**Project title:** Understanding life in extreme saline environments  
**Project code:** OU26  
**Host institution:** The Open University  
**Key words:** Evolution of Organisms and Ecosystems  
**Supervisory team:** Dr Karen Olsson-Francis (karen.olsson-francis@open.ac.uk) and Dr Vic Pearson

**Project Highlights:**
- Pioneering work to understand the limits of life in saline environments  
- Field work at Lake Tirez (Spain)  
- Training in interdisciplinary techniques including microbiology, molecular biology and geochemistry

**Overview:**
Extremophilic microorganisms can thrive in conditions that were previously deemed inhospitable for life. Of particular interest are halophiles (salt-loving), microorganisms that thrive in hypersaline environments, because they may have been one of the first groups of organisms to exist on early Earth. Therefore, studying these microorganisms is vital for the following reasons: 1) to understand how life may have evolved on Earth in hypersaline environments; 2) to determine the boundaries of habitability in such environments.

Microorganisms that live within hypersaline environments have physiologically adapted to survive the environmental stresses associated with salinity, such as high osmotic pressure and low water activities. There are predominately two strategies that allow halophiles to live at high salt concentrations: 1) the “high-salt-in” strategy, which is active in high concentrations of potassium chloride and other salts; 2) the “organic-solutes-in” strategy, which is based on the biosynthesis and/or accumulation of organic solutes. Both of these strategies work by balancing the internal osmotic pressure of the cells with the external osmotic pressure. In addition, the cell membranes of halophiles have adapted to ensure that they have low sodium permeability, are stable at high salt concentrations, and rely on sodium/proton antiporters to maintain their internal osmotic environment.

Current understanding of the physiology and diversity of halophiles is predominately based on studies of microorganisms in chloride-rich environments. Work has shown that chloride is crucial for growth in some halophiles. However, not all brines are dominated by chloride. Some natural hypersaline brines are sulfate-based, for example the magnesium-rich Lake Tiraz (Figure 1). Previous studies have demonstrated that the diversity of the microbial community differs between the wet and dry season in Lake Tiraz; seasonal fluctuations also result in changes in sulfate concentration in the lake.

The premise of this studentship is based on the following hypotheses. 1) Sulfate concentration influences microbial diversity within natural sulfate lakes. 2) Isolation of microorganisms from Lake Tiraz will result in the culturing of novel halophiles. 3) The composition of the salt will affect the molecular response to salinity in halophiles.

The overall aim of this project is to investigate the hypotheses and determine the effect that sulfate has on the diversity and physiology of halophilic
microorganisms. This will be addressed using a combination of microbiology, geochemical and molecular biology techniques.

Methodology:
Field work will be conducted at Lake Tirez. Samples of brines and sediment will be collected at different depths within the lake, which will have varying salinity, for geochemical and microbial analyses. These analyses include: 1) molecular analysis of microorganisms present in the samples; 2) isolation and characterisation of halophilic microorganisms within those communities; 3) geochemical analyses will be carried out to determine the composition of the brines (using ICP-AES) and salts (using SEM-EDX and Microprobe). Statistical analysis will be carried out to determine the effect of chemical composition on microbial diversity. The microorganisms isolated from Lake Tirez will be screened for their ability to grow in high sulfate and chloride environments. The molecular response to growth in high concentrations of sulfate and chloride will be investigated by studying gene expression in continuous culture.

Training and skills:
The student will gain training in field research and in the design of field campaigns, as well as molecular biology, microbiological, statistics and geochemical techniques that are necessary. The Open University has comprehensive laboratory facilities for all of the required analyses.

Partners and collaborations:
Terry McGenity (University of Essex) has extensive knowledge of halophiles and will advise of the field work. André Antunes (Edge Hill University) expert in isolation of microorganisms. The student will visit Edge Hill and utilise the laser microscope (optical tweezer) to assist with isolation.

Possible timeline:
Year 1: Perform a literature review and carry out field work. Initial training in microbiology, molecular biology, statistics and geochemical techniques. Characterise the microbial diversity of the samples and start culturing. Present results at UK conference.

Year 2: Prepare and submit manuscript(s) on the effect of sulfate concentration on microbial diversity. Finish isolation and community characterisation. Set up continuous culture experiment and optimise sampling method. Present results at UK conference.

Year 3: Analyse the molecular data, conduct associated analyses to characterise laboratory conditions, and prepare/submit associated manuscript. Write and submit thesis. Present data at an international conference.

Further reading:
Montoya et al., (2013). Microbial community composition of Tirez lagoon (Spain), a highly sulphated athalassohaline environment. Aquat Biosyst 9, 19.


Further details:
Students should have a strong background in environmental microbiology and/or molecular biology. The student will join a young, vibrant microbiology group that specialises in study microbes from extreme environments at the Open University.

Please contact Karen Olsson-Francis (k.olsson-francis@open.ac.uk) for further information.

Applications should include:
- a cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- an Open University application form, downloadable from: http://www.open.ac.uk/students/research/sites/www.open.ac.uk.students.research/files/documents/Application%20form.docx

Applications should be sent to STEM-EEES-PhD-Student-Recruitment@open.ac.uk by 5 pm on Monday 22nd January 2018

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