EEES Project Proposal Form – 2021 entry

Project Title	**OU15 - The influence of sulfur cycling on community diversity in saline environments**
Key words	Microbiology, Extremophiles, Sulfur
Supervisory team (including email address	**PI:** Karen Olsson-Francis (OU) karen.olsson-francis@open.ac.uk **Co-I:** Daniel Read (UKCEH) dasr@ceh.ac.uk Vic Pearson (OU) victoria.pearson@open.ac.uk Michael Macey (OU) michael.macey@open.ac.uk
Is the PhD suitable for part time study?	Yes ☐ No ☒

Project Highlights:

- Identifying key metabolic process that sustain life in extreme conditions.
- Isolating and characterising novel extremophiles.
- Training in state-of-the-art techniques across the fields of microbiology, molecular biology and bioinformatics.

Overview (including 1 high quality image or figure):

Extremophilic microbes thrive in conditions at the limits of life. They are thought to have been the first life on Earth and may have played a key role in its subsequent diversification. Studying extremophilic microorganisms is important in order to: 1) characterise the physical and chemical boundaries of life on Earth; 2) identify the keystone processes that underpin life in these extreme environments; 3) identify metabolites and proteins produced by these extremophiles that have industrial applications; 4) better develop the concept of habitability and an understanding of the potential for life in extra-terrestrial environments.

Extremophiles are also believed to be critical to the evolution of the Earth's biogeochemical cycles, including the sulfur cycle, with sulfur metabolisms having evolved early after the origination of life. Sulfur metabolising species continue to play a key role in extreme environments today, for example in saline environments where they are often the most abundant electron donors and acceptors. In turn, microbes with sulfur metabolisms often dominate and drive primary production. This project will focus on developing our understanding of the processes underpinning the survival of these extremophilic microbes as well as characterising interactions that fuel the persistence of microbes in extreme environments at the community level.

This studentship will focus on samples collected from a series of hypersaline lakes in Spain that undergo annual drying-rewetting cycles and are exposed to high levels of ultraviolet radiation. It will involve: 1) understanding the metabolic strategies that enable survival in this environment, using a metagenomic approach; 2) assessing the interactions between distinct functional clades of microbes *via* metatranscriptomics; 3) further definition of these interactions and dependencies through a series of growth experiments using type strain representatives of these functional clades. The project will use a combination of state-of-the-art molecular techniques and culture-based microbiology.

Figure 1: An example of an extreme, salt-rich environment – The basin of Lake Tirez in Spain

Methodology:

A combination of cultivation dependant and independent techniques will be applied to understand the functional diversity and survival strategies that underpin viability under hypersaline conditions. This will involve extracting DNA and RNA from environmental samples and identifying: 1) the taxonomic and metabolic diversity within the environment, and 2) the interactions between members of the community. This will be supported by cultivation experiments and microcosm manipulations to further define the interactions and inter-dependencies between the distinct taxonomic and functional groups identified within these environments. The student will have access to a range of additional techniques at the partner organisations that can be used to identify microbial interactions, including single-cell Raman spectroscopy, flow cytometry and flow sorting.

Training and skills:

The student will be trained in specific, laboratory-based techniques in molecular biology (DNA extraction, PCR, gel electrophoresis, library preparation and DNA sequencing), geochemistry and culture-based microbiology by members of the research team. Short placements with the project partners will enable access to laboratory facilities and training in specific laboratory techniques. The student will also be trained in computer-based techniques, including bioinformatic analysis of sequencing data and geochemical modelling.

The student will benefit from additional skills development opportunities offered by the AstrobiologyOU research group and wider faculty/university, e.g., communication skills, time management, academic writing and more.

Partners and collaboration:

Daniel Read (UKCEH) has expertise in environmental microbiology, including DNA sequencing, flow cytometry and Raman spectroscopy.

Eric Bapteste (Université Pierre et Marie Curie) has expertise in evolutionary bioinformatics. They will provide training in data mining and network analysis of metagenomic datasets.

Jennifer Pratscher (Lyell Centre) has expertise in environmental microbiology and analysis of metagenomics data. They will provide training for the characterisation of Lake Tirez and subsequent data analysis.

Centro de Astrobiologia (Spain) are a collaborating institute who will assist with fieldwork and analysis.

Possible timeline:

Year 1: Perform a literature review and undertake field work in Spain. Complete initial training in molecular techniques and bioinformatics. Set up cultures for isolation and perform initial growth experiments.

Year 2: Submit manuscript regarding microbial diversity of the Spanish field site. Perform metagenomic analysis of this field site and growth experiments with isolates and type strains to assess mechanisms underpinning survival and cooperation. Present results at a national conference (e.g. Microbiology Society annual conference).

Year 3: Prepare and submit manuscript regarding the metagenomic work and related growth experiments identifying mechanisms underpinning survival within this site. Present data at an international conference (e.g. Gordon Applied and Environmental Microbiology). Write and submit thesis.

Further reading:

Macey, M. C., Fox-Powell, M., Ramkissoon, N. K., Stephens, B. P., Barton, T., Schwenzer, S. P., *et al.* The identification of sulfide oxidation as a potential metabolism driving primary production on late Noachian Mars. Scientific Reports, **2020**, 10, 10941. doi:10.1038/s41598-020-67815-8.

Martin-Cuadrado, A. B., Senel, E., Martínez-García, M., Cifuentes, A., Santos, F., Almansa, C., *et al.*. Prokaryotic and viral community of the sulfate-rich crust from Peñahueca ephemeral lake, an astrobiology analogue. Environmental Microbiology, **2019**, 21, 3577–3600. doi:10.1111/1462-2920.14680.

Merino N; Aronson HS; Bojanova DP; Feyhl-Buska J; Wong ML; Zhang S; Giovannelli D. Living at the Extremes: Extremophiles and the Limits of Life in a Planetary Context. Frontiers in Microbiology, **2019**, 10: 780.

Morrison, P. R., and Mojzsis, S. J. Tracing the Early Emergence of Microbial Sulfur Metabolisms. Geomicrobiology Journal, **2020,** 10, 1–21. doi:10.1080/01490451.2020.1812773.

Further details:

Students should have a strong background in Microbiology or molecular biology, and enthusiasm for working in a laboratory and data analysis.

If you're not sure whether your academic background is suitable, please contact one of the supervision team or Olivia Acquah at STEM-EEES-PhD@open.ac.uk. We'd be happy to hear from you.

The successful student will join well-established teams researching microbiology and extremophiles at the Open University and CEH.

Applications should include:

- A covering letter that includes:
    - Your motivation to study for a PhD in general
    - Your interest in this project in particular
    - The project-specific skills, aptitude and experience you bring to the project
- an academic CV containing contact details of three references, one of whom should be able to comment on your academic abilities.
- and an Open University application form.
    - If you are British, please use the Home form
    - If you are not British, please use the International form

Applications should be sent to **STEM-EEES-PHD@open.ac.uk** **by 12 noon on Monday 1st March 2021.**