Zinc regulatory networks and metallomics in marine cyanobacteria

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Project description
Marine cyanobacteria of the genera *Prochlorococcus* and *Synechococcus* are the most abundant phototrophs on Earth contributing up to 70% of primary production in some oceanic regions. As autotrophs, these organisms require only inorganic forms of macro- and micro-nutrients. The biochemical processes to assimilate light and the macronutrients carbon, nitrogen, and phosphorus all require essential trace metal ions – for example, iron and copper are needed for electron transport and redox chemistry in photosynthesis, manganese for conversion of water to oxygen, molybdenum for nitrogen fixation, and zinc for phosphate utilisation and carbon fixation. It has been shown that the bioavailability of these micronutrients can restrict primary production [1,2].

Understanding the relationship between primary production and the details of trace metal metabolism for marine picophytoplankton is crucial for better understanding biogeochemical cycles and modelling the effects of climate change.

Like other organisms, marine cyanobacteria acquire essential trace metal ions from their environment, but microbes dwelling in the open ocean face particular challenges: many of these metals are extremely scarce in this oligotrophic environment, and it can be estimated that to be viable, a cell must “concentrate” metals such as Mn, Fe and Zn by factors of $10^5$-$10^7$. However, the molecular mechanisms that enable this remarkable feat are not well understood for any open ocean microbe. In addition, the metalloprotein inventories of marine microbes are scarcely characterised.

Previous and ongoing work in the Blindauer/Scanlan groups aims to develop methodology to study metal requirements, identify major cellular destinations of individual metals (in particular zinc), and to understand the regulatory networks involved [3,4]. Genome mining has suggested that all marine cyanobacteria are equipped with proteins that sense low zinc levels and regulate the expression of ABC-type zinc uptake transport systems. Metallo-proteomic studies of the oligotrophic strain *Synechococcus* sp. WH8102 have demonstrated that the periplasmic component of one of these transporters is expressed and capable of binding zinc. In addition, we have recently shown that zinc acquisition by this strain is extremely efficient. Hence, there is mounting evidence that zinc plays an important, but scarcely understood role in the physiology of marine cyanobacteria – impacts of zinc on carbon, phosphorus and nitrogen acquisition are predicted, but not experimentally established.

**This exciting PhD project will integrate information from a variety of approaches to obtain a qualitative and quantitative understanding of marine cyanobacterial zinc metabolism and its impact on macronutrient acquisition and utilization.** The network of genes and proteins that are directly or indirectly influenced by zinc bioavailability will be analysed using microarrays of *Synechococcus* sp. WH8102 cultured at different zinc concentrations. Moreover the zinc-dependent expression of key proteins (e.g. Omp2, Zur, ZnuA, metallothioneins) derived from previous bioinformatic and metallo-proteomic work as well as novel proteins identified via the new microarrays, will be quantified by real-time-quantitative PCR (RT-qPCR). These transcriptomic studies will be complemented by metallomics (establishing elemental stoichiometries under different growth conditions) and metallo-proteomic studies to provide a comprehensive study of the zinc biology of these ecologically key phototrophs.

The project will provide excellent training in marine microbiology and molecular biology, as well as cutting edge analytical chemistry (e.g. LC-MS/MS and ICP-MS) and ‘omic approaches (whole genome microarrays, proteomics), whilst at the same time developing a range of research skills. The student will be assisted by the wide array of scientific expertise already available in the Blindauer/Scanlan labs.

Applicants should have, or expect to obtain a BSc or MSc in a relevant subject, and have a strong interest in molecular microbiology and/or trace metal biochemistry. Informal enquiries should be made to Dr Claudia Blindauer (c.blindauer@warwick.ac.uk) or Prof Dave Scanlan (d.j.scanlan@warwick.ac.uk).

References: