Microbes may help fossilize ancient embryos

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Courtesy Indiana University and World Science staff

Bacterial decay was once viewed as the mortal enemy of fossilization. But new research suggests resilient colonies of bacteria, called biofilms, may have actually helped preserve the fossil record's most vulnerable stuff: animal embryos and soft tissues.

Scientists have found that bacteria can invade dying embryo cells and form densely packed biofilms in those those cells. These completely replace the cell structure and generate a replica of the embryo, say the researchers, who call this formation of bacteria filling out the shape of an embryo a "pseudomorph."

The investigators, led by Indiana University Bloomington biologists Rudolf and Elizabeth Raff, report their findings in this week's early online issue of the research journal Proceedings of the National Academy of Sciences.

"The bacteria consume and replace all the cytoplasm in the cells, generating a little sculpture of the embryo," said Elizabeth Raff, the report's lead author.

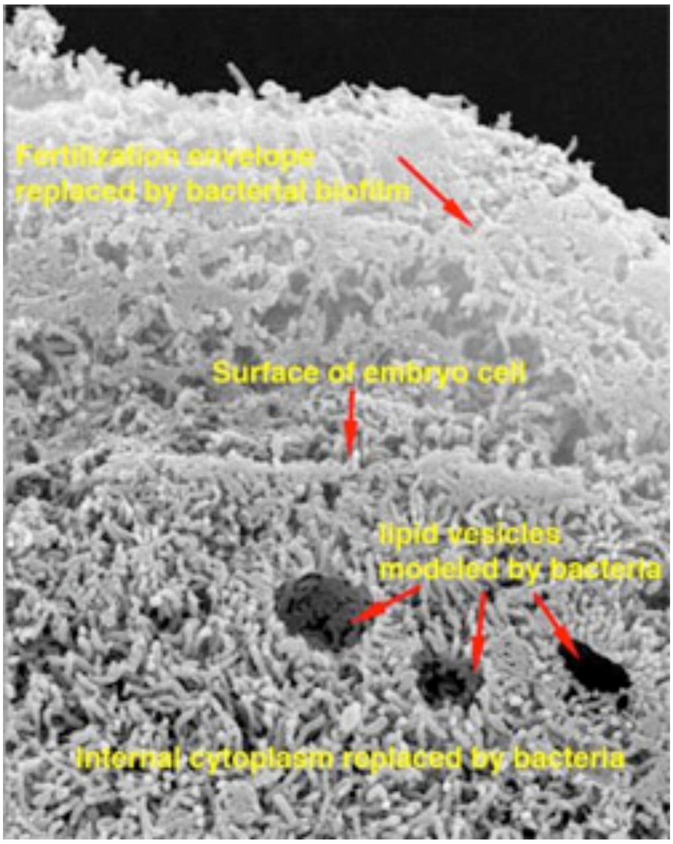
But "certain conditions must be met if the bacteria are going to aid the preservation process." For one, she explained, the embryo must have died in a low-oxygen environment, such as the bottom of a deep ocean or buried in lakeside mud. Oxygen would make embryos self-destruct as digestive enzymes break free and wreak havoc.

Then, "bacteria able to survive in low-oxygen conditions must then infest the cells of the dying embryo," Raff said. The bacteria form biofilms, crowded assemblies of bacterial cells held together by sticky fibers made of proteins and sugars. As the biofilms fill the embryo cells, the tiny bacteria insinuate themselves between and among the structures within the cells, forming a faithful representation of the cell's innards.

Last, the bacteria must leave a permanent record. In the case of finely preserved fossil embryos, the bacteria likely excrete tiny crystals of calcium phosphate which eventually replace the bacterial sculptures. These crystals, Raff said, provide the support for embryo and soft tissue fossilization.

High resolution imaging of a trove of half-a-billion-year-old animal embryo fossils from Doushantuo, China, offered scientists tantalizing evidence that bacteria may have been involved in the preservation of the delicate cells, Raff said.

The Raffs studied early-stage embryos of two Australian sea urchin species, Heliocidaris erythrogramma and Heliocidaris tuberculata. The experimental results with modern embryos were compared to the high resolution images of fossil embryos prepared by



colleagues from China, England, Sweden, and Switzerland.

Although it is impossible to know whether bacteria aided the preservation of 550-million-year-old embryo fossils from Doushantuo and elsewhere, the Raffs argue the evidence they gathered strongly favors the view that bacteria are a fundamental force in fossil formation, as rapid biological processes must be available to convert highly delicate cells into a stable form and trigger mineralization.

“This work is important because it helps us understand fossilization as a biological as well as geological process,” Elizabeth Raff said. “It gives us a window onto the evolution of the embryos of the earth’s first animals.”

Image 1; This early-stage embryo is protected by a fertilization envelope, seen here as a white line encircling the embryo cells. (Cred it: E.C. Raff and R.A. Raff)

Image 2; High-resolution imaging of a trove of half-a-billion-year-old embryo fossils from China, offered evidence that bacteria may have been involved in the preservation, re searchers say. (Credit: F.R. Turner, E.C. Raff, and R.A. Raff)