The Proterozoic record of early eukaryotes

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The origin of the domain Eucarya is not constrained and limited to debated Archean biomarkers. Up to now, unambiguous eukaryotic microfossils only appears around 1.8 Ga. Comparative morphology, wall ultrastructure and microchemistry allows the identification of fossils as early eukaryotes, permitting the calibration of molecular phylogenies. The pattern and timing of eukaryotic diversification and biological innovations (with or regardless of taxonomy) can then be examined, as well as hypotheses regarding their possible biological, ecological, and environmental causes.

The diversification pattern of early eukaryotes can be divided into three steps involving different taxonomic levels. During Period I (?-1.8 to ~1.1 Ga), moderately diverse (mostly stem) eukaryotes appeared, showing evidence for a recalcitrant wall, a flexible lipid membrane, a cytoskeleton, and thus a nucleus. During Period II (~1.1 to 0.63 Ga), a key diversification occurred at the supergroup level, in oxygenated shallow-water above sulfidic or ferrous anoxic deep waters, and coincided with major environmental changes. More diversified assemblages included members of all extant supergroups (but one) and unidentified eukaryotes. Major biological innovations consisted of eukaryotic multicellularity, cellular differentiation, sex, biomineralisation, heterotrophy, photosynthesis, and freshwater adaptation, leading to ecological tiering and complex food webs and interactions. During Period III (0.63–0.54 Ga), a second diversification occurred, this time within the supergroups. The Ediacaran recorded highly diversified acanthomorph acritarchs, microscopic animal embryos or encysting protists, macroalgae, the macroscopic Ediacara fauna and mineralized metazoans. Complex multicellularity and animal biomineralization and predation evolved in spreading oxygenated niches, leading to more complex ecosystems and diversification within supergroups.