16:45 – 17:30

Bacterial Micro-cables and Nanowires

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The discovery of bacterial nanowires, cable-like structures conductive over micrometer distances, has now intrigued many scientists for a decade [1]. The nanowires were observed in metal-reducing bacteria such as *Geobacter sulfurreducens* and *Shewanella oneidensis* and they enabled the bacteria to transfer electrons from the cell surface to extracellular electron acceptors such as insoluble metal oxides over micrometer distances or in long-range cell-cell networks in biofilms. The nanowires were proposed to be pilus-based as the *G. sulfurreducens* nanowires were found to be composed of the type IV pilin subunit PilA (Figure 1A). Furthermore, multiheme c-type cytochromes were shown to interact with the nanowire pili and based on these observations two hypotheses for electron conduction in nanowires were proposed. One of these (termed the multistep hopping or MSH hypothesis) suggested that the pilus would serve as a scaffold for highly ordered attachment of multiheme cytochromes. Based on this electron conduction could be carried out by electron 'hopping' between heme groups inside cytochromes and between adjacent cytochromes. The other (termed the metallic-like conductivity or MLC hypothesis) claimed that the pilus itself had the electron conductive properties and that the attached cytochromes were used for transfer of electrons from the pilus to the final electron acceptor. So far a number of experimental studies aimed at verifying either hypothesis have not been conclusive [2].

Recently, a novel type of bacterial long distance electron transport was proposed. The basis for this was observation of H_2S oxidation in the anoxic zone coupled with O_2 reduction in the oxic zone of seabed sediments [3]. These redox reactions were observed to be coupled over distances of centimeters

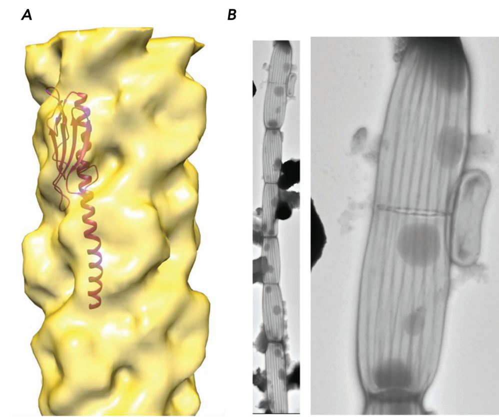

Figure 1 A: Cartoon representation of the P. aeruginosa PAK pilin structure (red) docked into the cryoelectron microscopy density map (yellow) of the type IV pilus of Neisseria gonorrhoeae to show the subunit building blocks in the pilus fiber. The diameter of the pilus is 50 A and the fiber can be several micrometers long (based on PDB entries 2HIL and 1OQW, as well as EMDB entry 1236.). B: Transmission electron microscopy at 11,000 x magnification of micro-cable bacteria stained with uranyl acetate. Dark lines are observed indicating fiber structures extending from one cell to the next through hubs at the cell-cell junctions and division septa. Left image is composite image from multiple micrographs showing cells of a micro-cable filament. Right image is close up showing cell division septum and cell-cell junction.

between the O_2 and H_2S reservoirs. Examination of the sediments revealed a novel form of filamentous bacteria having a very intriguing morphology [4]. On the surface of the bacteria multiple cable-like structures were observed to extend along the length of the individual cells. Surprisingly, these cable-like structures were shared between cells and they formed continuous structures along the entire length of the bacterial filament consisting of thousands of cells and being centimeters long (Figure 1B). It was therefore suggested that electron transport was taking place inside these structures thereby coupling the redox reactions. The molecular basis for this electron transport is currently not clear.

We have engaged structural and functional studies of these amazing bioelectrical wires at the molecular level to get a firm understanding of the underlying supramolecular organization and conduction mechanism and the status for this work will be presented.

References

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