MICROBIAL GENOMICS

My research interests have focused on understanding microbial physiology and evolution, by utilizing the “big picture” or global approaches such as genome sequencing, transcriptomics, proteomics and phenomics, in combination with established molecular biology and biochemistry techniques.

The research interests of my group are focused on applying high throughput genomic approaches to understand bacteria. Projects include:

FACTORS INFLUENCING THE SUCCESS OF THE PATHOGEN ACINETOBACTER BAUMANNII

The hospital intensive care unit should be a place of healing and care for the most vulnerable. Nonetheless, several microbial pathogens continue to plague this environment, causing serious infections in the immunocompromised patients that pose even more challenging problems for clinicians. *A. baumannii* has recently emerged as one of the most problematic hospital-acquired pathogens worldwide due to its highly drug resistant nature. This project aims to define the key mechanisms of drug resistance operating in clinical *A. baumannii* isolates using a combination of cutting-edge next-generation transcriptomics and proteomics, and essential resistance genes identified by saturation mutagenesis methods. We also research in identifying and characterising the function of microbial multidrug efflux pumps which play an important role in bacterial adaptation and antibiotic resistance. We use genomics to identify novel multidrug efflux pumps that could then be cloned and characterised.

UNRAVELLING GENOMIC ADAPTATIONS UNDERPINNING NICHE SELECTION IN MARINE CYANOBACTERIA

Unicellular marine cyanobacteria are globally significant microorganisms. As the foundation of marine foodwebs, the activity of these tiny photosynthetic machines impacts upon all marine life. Our objective is to decipher the mechanisms which underpin niche selection in cyanobacteria adapted to different ecological conditions. Improved understanding of molecular adaptations will contribute to cellular metabolic models, ecosystem models and global predictions of the overall health of the planet. We offer a selection of integrative and multidisciplinary projects to equip students with diverse research skills, including fieldwork, high-throughput physiological experiments, molecular genetics (based on a CRISPR toolbox) and big data analyses (based on machine learning). Specific research questions include: investigating cellular and molecular responses to marine heatwaves, characterisation of the global diversity of membrane transporters, exploring the microbial diversity of oceanic transition zones and understanding cyanophage-host dynamics using synthetic biology approaches.

INVESTIGATING THE IMPACT OF DIET AND DIETARY PATTERNS ON THE GUT MICROBIOTA

The human gut microbiota has been associated with various inflammatory and metabolic diseases such as type 1 and 2 diabetes, inflammatory bowel disease, cardiovascular and liver diseases. There is a growing scientific and public interest in investigating the methods for therapeutically modulating this complex ecosystem in order to maintain the host metabolic and inflammatory health. Diet and dietary patterns are key factors that contribute in shaping the composition and functions of the gut microbiota. Using next generation sequencing techniques, we examine the effect of dietary fibre and intermittent fasting on the gut microbiota and host physiology. In this project, we aim to correlate specific gut bacterial groups that respond to different dietary fibre and fasting patterns with the host physiological parameters.
SYNTHETIC BIOLOGY (WITH SAKKIE PRETORIUS)
We are the sole Australian node of the Yeast 2.0 project which is an international synthetic biology consortium aimed at building the world’s first synthetic eukaryote. We are part of the Yeast 2.0 program (http://syntheticyeast.org/), where six out of sixteen chromosomes have been published in Science, and we are energetically working on the construction of chromosomes 14 and 16. This revolutionary project incorporates new-to-nature mechanisms for controlling the evolution of genomes, which we can study to understand the principles of whole genome design. As well as the construction of synthetic genomes, the synthetic biology team is focused on developing novel metabolite biosensors for high throughput screening of synthetic metabolic pathways for the sustainable production of chemicals, pharmaceuticals, fuels, and food.
From a base at Macquarie University, we seek to build expertise in this discipline in Australia and establish foundational technologies for basic research and an evolving bio-manufacturing sector.

USING PSEUDOMONAS BACTERIA TO PROTECT PLANTS FROM DISEASE (WITH SASHA TETU)
Australia is home to a number of serious plant diseases, which, if left unchecked, could devastate our multibillion dollar agricultural industry. In modern agriculture, diseases are typically controlled mainly through the use of agrochemicals which are expensive and environmentally damaging. We are currently investigating a group of natural plant-associated bacteria that are able to act as biocontrol organisms suppressing infections from a range of important fungal, bacterial, viral and insect pests. This project will apply a combination of next- generation transcriptomic and proteomic technologies, as well as innovative genome-wide transposon mutagenesis methods to identify the key genes and gene clusters involved in biocontrol mediated by Pseudomonas bacteria.

COAL PROKARYOTIC PIONEERS (COLLABORATION WITH CSIRO)
Using natural gas, rather than coal for electricity generation provides a means of reducing CO₂ emissions and combating climate change. In coal seams where moisture and sufficient nutrition is available, natural gas is produced from microbial activity. To date, we have identified the types of microbes that inhabit coal, but have not identified those microbial pioneers whose metabolic degradation of the coal not only underpins the microbial community but also facilitates the production of natural gas. Using culturing, sequencing and bioinformatics techniques and an established coal-degrading microbial consortia, this project aims to identify these early pioneers and how they degrade coal.

Selected Publications

https://twitter.com/paulsenlab?lang=en

Department of Molecular Sciences