Altruistic electrical cooperation in multicellular cable bacteria

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Cable bacteria have evolved an ingenious division of labour in which redox transformations in distant cells are coupled via long-distance electron transport. Cells in deeper sediment layers oxidize hydrogen sulfide, the electrons generated are then transported via “wires” along the longitudinal axis of the filament towards cells residing in the oxic zone where these electrons are used to reduce oxygen. This electrical interaction between distant cells of the same filamentous organism provokes the question of how electron flow is coupled to energy conservation and biosynthesis.

Stable-isotope labeling (^{13}C and ^{15}N) followed by nanoscale secondary ion mass spectrometry (nanoSIMS) reveals that biomass formation and energy generation is restricted to the sulfide-oxidizing cells whereas cells within the oxic zone show no label uptake and thus no biomass formation. Cyclic voltamettry experiments not only showed that cable bacteria filaments directly channel electrons towards oxygen but also that the capacity for oxygen reduction is high. Furthermore, sediment manipulation experiments showed that this capacity for oxygen reduction appears to be present in every cell along the filament and each cell can switch from sulfide oxidation to oxygen reduction almost instantaneously once introduced to oxygen.

The combination of these results offer a new and surprising insight into the coupling of electron transport and energy conservation where oxic cells merely serve to efficienly dispense of electrons without energy generation. Oxic cells appear to “sacrifice” themselves to the benefit of the rest of the filamentous organism. Such an altruistic electrical cooperation adds another layer onto the division of labour within a cable bacterium filament and is unprecedented within multicellular organisms.