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Magnetotactic Bacteria: From Evolution to Biomineralization and Biomedical Applications

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INTRODUCTION

The creation of magnetosomes in magnetotactic bacteria is likely representative of one of the most ancient forms of biomineralization on Earth (MTB). Beginning 4.4 Ga-2.5 Ga ago, the Archean Eon is the time when magnetotaxis and the evolution of magnetosomes first appeared. Magnetosomes are composed of tiny magnetite nanocrystals encased in a lipidic membrane. Their observations in mammals and eukaryotic cells provide evidence for the evolutionary success of bio-crystallization, which is otherwise very energy intensive. Furthermore, it has only recently been suggested that the genes responsible for magnetite bio-mineralization are universally conserved. Magnetosomes have drawn interest from a number of scientific disciplines, including microbiology, biochemistry, biophysics, and bioengineering. Here, we address the most recent research on iron flow, which is involved in the bio-mineralization of magnetite nanocrystals in MTB.

DESCRIPTION

Biomineralization is widespread across the tree of life and gives living systems defence, physical power, or locomotion. What sets a living organism apart is the production of mineral(s) within its body. There are currently around 60 minerals created by organisms from different phyla. Ion intake from the environment, ion transport and build-up within the organism, and then mineralization to the appropriate structure is all highly specialised processes that are involved in mineralization in living systems. A huge network of organic molecules is often needed for the formation of highly organised minerals. Proteins, phospholipids, and polysaccharides are all a part of it.

A protein's genetic code controls how that protein participates in bio-mineralization, crystal growth, and nucleation. Modern biomedical procedures such as MRI diagnostics, cancer therapy, nutritional and water technical processes, and others regularly use magnetotactic bacteria (MTB), which are among bio-mineralizing organisms and stand out for their specific traits and ancient beginnings (Archeon Eon). MTB, or gram negative motile prokaryotes, are generally found in aquatic settings. Morphology, metabolism, and phylogeny of these groups differ from one another. Because MTB are originally anaerobes or microaerophiles, they can be found worldwide in freshwater and marine ecosystems in the oxic-anoxic transition zone (OATZ) (water column or sediments). In order to produce magnetically sensitive magnetite (Fe^{2+} Fe^{3+}2O4) or greigite nanoparticles ($Fe^{2+}Fe^{3+}$2S4), MTB biomineralize iron from the environment.

MTB are unique, ancient microorganisms with exceptional qualities that can be exploited in current scientific research. In this review, the origins of magnetotaxis and magnetosome biomineralization are investigated from an evolutionary and iron metabolism perspective.

CONCLUSION

Magnetosomes and magnetotaxis are the two main features of MTB. MTB are assumed to have already formed in the middle of the Archean Eon in a largely anoxic environment. Their evolution must therefore show that at least one or more local microaerophilic habitats existed throughout this period. Because of this, we concentrated on describing the environmental factors that resulted in the development of iron-based metabolism, which directly impacted nearly every living thing on Earth, including humans. As a result, iron was required for a number of crucial cell functions. The fact that iron has not been replaced by another element in these functions despite becoming a scarce resource after the GOE demonstrates its special properties. It was also covered how magnetosomes, which are essential for magnetotaxis, evolved and biomineralized. In the final chapter, we also go over all of their numerous contemporary uses in biological domains. We think that by looking at MTB iron metabolism and flow from an evolutionary perspective; we can learn more about these many animals as a whole.

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