Towards a structural investigation of MamP, a key player in redox control during magnetosome maturation

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Magnetotactic bacteria (MTB) are a group of bacterial species appearing in many diverse phyla. Uniquely, they are distinguished by their ability to biomineralise crystals of magnetite (Fe₃O₄) and greigite (Fe₃S₄) up to the range of 40-100 nm. These membrane-bound crystals are known as magnetosomes, and allow MTB to orient themselves along the axis of the Earth’s magnetic field. This constrains their freedom of movement to allow more precise positioning in their optimal micro-environment at the oxic-anoxic interface of aquatic habitats.

The redox management of Fe²⁺ and Fe³⁺ ions present during nucleation and growth of magnetosomes is crucial, as magnetite and greigite require a precise 1:2 ratio of these ions. There are multiple proteins involved in this control, including MamE, MamT, MamX, and MamP. These proteins all contain at least one magnetochrome domain, which is a class of c-type cytochrome, which each contain a covalently bound haem group with an associated Fe ion. MamP contains two magnetochrome domains, and is known to oxidise Fe²⁺, although the precise mechanism of this reaction in unknown [1].

The technique of spatially-resolved anomalous dispersion (SpReAD) uses synchrotron radiation to measure the oxidation state of metal ions inside protein crystal by carefully selecting the energy of the incoming X-ray beam [2]. Metal ions with different oxidation states exhibit subtly altered absorption edges. This allows precise measurements at a tunable synchrotron beamline, for example at BESSY II [3], to give information about the redox chemistry of these ions. By using this technique, I hope to gain information about the oxidation state of Fe ions at each position of MamP in conditions both relevant to its physiological functioning, and after some chemical and mutational perturbations. I also hope to experimentally demonstrate interactions with cellular electron donors and acceptors made by MamP. This will allow both a clearer picture of the mechanism of action of MamP and of the nucleation and growth of magnetosomes to emerge.