

The SIMBIOS Centre offers an Interdisciplinary Research Environment to Students who wish to obtain a Masters by Research. Projects are available to theoretical and empirical researchers in the field of soil science, biology, ecology, physics, mathematics and statistics.

For **self-funded students** we offer projects in the areas listed below. Please contact individual researchers for other possibilities and to discuss appropriate skills and details of the project. Details of application procedure will be made available shortly.

Theoretical:

- Hydrological models on networks for soil structures

Required skills: physics or related disciplines-

This project will test if three-dimensional networks can be used to predict hydrological properties of soils or porous rocks. Networks will be derived from X-ray CT data and hydrological models will be tested to predict characteristics as retention and permeability. Methods for fitting models and testing models predictions will be developed

contact: Dr Perez-Reche, SIMBIOS Centre, p.perez-reche@abertay.ac.uk

- Ecological network models for soil biodiversity.

required skills: physics or ecologist with mathematical skills

The project will develop models for species interaction on 3-D network representations of soils and test the role of soil structure and species trades in species-coexistence and resilience to environmental change to underpin a theoretical basis for biodiversity in soil ecosystems.

contact: Dr Perez-Reche, SIMBIOS Centre, p.perez-reche@abertay.ac.uk

- Meta-networks as a tool for controlling spread of epidemics.

required skills: physics or ecologist with mathematical skills

Networks have been successfully applied in the study of epidemics. Real life systems are however often more complicated and may reflect constantly changing inter-connected network, not unlike the internet. This project will examine the development of theories for spread of epidemics on meta-networks to develop novel control strategies.

contact: Dr Perez-Reche, SIMBIOS Centre, p.perez-reche@abertay.ac.uk

- Parallelisation of a fungal growth model

Required skills: mathematician/computer scientist/physicist

One of the main challenges in modelling processes in complex 3D systems are dealing with system sizes that are representative for real life problems whilst still being mathematically tractable. This project will aim to parallelise existing models for fungal growth and explore the role of sample size on system behaviour.

contact: Dr Ruth Falconer, SIMBIOS Centre, r.falconer@abertay.ac.uk

- Sample size estimation and statistical modelling of multilevel data structure with application to biomedical data.

Contact: Dr Simona Hapca, SIMBIOS Centre, s.hapca@abertay.ac.uk

- Gene order and clustering in bacterial genomes.

Required skills: Bioinformatics & associated scripting (theoretical).

The project will investigate gene order and clustering in bacterial genomes, including chromosomes and large plasmids. The efficient expression of complex phenotypes is believed to be in part due to the co-ordinated expression of genes clustered within operons. However, visual inspection of whole bacterial genomes suggests that a large proportion of genes may be distributed as 'single' genes or in small clusters, rather than large, well-ordered operons. This project aims to test this assumption, and will require a mixture of scripting and statistical analyses, as well as an interest in bacterial genomics.

Contact: Dr Andrew Spiers, SIMBIOS Centre, a.spiers@abertay.ac.uk

Theoretical or experimental

- Effect of Carbon distribution in soil on fungal dynamics.

Required skills: soil scientist/microbiologist (experimental) or physicist/ecological modeller (theoretical)

This project will aim to investigate the role of heterogeneity in soil Carbon on microbial dynamics. In particular it will investigate this within a heterogeneous soil structure. The project will suit an experimental scientist who will aim to develop new experimental systems to investigate the role of C distribution within structured soil on microbial invasion, or it will suit a theoretical scientist who will develop models that explore microbial dynamics within 3-D heterogeneous soil environments.

contact: Prof. Wilfred Otten or Dr Ruth Falconer, SIMBIOS Centre, w.otten@abertay.ac.uk, or r.falconer@abertay.ac.uk

- X-ray CT imaging of 3D soils: development of methods to evaluate image quality.

Contact: Dr Simona Hapca, SIMBIOS Centre, s.hapca@abertay.ac.uk

Experimental

- Experimental systems for species interactions in 3D structured environments

Required skills: biologists, ecologists or soil scientist

The aim of this project is to develop novel experimental systems to test the impact of interconnectivity within a 3D structured environment on species interaction. The environments can be constructed from soil systems, for which the structure is examined by X-ray CT, or by exploring the use of novel 3D printing technologies to design microcosms with specific structural properties.

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- Using X-ray CT to examine the dynamics of soil structure during organic matter decomposition

Required skills: soil science or environmental science

This project will design experimental systems to study the degradation of organic matter in soils and will use novel X-ray CT to visualize and quantify the structural changes. It will test how soil physical conditions will affect organic matter degradation and how organic matter degradation results locally in changes to soil physical conditions

contact: Prof. Wilfred Otten, SIMBIOS Centre, w.otten@abertay.ac.uk,

- Bio-imaging with X-ray CT

Required skills: biology, ecology, or imaging background

This project will explore the use of X-ray CT to visualize micro-organisms in 3D structures. The structures can be soil or any other porous material (e.g. wood) and the project will investigate the material properties and the size and properties of the microorganisms that will allow for non-destructive visualization in 3D environments.

contact: Prof. Wilfred Otten, SIMBIOS Centre, w.otten@abertay.ac.uk,

- Experimental quantification of hydrological properties of structured soils

Required skills: hydrology or soil science

The project will aim to quantify the impact of soil micro-structure on hydrological properties. Micro-structural heterogeneity will be quantified with X-ray CT and technologies can be developed to visualize the spatial distribution of water within heterogeneous 3D structures. The data will be compared with conventional bulk-measures such a water retention and permeability and will enable for comparison with model predictions.

contact: Prof. Wilfred Otten or Dr Ruth Falconer, SIMBIOS Centre, w.otten@abertay.ac.uk, or r.falconer@abertay.ac.uk

- Convergent evolution of Wrinkly Spreaders.

Required skills: Microbiology (practical).

The project will characterise and compare adaptive, biofilm-forming genotypes of *Pseudomonas fluorescens* SBW25. The adaptive radiation of SBW25 has been used extensively to examine bacterial evolutionary ecology, and a key genotype has been the Wrinkly Spreader (WS), able to form biofilms

at the air-liquid interface of static microcosms. This project will compare WS genotypes isolated from different environments in order to investigate convergent evolution, and will require a mixture of microbiology, evolution and statistical analyses.

Contact: Dr Andrew Spiers, SIMBIOS Centre, a.spiers@abertay.ac.uk

- Biofilm-formation amongst sewage-associated enteric bacteria.

Required skills: Microbiology (practical).

The project will investigate biofilm-formation and cellulose expression amongst sewage-isolated enteric bacteria. We have undertaken several surveys of *Pseudomonas* spp. investigating bacterial biofilm formation at the air-liquid (A-L) interface and the involvement of extra-cellular cellulose as a matrix component in these structures. Enteric bacteria, including medical and environmental *Escherichia* and *Salmonella* spp. isolates, are also known to produce cellulose-based biofilms. Enteric bacteria are also prevalent in sewage, but isolates from this environment has not yet been surveyed. This project will recover Enteric isolates from sewage, characterise these by growth and plate-based phenotype assays, and then investigate biofilm-formation and cellulose-expression in static liquid microcosms.

Contact: Dr Andrew Spiers, SIMBIOS Centre, a.spiers@abertay.ac.uk

- Environmental factors impacting on the evolution of biofilm-formation.

Required skills: Microbiology (practical).

This project will examine how the shape of the meniscus (the meniscus trap) aids biofilm-formation and evolution of *Pseudomonas fluorescens* SBW25 populations in static microcosms. The trap may enable rapid growth of the initial wild-type population, thus increasing the chances that biofilm-forming mutants may arise, or it may act by recruiting mutants to the air-liquid interface where they can begin to develop biofilms. This project will require a mixture of microbiology, evolution and statistical analyses.

Contact: Dr Andrew Spiers, SIMBIOS Centre, a.spiers@abertay.ac.uk

- Adaptation of a rhizosphere bacterium to mushrooms.

Required skills: Microbiology (practical).

This project will examine the adaptation of *Pseudomonas fluorescens* SBW25 populations to white mushroom caps. SBW25 is a model rhizosphere bacterium, and has recently been shown by us to colonise mushroom caps and produce limited blotch-like symptoms. This project will use an experimental evolution approach to produce and characterise adaptive SBW25 genotypes on mushrooms, and will require a mixture of microbiology, evolution and statistical analyses.

Contact: Dr Andrew Spiers, SIMBIOS Centre, a.spiers@abertay.ac.uk

Photodegradation in peat decomposition

Required skills: Biology, soil or earth science as well as basic lab experience.

Scotland has large stores of carbon in peat. Surprisingly little is known about the controls of peat decomposition in natural and semi-natural ecosystems, as decomposition appear to be patchy and the difference between active and inactive patches has been difficult to understand. It is possible that pre-exposure to sunlight primes the peat for subsequent microbial activity. This hypothesis will be tested in this project using lab incubations on peat samples collected in Scotland.

Contact: Dr. Foereid, SIMBIOS Centre, b.foereid@abertay.ac.uk

Biochar effects in different soil types

Required skills: Biology, soil or earth science as well as basic lab experience.

Use of charred material as a soil amendment, biochar, has been suggested to increase crop growth and reduce nitrogen losses. The mechanism for the effect of biochar is imperfectly known, and therefore our ability to predict its effect on individual sites is low. It has not been investigated how biochar effects depend on soil type, but reports of dramatic yield increases after biochar additions are often from experiments on light soils. In this project we propose to quantify how biochar effects interact with soil type. Soils with different textures will be collected and pot experiments will be set up to compare plant growth and nitrogen turnover in biochar amended and control pots.

Contact: Dr. Foereid, SIMBIOS Centre, b.foereid@abertay.ac.uk