Understanding magnetite nanoparticle biomineralization proteins: From magnetotactic bacteria to *in vitro* chemical precipitations.

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Magnetic nanoparticles (MNP) have numerous applications, from data storage to cancer treatment. For these applications, MNPs must have a uniform magnetic behaviour, and precisely controlled size and shape. Magnetotactic bacteria synthesize MNP of the iron oxide magnetite within lipid vesicles (known as magnetosomes). The magnetosome harbours a range of dedicated biomineralizaiton proteins to control the nucleation, growth and maturation of precise, species specific particle morphologies. Recent genetic studies have identified a "magnetosome island" on the genome which contains the genes necessary to produce magnetosome membrane specific (Mms) proteins responsible for the biomineralization of the magnetite crystal.

Here we present a study to investigate and understand how Mms proteins control the formation of magnetite MNP by studying their action *in vitro* in a chemical precipicaiton synthesis. We show our detailed analysis of how a range of Mms proteins (e.g. Mms6, MmsF) nucleate, bind to, and control MNP formation using NMR, diffraction, *in situ* pH titration, TEM and iron binding assays. Data from our *in vitro* experiments, coupled with existing *in vivo* analysis allows us to hypothesize how these unique proteins precisely control the crystallization process *in vitro* and how this can be related to the chemistry within the magentosome. Furthermore, this understanding can be used to generate a "tool box" of additives for controlling and tailoring magnetite MNP production for an improved, greener, chemical synthesis.