Metal oxide reduction to microbial fuel cells and growth on electrodes

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Extracellular electron transport, or EET, is the process whereby bacteria either donate electrons to an electron acceptor (usually insoluble), or take up electrons from an electron donor (usually insoluble) that is located outside the cell. We came upon this process with the isolation of *Shewanella oneidensis* MR-1, a Gram-negative bacterium capable of dissimilatory reduction of solid iron and manganese oxides. It was soon found that these bacteria possessed unusual molecular machinery (multi-heme c-type cytochromes) dedicated to the transport of electrons to the cell exterior. MR-1 has been intensively studied with regard to the mechanism(s) of EET, and shown to use several approaches to EET, including soluble electron shuttles, and conductive appendages called nanowires. Not long after the isolation of MR-1, it was apparent that one could use a properly charged (poised) electrode as an electron acceptor, and in the right configuration, transfer of electrons to the electrode surface resulted in microbial fuel cells (MFCs) – the anode being the only electron acceptor available, and EET to the electrode providing the mechanism production. Not surprisingly, electrode-dependent growth was easily demonstrated, and the study of electromicrobiology (in the modern era) was under way. The cathode of an MFCs is the site of oxygen reduction to water, commonly catalyzed by a metallic catalyst like platinum: it was thus not particularly surprising when aerobic bacteria were shown to be capable of catalyzing this reaction using cytochrome oxidase – MR-1 was able to act as a cathode catalyst, using oxygen, fumarate or other electron acceptors. The demonstration of this ability in several bacteria has led to the exciting prospect of electrosynthesis and a burst of activity showing both electrosynthetic activities, and the ability to use poised cathodic electrodes as energy sources for the isolation and growth of bacteria (electrotrophs?!). This, coupled with the recent findings that changes in electrode potential are sensed by bacteria, resulting in gene regulation, make it clear that electromicrobiology is far more intricate, and perhaps widespread, than any of us recognized with the isolation of the first metal reducing bacteria.