List of Projects available in SCELSE

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:
Dr Jamie Hinks (jhinks@ntu.edu.sg) or Dr Thomas Seviour (twseviour@ntu.edu.sg)

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 has been in progress for more than one year, for example sampling on campus every week over a year, 5 consecutive days 24-hour sampling, and monthly sampling at Primary Forest in Nature Reserve. Our preliminary findings are that microorganisms have their own daily (diel) cycles and their responses vary according to different ambient air conditions, such as temperature, relative humidity, and rainfall. We plan to sample outdoor and indoor air at sites distributed temporally and spatially across Singapore, incorporating different types of building ventilation and land use types.

For more information, please contact:
Prof Stephan Schuster
SCSSchuster@ntu.edu.sg

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.

For more information, please contact:
Assoc Prof/Cao Bin
BinCao@ntu.edu.sg

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.

For more information, please contact:
Assoc Prof/Cao Bin
BinCao@ntu.edu.sg

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.

For more information, please contact:
Assoc Prof Cao Bin
BinCao@ntu.edu.sg

Antibiotic Tolerance Development In Biofilms
(Supervisory team: Asst Prof Yang Liang)
Offered in SCELSE-NTU

Biofilm associated infections are increasing and pose a heavy burden for the public health systems. Biofilms are extremely tolerant to antimicrobial treatments and the underlying mechanisms are very complicated. This project will employ the latest molecular biology and systems biology tools to elucidate antibiotic tolerance development of biofilms formed by *Pseudomonas aeruginosa*.

For further information, please contact:
Asst/Prof Yang Liang
YangLiang@ntu.edu.sg

Hydrogen Production through Microbial-driven Hybrid Systems
(Supervisory team: Assoc Prof Joachim Loo)
Offered in SCELSE-NTU

Achieving a hydrogen economy can alleviate the universal fossil fuel crunch and rampant pollution driven by the insatiable demand for energy. Solar-illuminated photoelectrochemical (PEC) water splitting is an attractive strategy to generate hydrogen, which has witnessed significant breakthroughs recently. However, the need for external bias and low efficiency stymies the widespread application of this technology. By coupling water splitting (in a PEC cell) to a microbial fuel cell (MFC) as the biocatalyst, a sustainable hybrid PEC-MFC platform functioning solely by biocatalysis and solar energy can be achieved. This project aims to develop new technologies through the use of bacteria as a biocatalyst to drive hydrogen production in this hybrid system.

For more information, please contact:
Assoc/Prof Joachim Loo
JoachimLoo@ntu.edu.sg

Microbial Ecology of the coral holobiont
(Supervisory team: Assoc Prof Diane McDougald)
Offered in SCELSE-NTU

This project explores the effect of macroalgae on the microbiome of the coral holobiont. It is hypothesized that one effect of macroalgae on coral are due to shifts in the coral microbiome. The PhD candidate will examine microbial communities on coral and macroalgae in situ as well as in controlled laboratory experiments. Metabarcode profiling of the coral holobiont will be performed and microbial community shifts determined. Furthermore, we will compare gene expression profiles of the coral holobiont in response to treatments.

For more information, please contact:
Assoc/Prof Diane McDougald
MDIANE@ntu.edu.sg

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.

For more information, please contact:
Assoc/Prof Diane McDougald
MDIANE@ntu.edu.sg

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.

For more information, please contact:
Assoc/Prof Scott Rice
RSCOTT@ntu.edu.sg

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.

For more information, please contact:
Assoc/Prof Scott Rice
RSCOTT@ntu.edu.sg

Electrochemical characterization of mixed culture biofilms and their metabolites
(Supervisory team: Prof Enrico Marsili)
Offered in SCELSE-NTU

Bioelectrochemistry of biofilms has recently expanded beyond environmental microbiology applications, as recent studies showed that several bacterial species produce redox-active metabolites. In this project, the student will design novel electroanalytical methods for high-throughput and rapid characterization of biofilms and their redox active metabolites. This project has implications for novel biosensor development and pathogen tracking in healthcare setting. The ideal candidate will have a B.Sc. in Microbiology with interest in Analytical and/or Physical Chemistry.

For further information, please contact:
Asst/Prof Enrico Marsili
Emarsili@ntu.edu.sg

Effect of biofilms microstructure on microbially influenced corrosion (MIC) of mild steel
(Supervisory team: Asst Prof Enrico Marsili)
Offered in SCELSE-NTU

Corrosion leads to metal deterioration in any environment, with substantial environmental, economic damages and even health damages (e.g., infrastructure, drinking water pipes, prosthetic implants). Microorganisms play a key role in metal corrosion, particularly in nutrient-rich environments. Despite >100 years of fundamental and applied research on MIC, many aspects of this process are still obscure. In this project, the PhD candidate will assess the role of mixed microbial consortia in the onsets of corrosion, combining advanced microscopy and high-throughput electrochemistry. Following characterization, the researcher will devise novel strategies to minimize MIC by changing biofilm attachment and microstructure, in collaboration with researcher from A/P Scott A. Rice. Suitable candidates would have a B.Sc. in Microbiology or Physical Chemistry and interest in multidisciplinary research.

For further information, please contact:
Asst/Prof Enrico Marsili
Emarsili@ntu.edu.sg

Can we electro-trick biofilms? A new method to lower initial biofilm early attachment
(Supervisory team: Asst Prof Enrico Marsili)
Offered in SCELSE-NTU

Biofilm early attachment is arguably the most important step in biofilm formation. Once attachment has taken place, further biofilm development is inevitable. Therefore, reducing or delay initial attachment is crucial to control biofilm in industrial and health settings. We have previously observed as the application of electrochemical potential determine biofilm formation in a wide range of microorganisms, affecting their quorum sensing mechanisms and resulting in different concentration of secondary metabolites. In this project, the PhD candidate will apply a variety of electrochemical stimuli, such as low potentials and currents, to delay biofilm attachment on conductive surfaces. The interactions between electrochemical stimuli and antibiotic/antimicrobial applications will be also investigated, with the final goal of reducing antibiotic use in biofilm removal. Suitable candidates would have a B.Sc. in Microbiology or Engineering.

For further information, please contact:
Asst/Prof Enrico Marsili
Emarsili@ntu.edu.sg

Tracking initial biofilm attachment through electrochemical methods
(Supervisory team: Asst Prof Enrico Marsili)
Offered in SCELSE-NTU

The electrochemical signature of mature biofilms is well known. However, much less is known on the initial attachment and the electrochemical dynamic of biofilms in the first hours after inoculation, when attachment/detachment phenomena and determine the later morphology of the biofilm. In this project, the student will use voltamperometric and impedance methods to track cell attachments in commercially available bioelectrochemical flow cells. This project has implications for anti-biofilm coatings and biofilm control in healthcare settings. Suitable candidates would have a B.Sc. in Microbiology or Engineering and interest in multidisciplinary research across Microbiology, Physical Chemistry and Biophysics.

For further information, please contact:
Asst/Prof Enrico Marsili
Emarsili@ntu.edu.sg

Control of pathogens and biofilm formation in cooling towers
(Supervisory team: Prof Enrico Marsili)
Offered in SCELSE-NTU

Cooling towers provide an excellent environment for biofilm formation, because of high temperature and humidity and the presence of low-grade metal surfaces, prone to microbial attachment. Remote microbiological surveillance of these infrastructure is needed to minimize health risk and to reduce the high costs associated with manual inspection and cleaning. In this project, the candidate will apply biosensing principles recently developed in our group to design a low-cost bioelectrochemical sensor for biofilm identification and monitoring of specific pathogens. Suitable candidates would have a B.Sc. in Microbiology or Engineering and interest in industrial research.

For further information, please contact:
Asst/Prof Enrico Marsili
Emarsili@ntu.edu.sg

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.

For more information, please contact:
Assoc/Prof Kimberly Kline
KKline@ntu.edu.sg

Communication between Microbes, Muscle and Immunity - a link to understand healthy aging.
(Supervisory team: Prof Sven Pettersson)
Offered in SCELSE-NTU

While a causal relationship between gut microorganisms and regulation of host metabolism in liver is well documented, it is poorly understood how microbes influence metabolically demanding organs like the skeletal muscle. Moreover, while microbes shape the immune system early in life, our understanding of how the immune system is responding to changes of the microbiome composition in the aging body is very limited.

Preliminary findings:

I) Microbes can influence skeletal muscle growth & function. And since muscle growth is intimately connected to induction of angiogenesis, we hypothesize gut microbes can induce muscle and vascular growth of its host. The precise molecular mechanisms underlying microbe stimulation of muscle biology and angiogenesis are poorly understood.

II) Transplanting microbes from old mice into young recipients, results in massive metabolic disturbances and signs of cannibalism of the transplanted mice. Since the immune system is a very energy demanding organ we hypothesize that the dysfunctional immunity observed in elderly, in part maybe related to metabolic disturbances within the microbiome.

We are therefore looking for two (2) PhD students interested in these two projects. The project is joint initiative between Sven Pettersson LKC/SCELSE, NTU and Xiaomeng Wang LKC School of Medicine, NTU (project I) and Sven Pettersson and Nick Gascoigne, NUS (project II). The projects are focused on mechanisms using ex vivo cell culture systems, use of animal models for in vivo studies and omic analysis –microbiome– and metabolite profiling.

For further information, please contact:
Prof Sven Pettersson
Sven.Pettersson@ki.se
Mobile SMS: +65 9154-0498

Plant microbiomes for improving food production 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 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 role of such microbiomes in environmental stresses such as drought or salinity. Project requires 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
sanjay@nus.edu.sg

Understanding of antimicrobial mechanisms of carbon nanomaterials in biofilm
(Supervisory team: Asst/Prof Bae Sung Woo)
Offered in SCELSE-NUS

The main aim of this project is to gain fundamental knowledge of antimicrobial mechanisms of carbon nanomaterials (e.g., carbon nanotubes, graphene, and graphene oxides) on a biological system. Although antimicrobial mechanisms of carbon nanomaterials have been questioned, hypothesis for antimicrobial mechanisms of carbon nanomaterials in planktonic cell, biofilm and even biological systems have not fully examined yet. Therefore, understanding of the antimicrobial mechanisms of carbon nanomaterial will provide valuable information regarding toxicity effects (e.g., ecological toxicity in aquatic environments release) and potential applications (e.g., modification membrane surface by carbon nanomaterial to minimize biofilm growth on membrane surface) using the knowledge obtained from this study. The antimicrobial mechanism will be examined by physiological and genetic approach using cell viability / functional tests and molecular techniques. Furthermore, metagenome and transcriptome analyses will be applied to describe bacterial metabolism and microbial community structures upon exposure of carbon nanomaterials in a water system. 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:
Asst/Prof Bae Sung Woo
ceebsw@nus.edu.sg

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:
Asst/Prof Bae Sung Woo
ceebsw@nus.edu.sg

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.

For more information, please contact:
Asst/Prof Bae Sung Woo
ceebsw@nus.edu.sg
