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MAGNETOSOMAL MATRIX: POSSIBLE ROLE IN THE BIOMINERALIZATION OF MAGNETITE (Fe_3O_4) AND GREIGITE (Fe_3S_4)

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Marine, brackish and freshwater magnetotactic bacteria were analysed using transmission electron microscopy (TEM). Stained ultrasections of gutaraldehyde-fixed and Epon®-embedded magnetotactic bacteria were examined in a JEOL® JEM 1010 transmission electron microscope at 80 kV. Unstained, dehydrated whole-cell preparations of magnetotactic bacteria were analysed by analytical TEM (selected area electron diffraction, phase-contrast lattice imaging and energy dispersive X-ray spectroscopy), in a JEOL® 4000 FX high resolution transmission electron microscope fitted with an Oxford-Link® windowless silicon X-ray detector.

An organic iron-containing matrix was detected encapsulating magnetite and greigite magnetosomes in unstained whole-cell preparations, unstained ultraviolet-B-irradiated whole-cell preparations and stained ultrasections of fixed embedded magnetotactic bacteria. The magnetosomal matrix was detected using all three methods, which indicates that the magnetosomal matrix was not an artefact of specimen preparation. Pseudo-hexagonal prismatic magnetosomes in a variety of cells were surrounded by a mildly anionic capsule that extended 30–70 nm beyond the surface of the magnetosomes. The matrix was ~50 nm thick around bullet-shaped magnetosomes. In some cells the space between adjacent magnetosomes were consistently 1.8–3.0 nm wide, which is too small to contain two magnetosome boundary membranes each 5.7 nm thick, as reported by GORBY et al. (1988).

Phase-contrast lattice images of magnetosomes revealed lattice fringes in the magnetosomal matrix with approximately the same widths and orientations as lattice planes in the encapsulated magnetosomes. This correlation indicates that the magnetosomal matrix may act as a template for spatially defined catalysis of magnetite and greigite. A magnetosomal matrix was found encapsulating two types of pseudo-hexagonal prismatic, bullet-shaped and cubo-octahedral magnetite magnetosomes. A feint matrix was also detected encapsulating greigite magnetosomes. These data indicate a second biological mechanism for the mineralization of magnetite.

The magnetosomal matrix is hypothesised to be a semicrystalline polysaccharide gel that acts as a template (mother matrix) for spatially defined catalysis of precursors in magnetite and greigite biomineralization (unpublished data). The matrix may also control the influx of reactants and excretion of product(s) (e.g., iron chelation). The magnetosomal matrix may explain the structural integrity of some magnetosomal chains and the ultrafine-structural coordination between adjacent magnetosomes (e.g., mirroring).

References

GORBY, Y.A. BEVERIDGE, T.J. & BLAKEMORE, R.P. (1988). J. Bacteriol., **170** (2): 834–841.