Advanced electron microscopy techniques for studying magnetosomes in magnetotactic bacteria

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Several advanced transmission electron microscopy techniques, including off-axis electron holography, high-angle annular dark-field electron tomography and energy-selected imaging, have recently been used to characterize the magnetic fields, three-dimensional morphologies and chemical compositions of intracellular ferrimagnetic crystals of magnetite (Fe_3O_4) and greigite (Fe_3S_4) in air-dried cells of magnetotactic bacteria. These techniques have provided a wealth of information about the relationship between the structural and magnetic properties of the magnetosomes and the magnetotactic behavior of the cells. Here, we review the state of the art in the application of these techniques to the study of magnetotactic bacteria. We then discuss the possibility of studying magnetotactic bacteria using new and emerging electron microscopy techniques, including aberration-corrected electron microscopy, focused ion beam sectioning, live cell imaging in both transmission and scanning electron microscopes and magnetic vector field electron tomography. We also discuss the use of new specimen holder technologies and algorithms for obtaining improved information using conventional (scalar) electron tomography.