Project title: Evolution of Marine Symbionts and the Earth System

Lead Institution: University of Bristol
Lead Supervisor: Prof Patricia Sanchez-Baracaldo, School of Geographical Sciences
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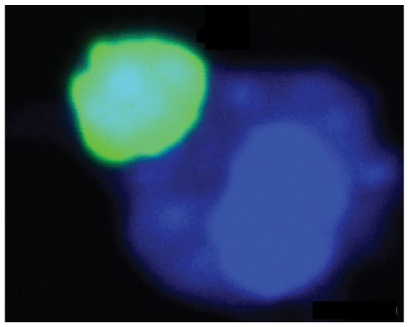
Project keywords: Genome evolution, genomics, Cyanobacteria, marine symbionts

Scholarship: A fully funded PhD studentship including UK fees, annual stipend, and a research budget, is available at the University of Bristol. Study will begin in September 2025 and is funded for four years. The deadline for applications is 31st January 2025.

Project



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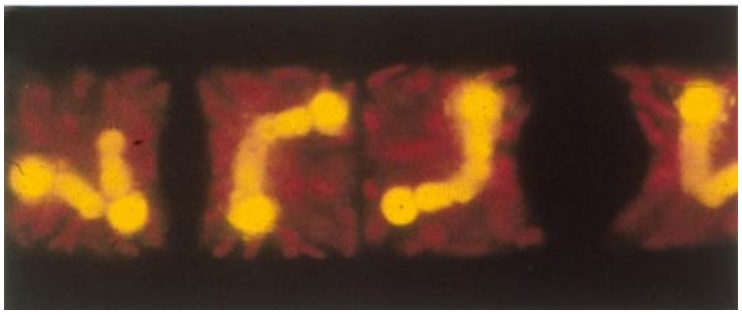

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Cyanobacteria have had a huge impact on the biological diversity of the Earth's ecosystems, in part due to their ability to establish symbiotic relationships with several different hosts (1, 2). Cyanobacterial symbioses are widely distributed in marine, freshwater, and terrestrial environments and these involve taxonomically diverse hosts. This project will focus mostly on marine cyanobacterial symbionts that significantly contribute to nutrient cycling at a global scale (3). Most of the cyanobacterial symbionts fix N_2 (nitrogen gas), a feature that that enable hosts to grow in areas deficient in bioavailable nitrogen. While genome reduction is a trait shared amongst symbionts, the processes that lead to the establishment and integration of symbionts into their hosts are still unclear, as are the genomic consequences. Comparisons at the genomic level will tease apart what changes were needed to enslave symbionts under different ecological contexts in marine environments (e.g., open-ocean vs costal settings).

Project Aims and Methods

This project aims to study the underlying genomic mechanisms driving cyanobacterial symbiosis. Here, we will study well known and newly discovered cyanobacterial symbionts. Comparisons at the genomic level will tease apart what changes were needed to enslave symbionts under different ecological contexts in marine environments (e.g., open-ocean vs costal settings). This project will implement phylogenomics to reconstruct the evolutionary history and occurrences of symbiosis within cyanobacteria. A Bayesian approach will be implemented to determine age estimates for cyanobacteria symbiotic events. Comparative genomics will enable the identification of genes and gene families that have been lost during the process of symbiosis when involving examples of both nitrogen fixation and photosynthesis. The Ph.D. student funded will have the unique opportunity to work in the lab and develop new phylogenetic/comparative genomic methodologies. This is a great

opportunity for students interested in photosynthesis, nitrogen fixation, evolutionary biology, genome evolution, phylogenetic methods, and bioinformatics.

The lead supervisor encourages and support students to change and adapt the original project idea to suit their research interests. This includes supporting students to seek out training opportunities, additional funding, and collaborations. Visit https://sanchezbaracaldo.wordpress.com/ to get researchers based at the Sanchez-Baracaldo lab.

Candidate requirements
At least a 2.1 (Hons) degree or equivalent in a relevant quantitative subject, e.g. microbiology, bioinformatics, marine biology, genetics, genomics, and computer science. For International students, English Language IELTS scores of at least 6.5 (please check entry requirements for Bristol). A Masters degree in a relevant subject would be desirable but not essential. Computer programming skills in a relevant language, e.g. C/C++, Python, R or Matlab would be an advantage. We welcome and encourage student applications from under-represented groups. We value a diverse research environment.

Project partners

This is an exciting opportunity involving a collaboration with the National Oceanography Centre in Southampton.

Training
By the end of the PhD program, the student will have learnt comparative genomics, molecular evolution and phylogenetics. The student will be trained in computer programming (e.g. Shall Scripting, R Scripting, or Python), bioinformatics and phylogenetics. In addition to this core set of skills they will have the opportunity to work in the lab doing basic molecular biology techniques. All the skills they will learn are highly transferrable and will be useful to them irrespective of what career path they will choose within the realm of evolutionary biology and microbial genomics more broadly (e.g. bioinformatics and genomics).

Background reading and references
1. Raven JA & Allen JF (2003) Genomics and chloroplast evolution: what did cyanobacteria do for plants? Genome Biol 4(3):209.

2. Cornejo-Castillo FM, et al. (2016) Cyanobacterial symbionts diverged in the late Cretaceous towards lineage-specific nitrogen fixation factories in single celled phytoplankton. Nat Commun 7:11071.

3. Pierella Karlusich, J.J., Pelletier, E., Lombard, F. et al. (2021) Global distribution patterns of marine nitrogen-fixers by imaging and molecular methods. Nat Commun 12, 4160.

Please contact p.sanchez-baracaldo@bristol.ac.uk for informal enquiries.

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