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Studies of Magnetosomes in Magneto Tactic Bacteria using Electron Microscopy

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Introduction

The magnetotactic bacteria are a widespread but diverse class of procaryotic microorganisms that navigate and position themselves along geomagnetic field lines, a process known as magnetotaxis. Each cell functions as a mobile biomagnetic compass because it is a permanent magnetic dipole. It is now believed that magnetotaxis aids cells in effectively locating their ideal oxygen content or redox potential in a water column or sediments. The fact that all magnetotactic bacteria in pure culture are either microaerophiles or anaerobes or both supports this theory. The existence of special organelles known as magnetosomes, which are intracellular, iron-rich, membrane-bounded, single magnetic-domain particles, is what gives magnetotactic bacteria their permanent magnetic dipole moment. These structures are found in large numbers within each cell and are typically arranged. Ferrimagnetic magnetite is present in the magnetosomes of the majority of the magnetotactic bacteria examined to far. But in recent years, we and others have found that the crystals of numerous iron sulphide minerals, some of which are related to copper, are found in the magnetosomes of magnetotactic bacteria isolated from sulfidic aquatic habitats. Reviewing and summarising research on the biomineralization of magnetic minerals in the magnetosomes of magnetotactic bacteria is the aim of this work.

Description

Moench and Konetzka's method of employing jars full of sediment and water on top of them to collect uncultured magnetotactic bacteria or a modified version of the magnetic "race-track" method were both used to gather the bacteria. The syringe was used to remove developing cells from pure cultures. Typically, cells were directly placed onto carbon-coated nickel electron microscopy grids and let to remain at room temperature for around 10 minutes before the extra fluid was removed using a small piece of filter paper. Because copper and iron-sulfide type magnetosomes appeared to react chemically, interfering with our chemical investigations, nickel grids were employed instead of copper ones. In certain instances, grids were initially coated with 3% formalin fixative before cells were placed on them. Extra safety measures [1]. Iron oxides and iron sulphides are the two main compositional forms of magnetosomes found in magnetotactic bacteria. The iron, oxygen, and sulphur elemental imaging produced by energy-dispersive X-ray analysis using a STEM is the most effective at revealing the kind of composition in a given cell. For an iron oxide-type organism and an iron sulfide-type organism, respective elemental pictures are displayed. The iron sulphide particle in the organism that was placed on a nickel grid, according to the EDX spectrum, on which the map in is based. the EDX spectrum for a beam that was focused inside a cell but not directly on a particle. Other inorganic or partially inorganic deposits within cells, such as "sulphur globules" and polyphosphate bodies only particles of one composition, can also be seen using elemental imaging.

Various tools were used to conduct transmission electron microscopy (TEM) research on magnetosomes and whole cells. A JEOL Model 200CX microscope operating at 200 kV or a JEOL Model lOOX instrument operating at 100 kV were used for conventional microscopy. A JEOL Model 2000FX TEM operating at 200 kV was used for high resolution analytical electron microscopy (HRTEM) of microorganisms and magnetosomes, as previously mentioned. A scanning TEM (STEM) powered by VG Microscopes Model HB5 that runs at 100 kV was used for analytical electron microscopy. This device had a field-emission electron cannon, an X-ray detector (Link LZ-5), and an X-ray multichannel analyzer (AN1000) that could identify any elements heavier than boron. This system's Xray analysis results had a rastering spatial resolution that was too low to be useful [2]. These characteristics include the magnitude, intensity, and severity of the disturbances as well as their geographical distribution, frequency; return interval, and rotation period. A phase of fast change is now occurring in many disturbance regimes. Because of warmer temperatures, earlier snowmelt, and lengthier fire seasons, for instance, the frequency of big fires has considerably risen in the western United States in recent decades. Even the tundra on Alaska's North Slope is at increased risk for big fires elsewhere in the world [3].

To date, just one organism has been found to have the greigite-pyrite particles. The fact that this bacterium is a many-celled, magnetotactic procaryote, or microcolony, of around 20 cells grouped in a conglobate fashion, makes it exceedingly unique in the bacterial world. It is prevalent in brackish, sulfidic, aquatic settings on numerous continents. The organism is mobile as a whole but not as a collection of cells. Each cell has many greigite and pyrite particles that are pleomorphic and exhibit inconsistent crystalline morphologies. Each cell is multi-flagellated exclusively on its exterior surface. If the observed pleomorphism serves as a marker for pyrite and greigite particles in magnetotactic bacteria, that would be intriguing. These new strains include MV-2, the first vibrioid magnetotactic strain, which, according to phylogenetic analysis, is an exact duplicate of strain MV-1. Magnetic interactions between magnetosomes lead their magnetic dipole moments to align parallel to each other in the chain direction when they are arranged in chains, most likely through a self-assembling process. The sum of the moments of each individual particle then equals the overall magnetic dipole moment. The cell may build a permanent magnetic dipole big enough to orient itself in the geomagnetic field while swimming by arranging the particles into chains. The water is at room temperature. The majority of magnetotactic bacteria have their magnetosomes organised in chains, independent of where and how many flagella they have. Bilophococcus magnetotacticus, a magnetotactic coccus with two tufts of flagella at one end of the cell, and a rod-shaped bacterium that contains greigite are among the cells that do this [4,5].

Conclusion

It is obvious that magnetotactic bacteria exert strong control over the biomineralization process involved in the synthesis of magnetosomes, maybe with the exception of the multicellular, magnetotactic procaryote. In the course of evolution, structures within animals, such as magnetosomes, have been honed and tuned to have particular characteristics and fulfil particular purposes. It is possible to determine and link the qualities of magnetosomes with their

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structure, despite the fact that the roles of magnetosomes and the specifics of their production are not fully understood. The magnetotactic bacteria provide a good illustration of how to optimise the magnetic characteristics of biomineralized magnetic particles by maintaining control over particle size and morphology and establishing a hierarchical structure via relative particle location within the cell. It's also impressive that they used the same basic framework.

Conflict of Interest

None.

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