Origin, Diversity and Evolution of Magnetotctic Bacteria: Implication for Earth’ s Magnetic Field

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The well-known prokaryotes capable of sensing the geomagnetic field are magnetotactic bacteria (MTB), a group of motile, diverse microorganisms that biomineralize intracellular, membrane-bounded magnetic single-domain crystals of either Fe_3O_4 or Fe_3S_4 called magnetosomes, usually organized into chain(s). The magnetosome chain(s) causes the cell to behave like a compass needle where the cell aligns and swims parallel to the geomagnetic field lines. So far, MTB have been found in almost all types of aquatic environments. It has been noted that the large-scale biogeographic distribution of MTB and their magnetotacitc velocity may be related to the strength of geomagnetic field. A fluorescence-coupled electron microscopy method has been developed for efficient characterization of uncultured MTB at the single-cell level. For geological perspective, the single-domain fossil magnetosomes (also referred to as magnetofossils) are nice records of ancient field. The origin of MTB could provide constraints on geomagnetic field in early time. Recently, we have shown that the gene cluster responsible for magnetosome formation and arrangement originated before or near the Archean divergence between the bacterial phyla of Nitrospirae and Proteobacteria, which occurred well before the Great Oxygenation Event (GOE). Magnetotaxis likely evolved due to environmental pressures conferring an evolutionary advantage to navigation via the geomagnetic field. Earth’ s dynamo must therefore have been sufficiently strong to sustain microbial magnetotaxis in the Archean, suggesting that magnetotaxis coevolved with the geodynamo over geological time.

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