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Archaea closest to eukaryotes' ancestor are simple inside and rely on partners

Two cultured Hodarchaeales strains suggest the first eukaryotic ancestor was a simple-celled anaerobe that fed on peptides and may have tolerated some oxygen.

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Photo: Cdc

Eukaryotes, the organisms whose cells keep their DNA inside a nucleus, from yeast to humans, are thought to have emerged from within a group of single-celled microbes called Promethearchaeota, formerly known as Asgard archaea. The ancestor itself cannot be studied, so researchers rely on its living relatives. The first members of the group to be cultured, however, sit far from what biologists call FECA, the first eukaryotic common ancestor. That leaves much of its biology open.

In a 2026 paper in Nature, a team from the Japan Agency for Marine-Earth Science and Technology, the National Institute of Advanced Industrial Science and Technology and JEOL reports isolating two strains from Hodarchaeales, the order that has been proposed as FECA's closest relative. Neither was isolated on its own. The strains were obtained as members of a pure co-culture and a tri-culture with methanogenic partners, which are microbes that produce methane.

According to the study, both strains are obligate anaerobes, meaning they need an oxygen-free environment. They are also syntrophic: they live in metabolic partnership with other microbes. They break down peptides, which are short chains of protein building blocks, and they grow at moderate temperatures. Inside, their cells are simple. Outside, they produce protrusions and vesicles, small membrane-bound sacs, much as members of the more distantly related order Promethearchaeales do. The authors also report that all the strains they examined concentrate on building their cells rather than on dividing, which sets them apart from typical prokaryotes, the cells without a nucleus.

Oxygen raised a puzzle. One strain, HC1, carries genes associated with oxygen-using lifestyles, yet it lacks complete pathways for aerobic respiration, and the co-cultures cannot grow in oxygenated or low-oxygen conditions. The authors therefore suggest that these genes help to neutralise oxygen rather than to breathe it. HC1 survived and grew in low-oxygen conditions only when oxygen-using organisms were also present. Phylogenetic analyses, which reconstruct evolutionary relationships from gene sequences, indicate that FECA may have carried the same genes, and so some tolerance of oxygen.

From the physiological, genomic and phylogenetic evidence together, the authors picture FECA as a simple-celled, anaerobic, peptide-degrading archaeon that lived with partners. They describe its lifestyle as not centred on growth and say it may have had adaptations towards a planet with oxygen. On that view, the jump from archaeal to eukaryotic cells was steep, both in cell structure and in the ability to use oxygen.

Those conclusions about the ancestor are inferences drawn from two living strains, whose lineages have had their own long histories since FECA. The phylogenetic result is stated only as a possibility. Because the strains have so far been grown only alongside partner organisms, experiments on them are experiments on small communities rather than on a single species.

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