PROJECT TITLE: Snowball Earth and the origin of life in extreme cold environments

DTP Research Theme(s): Living World, Changing Planet

Lead Institution: University of Bristol

Lead Supervisor: Dr Patricia Sanchez-Baracaldo (School of Geographical Sciences)

Co-Supervisor: Dr Chris Williamson, Bristol Glaciology Centre, School of Geographical Sciences, University of Bristol

Co-Supervisor: Adam Monier, Living Systems Institute, University of Exeter

Project Enquiries: p.sanchez-baracaldo@bristol.ac.uk

Project keywords: Evolution, genomics, phylogenetics, Cyanobacteria,

Greenland

Svalbard

Project Background

How long have cold-adapted life forms existed on our planet, and how did they survive ancient warm periods? Our planet has experienced periods of extreme glaciations through Earth history. The Earth also appears to have been more prone to cooling during the Precambrian, when our planet experienced some of the more extreme glaciations, also known as the Snowball Earths. Ecological studies have shown that modern Polar Regions are thriving with microbial life. Recent largescale phylogenomic studies of modern cyanobacteria have revealed that different groups of cyanobacteria from Polar Regions, which are major primary producers in glacial ecosystems, adapted to cold extreme environments several times during Earth history. It is unknown, however, whether ancestors of these cold-adapted cyanobacteria originated as far back as the time of the Snowball Earths. This study will explore how old these microorganisms are by implementing sophisticated molecular clock techniques. Cyanobacteria play a fundamental role in supporting life in Polar Regions contributing to the accumulation of organic carbon in these severe environments. Using cutting-edge computational tools, this project offers an exciting opportunity to work on how life originated in Polar Regions as well as help explain how complex life (e.g., eukaryotes) survived through the Snowball Earth.

Project Aims and Methods

This project aims to study when polar cyanobacteria first evolved (e.g., Snowball Earth) and how they have survived through Earth history. The student will employ phylogenetic and molecular clock analyses to determine time of origin of cyanobacteria from Polar Regions. In addition, a coupled climate – ice sheet modelling approach will also be used to assess whether ice could have existed permanently on the planet over geological timescales. We will make use of existing climate model simulations of the last 200 million years, and use them to drive an ice sheet model, and assess the extent of polar ice through varying continental configuration and greenhouse gas concentrations. This exciting project is novel and interdisciplinary and a great opportunity for students interested in the origin of life, evolution and climate.

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 (no less than 6.0 in any element). 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 project bridges across BRIDGE (Sanchez-Baracaldo lab), and the Bristol Glaciology Centre (MicroLab) at Bristol, as well as, the Life Sciences Institute (Monier's lab) at Exeter. The successful candidate will benefit from full exposure to scientists working on cold extreme environments, new lab facilities at Bristol (Life Sciences Building) and the new Life Sciences Institute at Exeter. The student will also have access to the high computing facilities at Bristol. This is a great opportunity for students interested in extremophiles, evolutionary biology, astrobiology, phylogenetic methods, and bioinformatics

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 (Shall Scripting, R Scripting, and either PERL or Python), bioinformatics and phylogenetics. In addition to this core set of skills they will be trained in biogeochemistry. 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. Sánchez-Baracaldo, P, Bianchini G, Wilson, J and Knoll A. Cyanobacteria and biogeochemical cycles through Earth history. Trends Microbiology. (2021)
2. Hoffman, P. F. et al. Snowball Earth climate dynamics and Cryogenian geology-geobiology. Science Advances 3, e1600983, doi:10.1126/sciadv.1600983 (2017)
3. Hoffman, P. F. Cryoconite pans on Snowball Earth: supraglacial oases for Cryogenian eukaryotes? Geobiology, doi:10.1111/gbi.12191 (2016).

Useful links

http://www.bristol.ac.uk/geography/courses/postgraduate/
https://sanchezbaracaldo.wordpress.com/

NERC GW4+ DTP Website:
For more information about the NERC GW4+ Doctoral Training Partnership please visit
https://www.nercgw4plus.ac.uk.

Bristol NERC GW4+ DTP Prospectus:
http://www.bristol.ac.uk/study/postgraduate/2022/doctoral/phd-great-western-four-dtp/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

The application deadline is Monday 10 January at 2359 GMT.
Interviews will take place during the period 23 February – 9 March 2022.

General Enquiries:
Bristol NERC GW4+ DTP Administrator
Email: bristol-nercgw4plusdtp-admin@bristol.ac.uk