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Magnetosymbiosis as an adaptation for microeukaryotes to life under oxic-anoxic interface

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The Earth's surface has been mostly anoxic until 2.4 Gyr, before GOE, when O2 started to accumulate in the atmosphere. This oxygenation had a huge impact on life, especially eukaryotes and was a driver of biological innovation to adapt to these new conditions. Yet, some eukaryotes adapted back to anoxic environments. Some of these innovations were allowed by symbiosis.

In 2019, the discovery of a holonbiont including a microeukaryotic host and prokaryotes ubiquitous in anoxic sediments revealed the first magnetosymbioses [1]. These magnetotactic symbioses are composed of a flagellated protist magnetically guided by dozens of non-flagellated bacteria biomineralizing magnetic crystals. The magnetic guidance is influenced by oxygen concentrations, while genome sequencing supported that the symbionts could not sense these chemical gradients. It is thus likely that in this consortium magneto-chemotaxis is collectively ensured by the protist chemotaxis and microbial magnetoreception. Similarly to magnetotactic bacteria, collective magnetotaxis seems to facilitate the navigation of the holobionts under specific chemical conditions just below the oxic-anoxic transition zone [2]. The host and symbionts interdependency also relies on metabolic exchanges. Some of them were identified based on the bionts ultrastructure and the symbiont genome and partially rely on the transfer of molecular hydrogen from the host to the bacteria that use it to reduce sulfate.

Since the first description of a magnetosymbiosis, the prospection of various aquatic environments revealed numerous magnetotactic consortia involving different host and symbiotic species with different levels of symbiont integration into the host cells. Through single-cell genomic and microscopy approaches, we identified different interactions and common features to magnetosymbiosis functioning. Integrated to a wider evolutionary framework, we inferred the diversification history of this cosmopolitan group of microbial symbioses. The abundance of magnetotactic symbiosis supports that collective magnetotaxis is a key adaptation of protists to an anaerobic lifestyle in marine and freshwater sediments. In this poster, I will share new insights into this form of cooperation and introduce the diversity, ecology and evolution of magnetotactic holobionts.

References:

[1] Monteil CL (2019), Nature Microbiology, 4:1088-1095

[2] Chevrier DM (2023), Proc Natl Acad Sci U S A, 120:e2216975120