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Magnetosome Genes in the Gammaproteobacterium
Strain BW-2

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Abstract

Magnetotactic bacteria (MTB) biomimicize intracellular nanometer-sized, magnetic crystals surrounded by a lipid bilayer membrane known as magnetosomes. These crystals, which consist of magnetite (Fe₃O₄) or greigite (Fe₃O₄·FeO), cause the cell to align along the geomagnetic field lines as they swim, a phenomenon known as magnetotaxis. Strain BW-2 is a magnetite-producing magnetotactic bacterium isolated from Bawdwin Basin, Death Valley National Park (California) and is one of only two species of MTB that are known to phylogenetically belong to the Proteobacteria phylum. The biomimORIZATION of magnetite in magnetotactic bacteria is mediated by a series of genes that include the mam, red, and mms genes that presumably control the production of and the size and shape of the magnetite crystal within the magnetosome. Magnetosome genes have not yet been found in the genomes of newly discovered magnetotactic Gammaproteobacteria.

In this study, we use polymerase chain reaction with degenerate primers designed from mom genes found in other MTB, and DNA sequencing to search for and amplify possible mom genes in the genome of BW-2. In addition, with enough DNA sequence, we may be able to find evidence of the presence of a magnetosome gene island in this organism. Positive results from this study will be instrumental in determining evidence for lateral gene transfer of the magnetosome gene island to the Gammaproteobacteria and the evolution of magnetotaxis based on magnetite biomineralization in general.

Introduction

Magnetotactic bacteria (MTB) are Gram-negative prokaryotes that display a phenomenon known as magnetotaxis where these organisms align along geomagnetic field lines as they swim (Lefevre et al. 2011). MTB experience a torque in a magnetic field that causes them to passively align along magnetic field lines: cells are not being pulled in any direction (as shown in Figure 1) and even dead cells align but don’t swim. This phenomenon is caused by the ability of MTB to biomimicize intracellular magnetic crystals (Figure 2) that consist of either an iron oxide or iron sulfide surrounded by a lipid bilayer known as magnetosome (Bazylinski and Frankel, 2004). Most of these organisms organize magnetosomes in one or more chains (Bazylinski and Frankel, 2004). The control of production and specific characteristics that these crystals display is mediated by a series of genes known as the mam, red, and mms genes. These genes are organized in the genomes of MTB of the Alpha- and Deltaproteobacteria within a genomic island, known as the magnetosome island. Genomic islands are typically surrounded by transposable elements such as insertion sequences, transposasises, and pseudogenes (Bazylinski and Frankel, 2004). Because of this, magnetosome genes and the trait of magnetotaxis is thought to have been transmitted to many different bacteria through horizontal gene transfer.

The purpose of this study is to search for and amplify mom genes in the newly-isolated Gammaproteobacterium strain BW-2. If enough DNA sequence is obtained, it may be possible to show evidence for the existence of the magnetosome island in this organism thus also providing evidence for horizontal gene transfer of the magnetosome island to the Gammaproteobacteria.

Methods

The polymerase chain reaction (PCR) using degenerate primers (Table 1) for specific magnetosome genes was employed to amplify possible mom genes in strain BW-2. Primers were designed from mom genes found in magnetotactic Alpha- and Deltaproteobacteria. PCR products were sequenced using primers designed from strain BW-2. However, we did not find evidence of the presence of a large number of other magnetosome genes was found in strain BW-2, the genes may still be present. This is most likely due to the fact that magnetosome genes and the trait of magnetotaxis is thought to have been transmitted to many different bacteria through horizontal gene transfer.

Results

Discussion

Here we show strong evidence that the magnetosome genes, mamK and mamO, are present in the genome of BW-2. Although, no evidence for the presence of a large number of other magnetosome genes was found in strain BW-2, the genes may still be present. This is most likely due to the fact that the degenerate primers we used were designed from gene sequences from magnetotactic Alpha- and Deltaproteobacteria. It is possible that some genes from other Gammaproteobacteria may be present in the magnetosome genes and the trait of magnetotaxis is thought to have been transmitted to many different bacteria through horizontal gene transfer.

Our results make strain BW-2 an excellent candidate for a whole genome sequencing.

Future Directions

Studying magnetite biomimicization in magnetotactic bacteria is important because magnetofossils have been shown to have unique magnetic, physical and optical properties that can be exploited in a very large number of scientific, commercial and medical applications (Lang and Schiller, 2006) including magnetic cell separation and the diagnosis and treatment of cancerous tumors.

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References