionary change [1,2]. Although recent advances in developmental genetics have revolutionised this field, fossils also have a vital role. They provide insight into the sequence of changes involved in the assembly of new body plans or structures, and also document the historical patterns of anatomy and ontogeny that models of developmental evolution aim to explain. As almost all evolutionary history took place in species that are now extinct, evo-devo workers ignore this evidence at their peril.

In *Embryos in Deep Time*, Marcelo Sánchez eloquently outlines the myriad ways in which palaeontology can inform about development in deep time; he does not restrict himself to embryology, as the title of the book might suggest. One chapter describes the evidence that comes from fossilised embryonic and juvenile vertebrates, which can provide important information about ancient life-history strategies. The amount of data available is perhaps surprising: there are hundreds of scientific papers describing such fossils in the literature. Another chapter details the ontogenetic information that can be gleaned from bones and teeth. These preserve a record of the life of the animal and can be used to infer traits such as the age at sexual maturity and growth rate of extinct animals.

A fine example of what can be achieved when palaeontology is combined with developmental genetics comes from Sánchez' own work on vertebral numbers in amniotes (tetrapod vertebrates with a terrestrially adapted egg) [3]. The number of vertebrae corresponds directly to segmentation, whereas the subdivision of the vertebral column into distinct regions correlates with *Hox*-gene boundaries. Surveying the vertebral number of extinct as well as extant amniotes showed that segmentation and *Hox*-gene reorganisation act independently, at least at higher taxonomic levels. It also revealed that the conservative pattern seen in living mammals extends right back to the early evolution of the synapsids during the Palaeozoic. By contrast, reptiles have had a much more plastic vertebral number since early in their evolution.

The inclusion of information from stem-group taxa, as in Sánchez' study, is an area where fossils can provide key insights. Stem-group fossils document the acquisition of the characters that are diagnostic of the living members of a particular group. In the case of mammals, the last common ancestor of the living groups evolved some 220 million years ago, yet the stem group extends back to the divergence from reptiles up to 100 million years earlier. The inclusion of these fossils means that it is possible to begin to understand ancient developmental mechanisms and transformations that occurred as the mammalian body plan was being established. Sánchez describes other examples of the importance of such 'missing links', including Friedman's work on the origin of asymmetry in flatfish [4], which adorns the cover of the book and is surely set to become a classic.

Sánchez is well placed to provide such a synthesis, given his expertise in integrating fossils into the study of developmental evolution. He has written an engaging personal book that largely sticks to the vertebrate fossil record, and often to his own work or that of his close colleagues. The flip side is that there is no attempt to be comprehensive; famous examples, even among the vertebrates, are not included (work by Shubin and colleagues on the evolution of tetrapod limbs [5] springs to mind). There is a single chapter on invertebrates, although Sánchez steers clear of a discussion of the origin of the animal phyla. This is perhaps one of the prime areas where fossil data, including preserved embryos, can provide new insights into developmental evolution [6,7]. Only animals are covered, meaning that there is no discussion of plants, which represent another fertile ground for developmental palaeontology [8], not least because the entire developmental sequence can sometimes be preserved.

Ultimately, Sánchez' focus on the vertebrates is the strength of the book as it means that the reader is entertained by his personal take on numerous examples from charismatic organisms. This makes for a captivating account of what the fossil record can say about development. The existence of other groups where the developmental evidence is just as good as in the vertebrates (and, in a few cases, possibly even better) offers up opportunities for additional books in a series on *Embryos in Deep Time*.

References

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The fossil record shows a staggering wealth of organisms. Surprisingly, most of the organisms of the past were much larger and more impressive than present day animals. In fact, the fossil record is evidence for devolution rather than evolution. Layers of Fossils Explained. There are many reasons beyond progressive development that could be given for the order of fossils. The sequence from sessile to free-swimming to terrestrial indicates habitats being destroyed progressively. Imagine a bulldozer rapidly covering a duck pond with soil. The development of distinct regions in the amniote vertebral column results from somite formation and Hox gene expression, with the adult morphology displaying remarkable variation among lineages. Mammalian regionalization is reportedly very conservative or even constrained, but there has been no study investigating vertebral count variation across Amniota as a whole, undermining attempts to understand the phylogenetic, ecological, and developmental factors affecting vertebral column variation.Â The early fossil record of octocorals is shortly discussed. View full-text. Article. The earliest fossil record of a modern-type piciform bird from the Late Oligocene of Germany. January 2001 Â· Journal of Ornithology. Gerald Mayr.