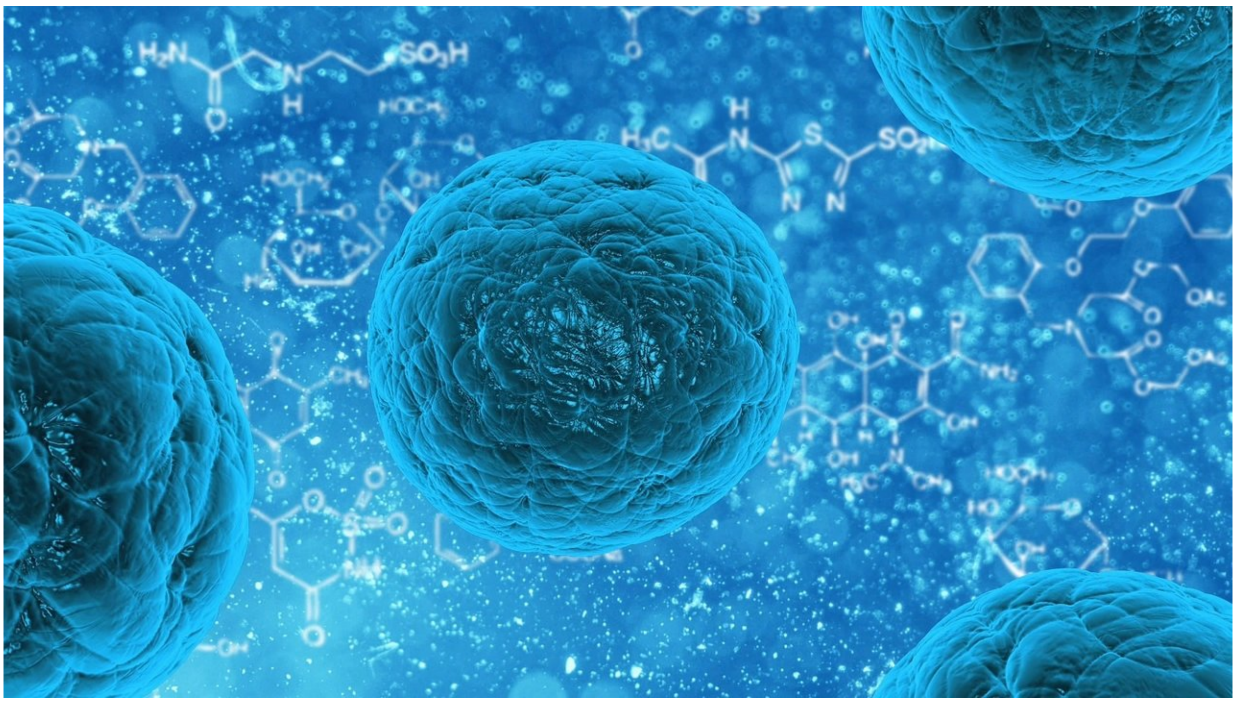
Cell death shines a light on the origins of complex life

January 27 2021



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Organelles continue to thrive after the cells within which they exist die, a team of University of Bristol scientists have found, overturning previous assumptions that organelles decay too quickly to be fossilized.

As described in the journal *Sciences Advances* today, researchers from Bristol's School of Earth Sciences were able to document the decay process of eukaryotic algal cells, showing that nuclei, chloroplasts and pyrenoids (organelles found within chloroplasts) can persist for weeks and months after cell death in eukaryote cells, long enough to be preserved as fossils.

Emily Carlisle, a Ph.D. student from Bristol's School of Earth Sciences and co-author, was able to characterize the transformation of the organelles into something resembling snot. She said: "I spent several weeks photographing algal cells as they decayed, checking the condition of the nuclei, chloroplasts and pyrenoids. From this, we could tell that these organelles don't decay immediately after cell death, but actually take many weeks to dissolve."

When life first appeared on Earth it was limited to simple bacteria. Two billion years later, complex life emerged in the form of large eukaryote cells with membrane-bound organelles, such as a nucleus and chloroplasts. The evolution of fungi, plants and animals followed.

However, precisely when complex life emerged has proved difficult to say. Previous genomic studies suggested that eukaryote cells could have evolved anywhere from 800 million to 1,800 million years ago, an imprecise range that needs fossils to narrow it down.

"The evolution of eukaryotes was a hugely important event in the history of life on Earth, but fossils of these cells are difficult to interpret," said Professor Phil Donoghue, expert in molecular palaeobiology and one of the co-authors of the study. "Some of them have structures that could be organelles, but there's long been this assumption that organelles cannot be preserved because they would decay too quickly."

Although living eukaryotes include large forms that are easily spotted, early eukaryotes were predominantly single cells, difficult to distinguish from bacterial cells.

Historically, large size and intricate cell walls have been used to identify early eukaryotes, but some bacteria can attain large size, and cell wall decorations might be lost to the ravages of time and erosion. Organelles such as nuclei and chloroplasts are not found in bacteria, and would therefore be a definitive indicator of complex life, but they have been assumed to decay too quickly to be fossilized.

The results of these experiments shed light on the controversial fossils of early complex life that include structures within the cells. Dr. John Cunningham, a Bristol co-author, said: "The structures in *Shuiyousphaeridium*, a fossil from 1,700 million years ago, closely resemble nuclei. This interpretation has previously been dismissed because of the assumed rapid decay of nuclei. Our decay experiments have shown that nuclei can persist for several weeks, meaning the structures in *Shuiyousphaeridium* are likely to be nuclei."

By revealing the decay patterns of organelles, the study's authors say they can demonstrate the presence of complex life to 1,700 million years ago, helping to elucidate their evolutionary history with greater precision and clarity.

More information: "Experimental taphonomy of organelles and the fossil record of early eukaryote evolution" *Sciences Advances*, advances.sciencemag.org/lookup … .1126/sciadv.abe9487

Provided by University of Bristol