**Project Title**

Nitrogen metabolism in phytoplankton under natural conditions and the presence of inorganic fertiliser and organic waste

**Lead Supervisor Name**

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**Lead Supervisor Location/Student Home Institution**

Institution: Bristol

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**Full Project Description**

Nitrogen is an essential nutrient controlling phytoplankton productivity in freshwater ecosystems. In aquatic environments, some bacteria can transform atmospheric nitrogen gas (N2) into bioavailable forms (ammonium, nitrates). The dissolved N pool is dominated by dissolved organic N compounds (80-90%), with around 10-20% in the form of inorganic N compounds, both organic and inorganic N compounds can be easily assimilated into living systems. Worldwide, the increasing export of N to waters from the use of artificial fertilisers (Haber-Bosch), livestock production and the discharge of N rich effluent from wastewater treatment works together with atmospheric N deposition, have contributed to nutrient pollution of freshwater ecosystems with adverse consequences for ecosystem health. These have likely affected the species assemblages, distribution and productivity of the phytoplankton community, though our understanding of these impacts is incomplete, particularly in freshwater ecosystems. Picophytoplankton play a key role in global primary productivity, particularly in natural freshwaters. Ecological studies have previously suggested that both marine and freshwater picocyanobacteria represent the main component of picophytoplankton in low nutrient habitats exceeding the eukaryotic component. Despite their central role in the food chain dynamics (e.g. as a food source for flagellates and larger grazers), freshwater picocyanobacteria remain poorly studied, especially at the genomic level and in comparison, to their closest relatives in marine habitats. Furthermore, traditional cell count methodologies and molecular ecology studies have identified picocyanobacteria seasonal changes in terms of abundance in freshwater lakes, yet few studies have studied seasonal changes in phytoplankton communities, and/or in relation to the changing chemistry of the dissolved N pool as this varies along gradients of nutrient enrichment. A handful of freshwater picocyanobacteria genomes studies have identified genes involved in nitrate incorporation as well as chitin degradation (a polymer produced by fungi and arthropods). The latter suggests that complex organic molecules might be bioavailable, supporting evidence emerging from recent laboratory bioassay research led by the supervisors. However, the metabolic pathway, genetic information and biochemical mechanisms used by the freshwater picophytoplankton in assimilating environmental sources of nitrogen are not well understood. Using an interdisciplinary approach this project aims to study how picocyanobacteria communities respond to different gradients and chemical forms of nitrogen availability both in the field and under controlled lab experiments. The student will design and carry out novel experiments to isolate, culture, and sequence picocyanobacteria from the English Lake District, where long-term contextual data are available and the nearby Cotswold Water Park at South Cerney. The questions this studentship will address are as follows: 1. How do picocyanobacteria communities change across different trophic/nutrient gradients, and in relation to other microorganisms? 2. What is the nitrogen assimilation machinery present in picocyanobacteria? How are these genes expressed under different experimental conditions? 3. How does the presence of artificial fertilisers and organic waste affect N assimilation by picocyanobacteria under controlled lab conditions?

**Real Life challenges this project will address**

Organic waste and artificial nitrogen fertilisers have likely affected the distribution and assemblage of primary producers. Currently, it is unknown the metabolic pathways, and biochemical mechanisms used by the freshwater picophytoplankton in assimilating environmental sources of nitrogen including organic waste and/or from artificial nitrogen fertilisers. This project is novel because it will use a genomic approach to study metabolic pathways in range phytoplankton communities, as well as fieldwork and lab based bioassays to study how these sources of nitrogen might affect phytoplankton communities in freshwater ecosystems. This cutting-edge project will involve fieldwork, genomics, lab based experiments.

**What you should know about this project**

The proposed project is fully interdisciplinary, drawing on and integrating knowledge and skills training from ecology, microbiology and genomics, and biogeochemistry. The project is reliant on statistical approaches to experimental design, bioinformatics and genomics. The student will be supported by an interdisciplinary team with expertise in culturing, genomics, microbiology phylogenetics (Dr. Patricia Sanchez-Baracaldo, Bristol), field sampling, freshwater ecology, and ecophysiology (Prof Stephen Maberly, CEH Lancaster), and aquatic biogeochemistry, nitrogen cycling and organic nitrogen chemistry (Prof Penny Johnes, Bristol).

**What expertise you will develop**

The student will develop expertise in bioinformatics, culturing, genomics, freshwater ecology, nutrient analyses, and aquatic biogeochemistry.

**Why this project is novel**

Increasing export of N to waters from the use of artificial fertilisers (Haber-Bosch), livestock production and the discharge of N rich effluent from wastewater treatment works together with atmospheric N deposition, have contributed to nutrient pollution of freshwater ecosystems with adverse consequences for ecosystem health. These have likely affected the species assemblages, distribution and productivity of the phytoplankton community. This project seeks to address this issue by understanding how excess N affects natural populations of phytoplankton and how these deal with N assimilation in freshwater ecosystems.

**Rest of Supervisory Team:**

**Co-Supervisor 1**

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