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The earliest fossil embryos begin to mature

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The Ediacaran Doushantuo Formation of South China is perhaps the most remarkable of all sites of exceptional fossilization. Fossils interpreted as animal embryos, which are otherwise vanishingly rare in the fossil record, are so abundant that in some layers they are the main constituent of the rock. The Doushantuo is of Precambrian age and the putative embryos predate the 542 million-year-old base of the Cambrian by as much as 40 million years. Indeed, these fossils constitute the oldest widely accepted record of animals.

Viewed as embryos, the fossils provide a tantalizingly direct insight into development during the dawn of animal evolution. They provide a basis for addressing some of the classical questions in comparative embryology, such as the relative primitiveness of cleavage patterns, blastomere packing arrangements, and mechanisms of gastrulation. Peculiarly, however, only the very earliest cleavage stages have so far been recovered, leading to the suggestion that later stages were not preserved (Raff et al. 2006), or that the fossils are not embryos at all (Xue et al. 1999; Bailey et al. 2007). A radical recent proposal is that they represent giant sulfur-oxidizing bacteria occurring in clusters formed from reductive binary division of progenitors (Bailey et al. 2007). While this thesis explains some of the inadequacies of the animal embryo interpretation, it suffers from others (Donoghue 2007).

A recent paper by Xiao et al. (2007) adds another twist (literally) to the story. Xiao and colleagues describe what appear to be late embryonic stages of Doushantuo embryos. These are comparable in size and in structure of the enveloping membrane to the putative fossil blastula/bacterium *Megasphaera ornata*, but in addition the outer membrane has a superficial helical groove, or else a tunnel with radiating canals running through its wall. Inside the membrane there are no blastomeres, but a large body with corresponding helically coiled invagination. If there really is a connection to the alleged cleavage-stage embryos, these fossils preclude a bacterial interpretation of the latter, but they are not much more help in terms of resolving affinity. Xiao and colleagues speculate that the helical fossils represent embryological stages of the stem-cnidarian *Sinocyclocyclicus guizhouensis* found in the same deposit, or that they represent larvae whose cilia were located in the radial canals of the helical tunnel. But in fact, they could be anything—although they look like nothing seen before (Fig. 1).

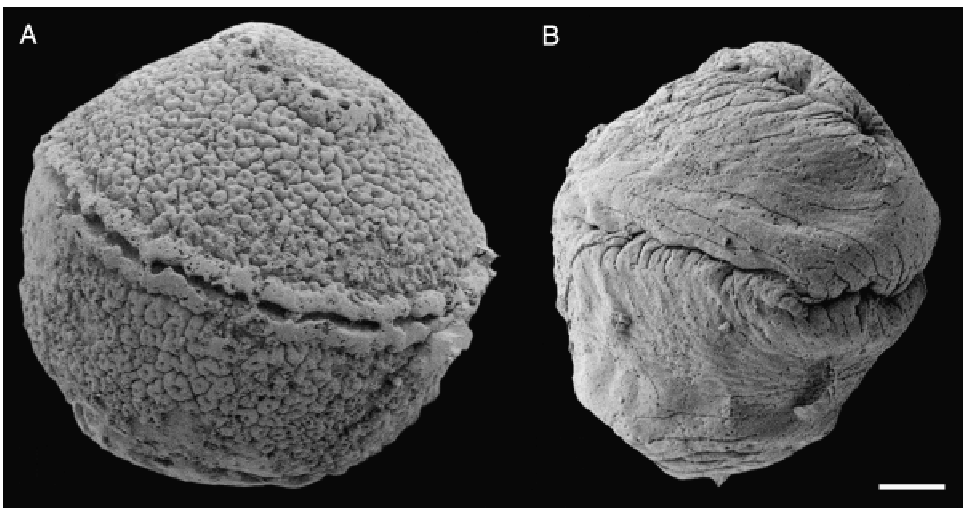

Fig. 1. Helical embryos from the Ediacaran Doushantuo Formation of South China. (A) The fertilization/cyst envelope showing the helical row of radial pits that connect to a superficial canal. (B) An embryo with the envelope removed showing a helical ingression. Scale bar 100 μm. Both images courtesy of Shuhai Xiao, Virginia Tech.

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Like many great discoveries, then, these fossils beg more questions than they answer. Ultimately, we need to know what kind of animal these embryological stages represent. Evidently, we are closer than ever before, but further progress is only going to be made by searching through yet more rock for even later embryological stages and adults. Of course, a putative adult, *Vernanimalcula*, has already been described (Chen et al. 2004). However, this has been the subject of a critique—yet to be adequately met—which highlights that the described fossils are a complex melange of biological and mostly diagenetic (geological) features (Bengtson and Budd 2004). Discriminating geological and biological structure will be integral to squeezing every drop of data from the embryos described by Xiao and colleagues. The description of regularly shaped and arranged subcellular structures preserved in the earlier cleavage stages indicates that this is not an unreasonable expectation (Hagadorn et al. 2006).

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