Microbial lipid cycling in the oceans: an integrated ‘omics’ approach

Host University
University of Warwick

Theme
Organisms & Ecosystems

Supervisory team
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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. Global warming and the rise of sea surface temperature are predicted to enhance nutrient limitation on our oceans. Understanding how marine bacteria meet their nutrient demand and how organic macromolecules are recycled in the oceans holds the key to predicting the future Oceans’ functioning under natural and anthropogenic changes.

Lipids, containing carbon, nitrogen, phosphorus and sulfur, are a major component of all living cells and are constantly released into the oceans due to programmed cell death, viral infections and zooplankton grazing. Current estimates suggest that lipids can account for ~10% of total dissolved organic matter (DOC) in the oceans. However, our knowledge on microbial lipid transformation in the oceans is very limited. Neither the identities of the microbes involved, nor the mechanisms by which lipids are degraded, have been well understood.

A major hurdle in understanding the microbial lipid cycle lies in the difficulty in characterizing and quantifying numerous lipid classes in marine samples. Commonly observed lipids in marine ecosystems include phospholipids, glycolipids and amino acid-containing lipids. 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 (Shevchenko, 2010), which now enables lipid characterization both qualitatively and quantitatively. Indeed, lipidomics is starting to complement the rapid progress made in genomics, metagenomics, transcriptomics and proteomics.

Figure 1: amaZon liquid chromatography ion trap mass spectrometry at Warwick dedicated for lipidomics analyses (see Sebastian et al 2016).
The aim of this project is therefore twofold, Firstly, we aim to establish a high throughput workflow for simultaneous determination of common lipids species in marine surface waters using our in house HPLC MS platform (see above figure 1). Secondly, we aim to determine the identity and activity of key microbial populations in the recycling of representative lipids in marine surface waters and costal marine sediment using integrated omics approach, e.g. high throughput sequencing of 16S rRNA, metagenomics, metagenomics and lipidomics.

Methodology
Microbial lipids identification will be carried out by liquid chromatography-mass spectrometry (LC-ESI-MS). Nutrients and key intermediates in lipid degradation pathways will be analysed by established chromatography techniques, such as ion-exchange chromatography and gas chromatography. Microbial community analyses will be carried out using amplicon sequencing of 16S rRNA genes, metatranscriptomics and metagenomics.

Training and skills
CENTA students are required to complete 50 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 CENTA research themes.

The Supervisory team has an excellent record in PhD supervision. The last two PhD students completed from the Chen group has published 4 and 3 first-authored papers respectively, including 2 in PNAS, 1 in the ISME Journal, 3 in Environmental Microbiology and 1 in the FEBS Journal.

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

Partners and collaboration (including CASE)
The supervisors are world-leading experts in marine microbiology and publish regularly in 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 NERC, the Leverhulme trust and The European Union. 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
Prof Scanlan’s group http://www2.warwick.ac.uk/fac/sci/lifesci/people/dscanlan

Possible timeline
Year 1: Mass spectrometry-based identification of bacterial lipids in marine systems (lipidomics).
Year 2: Microbial lipid cycling in anaerobic sediment, microcosm setup and measurement of lipid degradation, amplicon sequencing, metagenomics and metatranscriptomics sequencing and bioinformatics.

Year 3: microbial lipid cycling in marine waters, microcosm setup, amplicon sequencing, metagenomics sequencing and bioinformatics.

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. Informal enquires can be made to Dr Yin Chen (y.chen.25@warwick.ac.uk).
Details of how to apply can be found at https://warwick.ac.uk/fac/sci/lifesci/study/pgr/studentships/nerc-centa/