List of Projects available in SCELSE

Plant microbiome and metabolome for improving plant immunity and resilience
(Supervisory team: Assoc Prof Sanjay Swarup)
Offered in SCELSE-NUS
Plants and microbes have co-evolved for more than 2,000 million years during which they have developed highly interdependent functions to help in the functioning of each other. This project will extend the current work of plant-associated microbes using two highly related plant models of Arabidopsis and Asian Brassica leafy vegetables. Lab-based experimental models have been developed to achieve enhanced plant growth by highly complex root-associated microbiomes. This project will explore the role of such microbiomes in environmental stresses such as drought or salinity. Additionally, role of plant volatiles would also be investigated. As plants release a bouquet of volatiles, many of them, being bioactive, are likely to have an impact on the composition of the microbiome. The project requires a background in basic biology, love for plants and keenness to work on microbiomes in both laboratory and greenhouse.

For more information, please contact:
Assoc Prof Sanjay Swarup
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Transferability of antimicrobial resistant plasmids in wastewater treatment plant
(Supervisory team: Asst Prof Bae Sung Woo)
Offered in SCELSE-NUS

Horizontal gene transfer (HGT) has a major role in microbial evolution, in sharping the structure and function of microbial communities in environments. For example, uptakes of antimicrobial resistance gene in wastewater treatment plant are growing concerns due to the increase of antimicrobial resistance bacteria in aquatic environment receiving wastewater. Mobile genetic elements (MGEs), such as plasmid, transposon, and virus, play an important role in gene exchange between bacterial cells, thereby promoting evolution and adaptation of bacteria. Of MGEs, conjugative plasmids are mediator of gene transfer over large taxonomic distances. Since the existence of plasmids was discovered in the early 1950s, the most of studies on plasmid were performed with culturable hosts grown under laboratory condition. There is possibility that unknown plasmids which cannot be maintained by culturable strains but by uncultured ones play an important role in horizontal gene transfer (HGT) under real environmental conditions. For instance, chlorination could trigger to enter an uncultivable stage of bacteria but transfer of the plasmid containing antimicrobial resistance genes might occur in wastewater treatment. Most of bacteria cannot be cultured in the laboratory condition. Moreover, it is necessary to discrimination between viable and non-viable bacterial cells, because HGT can occur through only viable cells including viable non-culturable state in bacteria. The viable cell density measurement is a key determinant of the behavior of bacterial populations. Therefore, the main aim of this project is to evaluate the effect of transfer frequency of plasmids of antimicrobial resistance genes in wastewater sample by using propidium monoazide (PMA) - quantitative polymerase chain reactions (qPCR). In addition, fluorescently tagged plasmid is used for distinguish its development and behavior differences in environmental samples. The ideal candidate will have a B.Sc in Environmental Engineering or Microbiology and interest in multidisciplinary research across engineering, chemistry and microbiology.

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Development of a mobile microfluidic platform for ballast water quality monitoring
(Supervisory team: Asst Prof Bae Sung Woo)
Offered in SCELSE-NUS

The current methods for detecting microbiological contaminants in a ship ballast treatment system are inconvenient, requiring intensive labor, and expensive. Often, environmental regulation agencies could not receive accurate, reliable and timely information of microbial water quality data from field.
Traditionally, the quality of biological water in marine and ballast water have been examined by enumerating fecal indicator bacteria (FIB) such as E. coli, Enterococcus or waterborne pathogens. The testing process for bacterial water quality is long, as it usually takes more than 24 hours to enrich bacteria in a laboratory. This delay could have dire consequences, as environmental regulation agencies will have to wait to be notified of the biological water quality, even though the pollutants still pose potential threats to the humans and the marine ecosystem. The goal of the proposed research is to develop a novel microfluidic platform integrated with a smartphone that enables real-time in situ monitoring of microbial contaminations in ballast and marine water. The ideal candidate will have a B.Sc in Environmental Engineering or Microbiology and interest in multidisciplinary research across engineering, chemistry and microbiology.

For more information, please contact:
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Understanding bacterial lipid trafficking and outer membrane biogenesis
(Supervisory team: Assoc Prof Chng Shu Sin)
Offered in SCELSE-NUS

In our laboratory, we use bacterial outer membranes as interesting models for studying the biochemistry of lipid transport and membrane assembly (Figure 1). We focus on both Gram-negative bacteria and mycobacteria, which have separately evolved to assemble a second (outer) membrane in their cellular envelopes. These bacteria have to transport proteins and lipids, and build their outer membranes at a distance away from the cytoplasmic membrane, all in an environment devoid of any apparent energy source. The outer membrane demarcates a second aqueous compartment in these bacteria cells. In addition, it serves as a formidable permeability barrier against toxic substances, in part rendering Gram-negative bacteria and mycobacteria intrinsically resistant to many clinically-relevant antibiotics. Using a combination of chemical, biological, genetics, and structural approaches, we tackle problems in bacterial lipid trafficking and outer membrane assembly. In particular, we deploy major efforts in characterizing transport of phospholipids in Gram-negative bacteria, and mycolic acids in mycobacteria. In each theme, we work towards identifying and characterizing molecular machines in order to gain mechanistic understanding of their functions in lipid transport. Through our studies, we shed light on the fundamental principles of how bacterial cells assemble the outer membrane, maintain homeostasis, and control the function of this very important lipid bilayer. We are always open to new PhD students; interested candidates should have a B.Sc. in Chemistry, Biochemistry, Microbiology or Biology.

For more information, please contact:
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Overcoming recalcitrant biofilm infections through nano-delivery systems
(Supervisory team: Assoc Prof Joachim Loo)
Offered in SCELSE-NTU

Bacteria enmeshed in an extracellular matrix, biofilms, exhibit enhanced antibiotic tolerance. Coupled with the rapid emergence of multidrug-resistant strains, the current cohorts of antibiotics are becoming ineffective. Alternative antimicrobial approaches are therefore urgently needed to overcome recalcitrant biofilm infections. In this project, we aim to develop a highly robust and customizable nanoscale carrier that integrates the liposomal and the polymeric systems for the delivery of different classes of antimicrobials to both biofilms and intracellular pathogens. The latest molecular biology and systems biology tools as well as nanoparticle synthesis approaches will be used in this project. Suitable candidates would have interest in multidisciplinary research across Microbiology, Physical Chemistry and Nanoscience.

For more information, please contact:
Assoc Prof Joachim Loo
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Marine microbial communities
(Supervisory team: Assoc Prof Scott Rice)
Offered in SCELSE-NTU

In the natural environment, microbial biofilms are formed by complex consortia of bacteria. The process of biofilm formation is driven by the substratum, local conditions (e.g. nutrients, temperature, UV etc). The consequences of biofilm formation are varied, where in some cases, microbial biofilms may play an important role in the subsequent recruitment of fouling organisms and thus, such communities are important in the biofouling process. Similarly, biofilm consortia may drive the degradation of the substratum through the process of microbially induced corrosion, which is responsible for significant costs to maritime industries. This project will, through a combination of field and laboratory based studies, quantify and characterise microbial biofilm communities in the marine environment. The goal will be to characterise successional processes in the community and to relate community composition to biofouling and corrosion processes to identify keystone species responsible for these processes. The project will be led by Assoc Prof Scott Rice and the candidate will join a multidisciplinary team of microbiologists, microbial ecologists, engineers and data scientists. Students ideally have a strong background in Microbiology, Molecular Biology or Biotechnology. They should be self-motivating, diligent and willing to learn new approaches as these projects are often cross-disciplinary.

For more information, please contact:
Assoc Prof Scott Rice
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Experimental mixed species biofilms
(Supervisory team: Assoc Prof Scott Rice, Prof Staffan Kjelleberg)
Offered in SCELSE-NTU

We are developing laboratory models of mixed species microbial biofilms to explore the benefits and challenges microorganisms experience within complex communities. For example, we have shown that growth within such biofilms results in community level stress tolerance, not observed in the single species context and that the organization of such communities is in part dependent on production of specific polysaccharides that make up the biofilm matrix. This model is readily amenable for testing a range of concepts including the impacts of immigration on microbial communities, the role of genetic diversity in mixed species communities and the resilience of communities under stress. The project will explore the genetic basis for mixed community development, the global impact on metabolism, the role of metabolites and cues on biofilm development as well as the physiological benefits of self-organization as a mixed species community. The project will be led by Assoc Prof Scott Rice and Prof Staffan Kjelleberg and will involve a team of Post-doctoral researchers as well as PhD students. Students ideally have a strong background in Microbiology, Molecular Biology or Biotechnology. They should be self-motivating, diligent and willing to learn new approaches as these projects are often cross-disciplinary.

For more information, please contact:
Assoc Prof Scott Rice
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Predation by protozoa and its impact on evolution of virulence in opportunistic pathogens
(Supervisory team: Assoc Prof Diane McDougald)
Offered in SCELSE-NTU

We are seeking a PhD student to explore the hypothesis that protozoan predation and the associated expression of defensive traits by bacteria, is responsible for the evolution and maintenance of virulence factors in opportunistic pathogens. Understanding the selection pressures exerted on disease-causing organisms will improve our understanding and approach to disease prevention, control and surveillance.
The successful applicant will determine the impact of protozoa on virulence traits of bacteria. In addition predation is predicted to increase with increasing global temperatures, resulting in stronger selective pressure for the evolution of defensive traits. We will develop an understanding of the impact increased grazing pressure has on bacteria so we are better able to predict new, emerging pathogens or increased disease potential of known pathogens as climate changes. Suitable candidates would have a B.Sc. in Microbiology and have an interest in microbial ecology or eukaryotic/prokaryotic interactions.

For more information, please contact:
Assoc Prof Diane McDougald
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Engineering beneficial biofilms for chemical, energy and environmental applications
(Supervisor: Assoc Prof Cao Bin)
Offered in SCELSE NTU

The objective of this project is to apply insights obtained from the state-of-the-art biofilm biology into developing high performance biofilm-mediated bioprocesses for various applications such as production of high value chemicals, generation of energy, and (waste)water treatment. Various molecular and synthetic biology approaches, omics, and engineering principles will be used in this project. Suitable candidates would have a B.Sc. or B.Eng. in Microbiology/Microbial Biotechnology or Environmental/(Bio)Chemical Engineering and interest in multidisciplinary research across Microbiology and Engineering.

For more information, please contact:
Assoc Prof Cao Bin
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Biofilm-metal(loid)s interactions
(Supervisor: Assoc Prof Cao Bin)
Offered in SCELSE-NTU

The project focuses on understanding soil/sediment biofilm-mediated redox transformation of metal(loid)s and its influence on the fate and transport of metal(loid)s in natural and engineered ecosystems. Specifically, we are interested in metal(loid)s that are of great importance to South East Asia, for example, arsenic and chromium. Suitable candidates would have a B.Sc. or B.Eng. in Microbiology/Microbial Biotechnology or Environmental/(Bio)Chemical Engineering and interest in multidisciplinary research across Microbiology and Engineering.

For more information, please contact:
Assoc Prof Cao Bin
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Bioprospecting of magnetic bacteria for environmental and biotechnological applications
(Supervisor: Assoc Prof Cao Bin)
Offered in SCELSE-NTU

This project focuses on exploring biodiversity and bioprospecting of magnetotactic bacteria in the tropical marine environment around Singapore. Multidisciplinary tools including experimental biofilm systems, optical and molecular imaging, microbiology, analytical chemistry, and biochemical engineering will be used in this project. Suitable candidates would have a B.Sc. or B.Eng. in Microbiology/Microbial Biotechnology or Environmental/(Bio)Chemical Engineering and interest in multidisciplinary research across Microbiology and Engineering.

For more information, please contact:
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Understanding the mechanism for *E. faecalis* niche-specific virulence during urinary tract infection
(Supervisory team: Assoc Prof Kimberly Kline)
Offered in SCELSE-NTU

Enterococcus faecalis is a member of the healthy microbiota of the human gastrointestinal tract. *E. faecalis* is also an opportunistic pathogen and causes biofilm-associated infection in a variety of niches including wounds and the urinary tract. We are interested in the spectrum and specialization of virulence strategies *E. faecalis* uses to cause infection and to evade the host immune response, and how these strategies differ between different infection niches. We recently determined that *E. faecalis* displays preferential tropism for the prostate, displaying niche specificity within the urinary tract. In this project, we will elucidate the niche-specific virulence mechanisms underlying *E. faecalis*-mediated tropism for biofilm-associated prostate infection during urinary tract infection. Suitable candidates would have a B.Sc. in Microbiology or Biology.

For more information, please contact:
Assoc Prof Kimberly Kline
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Defining *E. faecalis* mechanisms for persistence during biofilm-associated wound infection
(Supervisory team: Assoc Prof Kimberly Kline)
Offered in SCELSE-NTU

Enterococcus faecalis is a member of the healthy microbiota of the human gastrointestinal tract. *E. faecalis* is also an opportunistic pathogen and causes biofilm-associated infection in a variety of niches including wounds and the urinary tract. We have recently shown that *E. faecalis* can persist within mammalian cells and modulate the host response to infection. In this project, we will define the mechanisms by which *E. faecalis* is taken up, persists, and modulates mammalian cells encountered during wound infection. Suitable candidates would have a B.Sc. in Microbiology or Biology.

For more information, please contact:
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Fortification of microbial membranes
(Supervisor: Prof Staffan Kjelleberg)
Offered in SCELSE-NTU

Microbes draw on several natural strategies to fortify their membranes against environmental chemical assaults. For example, they can change the fatty acid profile of membrane phospholipids or they can express hopanoids. A vacancy for a bright, enthusiastic, and independently driven PhD student is available on an exciting project to develop chemical interventions to fortify membranes beyond the natural range of microbes. The intended utility of such an effort is to improve the performance of industrial bioprocesses. The successful candidate will work in a team of multidisciplinary scientists representing skills in computational modelling, biochemical engineering, microbiology, synthetic chemistry, analytical chemistry, and environmental engineering. Flexible and intellectually curious candidates who are strong in any of the disciplines listed above and with a proven interest in any of the others should apply immediately.

For more information, please contact:
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High Pressure Microbial Electron Transfer
(Supervisor: Prof Stefan Wuertz)
Offered in SCELSE-NTU

Microbes deploy remarkable strategies to gain an energetic advantage in the environment. Over the last few decades, electrogenic bacteria, those which are able to 'breathe' solid minerals, have received much attention particularly in the context of electricity generation in microbial fuel cells. This focus on energy production has ignored many of the natural environmental conditions where electricigens thrive; namely deep sea benthic environments. In this project you will study the energetics of microbial electron transfer in model organisms like Shewanella spp. and Geobater spp. at high hydrostatic pressure to describe these processes in representative environmental conditions. The successful candidate will work in a multidisciplinary setting on a project that will combine microbiology, bioelectrochemistry and environmental engineering. Flexible and intellectually curious candidates who are strong in any of the disciplines listed above should apply immediately.

For more information, please contact:
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Urban air microbiomes
(Supervisory team: Prof Stephan Schuster)
Offered in SCELSE-NTU

The microorganisms around us in air (including fungi, bacteria, archaea and viruses) remain poorly understood compared to environments such as soil or water, especially in the tropics. To address these gaps, SCELSE's five year MOE Tier 3 urban air microbiomes project aims to: 1) Investigate the identity and function of airborne microorganisms in indoor and outdoor environments in Singapore; and 2) study their sources and sinks, revealing where the airborne microbes come from. The urban air microbiomes project will include establishing protocols for sample collection and processing, capable of collecting enough biological material from the air for sequencing and DNA analysis. High-volume filter-based samplers are used to collect microorganisms for DNA extraction, while high-volume liquid cyclonic samplers are used in parallel for imaging with bright field, fluorescence and scanning electron microscopy. In addition, airborne microorganisms are isolated from air using agar plates and their whole genomes will then be sequenced to build a database, which would be the first comprehensive collection of airborne microorganisms in tropical environment.

Our outdoor air sampling project is now in the final year, we have accomplished sampling on campus every week over a year, 5 consecutive days 24-hour sampling, and monthly sampling at Primary Forest in Nature Reserve. Our findings are that microorganisms have their own daily (diel) cycles and their responses vary according to different conditions, such as temperature, relative humidity, UV, and rainfall. We sample outdoor air at sites distributed temporally and spatially across Singapore and globally to identify microbes locally and globally distributed. Additionally, we also sample indoor air to understand correlation with airborne and human respiratory microbiome.

Suitable candidates would have a B.Sc or M.Sc in Microbiology, Mycology, Molecular Biology, or Biochemistry and interest in multidisciplinary research across medical and atmospheric chemistry, involving plenty of computational analysis (bioinformatics).

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