**Project title:** Adaptation and physiological response to nutrient limitation in marine microbes, an integrated lipidomics, transcriptomics and proteomics approach

**Project code:**

**Host institution:** University of Warwick

**Theme:** Organisms, ‘omics’ and biogeochemistry

**Key words:** nutrient stress, lipidomics, transcriptomics, marine bacteria, cell surface

**Supervisory team (including institution & email address):**

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**Project Highlights:**

- World-leading supervisory team on marine microbiology
- Uniquely opportunity at Warwick to apply cutting-edge techniques on integrated omics
- Hands-on training from experienced senior colleagues in the research team

**Overview:**

The growth of marine bacteria in the vast open ocean ecosystem is limited by the availability of nutrients (Scanlan et al, 2009; Merchant & Helmann, 2012). Marine cyanobacteria are responsible for the generation of around half of oxygen in the atmosphere. Heterotrophic marine bacteria play a crucial role in marine elemental cycling which regenerates essential nutrients for oceanic primary production. Understanding how marine bacteria meet their nutrient demand and how they adapt to nutrient limitation holds the key to predicting the future Oceans’ functioning under natural and anthropogenic changes.

Lipids are a major component of all living cells and lipidomics is a large scale, high throughput study of all lipid contents in biological systems (Shevchenko & Simons, 2010). Recent advances in technologies such as liquid chromatography electrospray ionization mass spectrometry (LC-ESI-MS) has enabled high throughput identification and quantification of thousands of cellular lipid molecular species. Indeed, lipidomics is starting to complement the rapid progress made in genomics, metagenomics, transcriptomics and proteomics, which will enable reconstitution of metabolic functions in biological systems.

Using model marine bacteria, we and others have shown that nutrient availability in marine waster columns not only determines their growth rates, but also can significantly affect their cell surface. For example, our recent study has demonstrated that a variety of marine bacteria remodel their membrane lipids in response to the limitation of phosphorus, an essential, often limiting nutrient in the sea (Sebastian et al 2015). It is conceivable that such modification of cell surface can have significant impact on the physiology and fitness of these microbes in the environment.

**Figure 1:** AmaZon liquid chromatography ion trap mass spectrometry at Warwick dedicated for lipidomics analyses (see Sibbastian et al 2015).

The aim of this project is therefore twofold, Firstly, using model marine bacteria, we aim to determine the impact of a range of nutrients on the formation of cell surface modification (e.g. lipid remodelling). Secondly, we aim to determine the impact of cell surface modification on adaptation and subsequent physiological response to environmental changes through an integrated omics approaches.
Methodology: Growth of selected marine bacteria will be achieved using both defined synthetic medium as well as nutrient broth. Cell surface modification will be determined by liquid chromatography-mass spectrometry (LC-ESI-MS). Nutrients in the defined media will be analysed by established chromatography techniques, such as ion-exchange chromatography and gas chromatography. Mutagenesis of targeted genes in these marine bacteria will be carried out by marker-exchange mutagenesis. The adaptation of wild type and mutants in response to nutrient limitation will be determined by RNA-seq based transcriptomics and/or LC/MS based proteomics and metabolomics.

Training and skills: This exciting project provides cutting-edge training on contemporary omics approaches, including lipidomics and transcriptomics. It will also provide excellent training in wider aspects of marine microbiology, biogeochemistry and molecular biology using cutting edge biochemical and molecular techniques as well as in a variety of analytical techniques currently available Warwick, including gas chromatography, ion-exchange chromatography, liquid chromatography-mass spectrometry.

CENTA students will attend 45 days training throughout their PhD including a 10-day placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to the student’s projects and themes.

Partners and collaboration (including CASE): The supervisors are world-leading experts in marine microbiology and publish regularly on high profile interdisciplinary journals (e.g. Proc. Natl. Acad. Sci. USA) and field specific high impact journals (e.g. The ISME Journal). They have complementary expertise in marine microbiology and biogeochemical cycles. Current research in the groups is well-funded by the Nature Environment Research Council (UK), The European Union and the Gordon and Betty Moore Foundation. Further details on their research activities and their group members can be found via the links below.

Dr Chen’s group: [http://www2.warwick.ac.uk/fac/sci/lifesci/people/ychen](http://www2.warwick.ac.uk/fac/sci/lifesci/people/ychen)
Prof Scanlan’s group [http://www2.warwick.ac.uk/fac/sci/lifesci/people/dscanlan](http://www2.warwick.ac.uk/fac/sci/lifesci/people/dscanlan)

Possible timeline:

Year 1: Mass spectrometry-based identification (lipidomics) of cell surface modification in response to nutrient availability in model marine bacteria.

Year 2: Determine the impact of cell surface modification on adaptation and subsequent cell physiology. Construction of mutants in cell surface modification, subsequent investigation of mutant phenotype.

Year 3: Comparative transcriptomics and proteomics analyses of wild type and mutants in response to nutrient availability. Integrated omics-driven investigation of cell-surface modification on environmental adaptation and fitness.

Further reading:


Further details:

Applicants from the UK or the EU are eligible. Applicants should hold a BSc and/or MSc degree in relevant subjects.

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