Electron Transfer to the Microbe-Mineral Interface at Nanometer Resolution

PNNL SFA (Laboratory Research Manager: Harvey Bolton)

D.J. Richardson, *University of East Anglia, U.K.*

A key question regarding electron exchange between a bacterium and extracellular electron acceptors or donors is the mechanism of electron transfer across the outer membrane. We have developed a conceptual model as a framework in which we propose that the multi-heme cytochrome “wires” can embed within an outer-membrane porin sheath to form electrically conductive complexes. These porincytochrome complexes can then interact with various biochemical termini on either side of the outermembrane, depending on their physiological function (e.g., Fe(III) reduction or Fe(II) oxidation). Our objectives are to solve the molecular structure of this complex, reconstitute it into liposomes, study electron transfer to a range of minerals in these artificial membrane systems, and prove that this model applies widely in environmental systems where it is necessary to elucidate the molecular properties of the cytochrome-porin complexes and the termini that interact with them, over a range of environmentally relevant bacterial species. In addressing these broad objectives, we have: (1) obtained 3-Angstrom and 1.8- Angstrom crystal structures of decaheme Fe(III) reducing terminis of an outer-membrane cytochrome-porin wires and used this to explain how electron transfer at the microbe-mineral interface can be direct protein-to-mineral or mediated by soluble electron shuttles such as flaving; (2) incorporated a porin-cytochrome complex into proteoliposomes,enabling us to examine electron exchange with different mineral surfaces, for example hematite,goethite, or birnessite, and study the effectiveness of different outer membrane deca-heme termini inthese processes; (3) undertaken biochemical, spectro-potentiometric; and structural studies on a rangeof outer-membrane electron transport systems to understand functional commonalities and differences and (4) solved crystal structures of outer-membrane cytochromes with Fe(III) complexes bound that give the first nanometer resolution of a cytochrome-ferric iron electron transport complexes.