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Geobiologists propose that the earliest complex organisms fed by absorbing ocean buffet

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Research at Virginia Tech has shown that the oldest complex life forms -- living in nutrient-rich oceans more than 540 million years ago - likely fed by osmosis.

The researchers studied two groups of modular Ediacara organisms, the fern-shaped rangeomorphs and the air mattress-shaped erniettomorphs. These macroscopic organisms, typically several inches in size, absorbed nutrients through their outer membrane, much like modern microscopic bacteria, according to the cover story of the Aug. 25, 2009 issue of the Proceedings of the National Academy of Sciences (PNAS), "Osmotrophy in modular Edicara organisms," by Marc Laflamme, Shuhai Xiao, and Michal Kowalewski. Laflamme, now a Postdoctoral Fellow in the Department of Geology and Geophysics at Yale University, did the research as a postdoc in Xiao's lab at Virginia Tech. Xiao and Kowalewski are professors of geobiology in the College of Science at Virginia Tech.

The rangeomorphs had a repeatedly branching system like fern leaves and the erniettomorphs had a folded surface like an inflated air mattress to make tubular modules. "These organisms are unlike any life forms since and so are poorly understood," said Laflamme.

Their feeding strategy has been a topic of controversy, with theories ranging from parasitism to symbiosis to photosynthesis. "Some hypotheses can be ruled out because the organisms lack feeding structures, such as tentacles or mouths, and because many of them lived in the deep ocean where there was no sunlight for photosynthesis" said Xiao.

The researchers decided to simulate various morphological changes in the overall construction of the organisms to test whether it would have been possible for them to attain surface area to volume ratios on the same order as modern bacteria that feed by osmosis. Theoretical models were constructed to explore the effects of length, width, thickness, number of modules, and presence of internal vacuoles, on the surface area of the Precambrian fossils. "Modeling efforts suggest that internal vacuoles - that is, voids filled with fluids or other biologically inert materials - are a particularly effective way of increasing surface-to-volume ratio of complex, macroscopic organisms," said Kowalewski.

They discovered that the two groups (the repeatedly branching rangeomorphs and the air-mattress like erniettomorphs) grew and constructed their bodies in different ways; however both groups attempted to maximize their surface-area to volume ratios in their own way. "The increase in size was clearly accomplished primarily by addition of modules for the erniettomorphs and repetitive branching and inflation of modules for the rangemorphs," Laflamme said. "The repeated branching system in rangeomorphs was essential to allow for a high surface-area to volume ratio necessary for proper osmosis-based feeding."

Today, only microscopic bacteria find it efficient to us only osmosis to feed, although some animals, such as sponges and corals, use osmosis as a supplementary food source. But in the Ediacaran period, 635 to 541 million years ago, with nutrient-rich oceans, "a diffusion-based feeding strategy was more feasible," Laflamme said.

"We believe the Ediacarans were feeding on dissolved organic carbon, which can come in many forms," he said. "It represents the organic material originating from plants, fungi, animals -- you name it, which has dissolved into fats and proteins during natural organic decay. There is a growing body of evidence that in Ediacaran times, due mainly to the absence of animals with true guts capable of packaging organic matter into fecal pellets, there was a much greater pool of dissolved organic nutrients, especially in deeper waters. Without fecal pellets, organic substances would have remained in suspension and decomposed into fats and proteins capable of dissolution into marine waters," he said. "We believe these compounds were then absorbed via osmosis through Ediacaran "skin" due to the high surface-area to volume ratios."

The PNAS article concludes that today "giant sulfur bacteria, such as Thiomargarita, thrive along the coastal area of Namibia, where constant upwelling allows for greater access to (dissolved organic carbon) and nutrients. Such nutrient-rich areas may be modern-day analogs to Ediacaran deep oceans ... suggesting that it may be more than coincidental that the earliest rangeomorphs occurred in (dissolved organic carbon)-rich deep waters."

More information: www.pnas.org/content/early/200 … /0904836106.abstract

Source: Virginia Tech (news : web)