Project 1: Could the eye be a window to the brain in Multiple Sclerosis?

PI: Denise Fitzgerald

Wet lab project

Summary of the project:

Multiple Sclerosis (MS) is an inflammatory, neurodegenerative disease that is caused by damage to myelin in the central nervous system (CNS). Myelin is the insulation surrounding large nerve axons in the CNS, which speeds up neuronal signals and provides metabolic support to these axons. Damage to myelin disrupts neuronal signalling and can lead to permanent, irreversible death of neurons, causing disability for patients.

Previous QUB researchers and their collaborators discovered that in MS, inflammation and neurodegeneration also occur in the retina at the back of the eye. As it is much easier to study the eye than the brain in living patients, the retina may be an accessible site to study inflammation in MS. If so, this will open possibilities of identifying mechanisms of tissue damage, disease worsening and response to treatments supporting treatment decisions and clinical trials.

This project is part of a study to determine if the type of inflammation in the retina is similar to inflammation in the brain in MS. This will be achieved by staining tissue sections from people that had MS for a range of immune cell and neural markers and visualise staining by microscopy. Analysis will be performed to determine best methods of staining and to compare differences in different tissue sections by image analysis and statistical testing. The student will learn techniques such as tissue sectioning, histology/immunohistochemistry, microscopy, image analysis and statistical analysis.

Project 2: Mechanisms and Models of GREMLIN1 signalling in colorectal cancer

PI: Derek Brazil

Wet lab project

Summary of the project:

Gremlin1 (Grem1) is a secreted protein that binds to and antagonizes the action of bone morphogenetic proteins (BMPs). Grem1 binding to BMPs is essential for the normal development of limbs, kidneys and other tissues. Apart from its developmental role, Grem1 is an important protein in a range of human diseases including diabetic kidney disease, lung fibrosis and cancer. High levels of Grem1 expression has been shown to act as a biomarker for a range of cancers (including colon, brain and liver). Indeed, high levels of Grem1 expression match with poor patient survival in triple negative breast cancer and other forms of cancer, suggesting that increased Grem1 expression contributes to more aggressive tumour development. The focus of this project is the to define the cellular function of Grem1 in colon cancer and intestinal cells.

Project Aim: to identify the protein expression of GREM1 in human cancer cells and GREM1 signalling in cancer cells. Techniques such as cell culture, transient transfection, Western blotting, qPCR and fluoresence microscopy will be employed. The student will be supervised by Dr. Brazil and members of his team. They will receive training on the key techniques involved in the project. The student will have the opportunity to present at the weekly group meeting, and data generated by the student will be included in abstracts and papers from the group.

Project 3: Can we resuscitate the "temporary Lincoff-Kreissig balloon" using new technologies/materials to repair retinal detachments in an outpatient setting?

PI: Noemi Lois

Dry lab project

Summary of the project:

The retina is the layer at the back of the eye that gives sight. Normally it is attached to the wall of the eye but it can separate in a condition called retinal detachment (RD). RD causes sight loss and needs surgery.

A RD happens because the vitreous, which fills the inside of the eye and is attached to the retina, detaches (separates) from the retina. As it separates, it may pull on the retina tearing it. Fluid from the vitreous passes then through the retinal tear and collects behind the retina, pushing it away from the eye wall. As the retina separates, sight gets worse because the retina is nourished by blood vessels in the eye wall and when it separates this cannot happen.

Surgery for RD requires closing the break(s) present and creating a scar around it(them) so that fluid cannot pass through the break any longer. If the break is closed, the fluid under the retina will progressively be resorbed and the retina will re-attach.

Closing the retinal break to repair a RD can be done by pushing the wall of the eye against the tear from the outside of the eye using what is called a "buckle". In this project, the student will review the literature on buckle surgery concentrating on newly proposed surgical techniques (i.e. suprachoroidal buckles), contrasting their potential benefits/risks with those of standard buckles. A detail review on the "Lincoff's-Kressig Balloon" will be conducted; ways to improve it with current new technologies/materials will be investigated.

Project 4: Endothelial hypoxia in pulmonary fibrosis - the role of SASP

PI: Bettina Schock

Wet lab project

Summary of the project:

Systemic sclerosis (SSc) is a rare autoimmune disease characterised by vascular dysfunction and fibrosis. One of its severe and life limiting complications is the development of interstitial lung disease (ILD), which occurs in up to 50% of SSc patients.

This project will explore the role hypoxia on endothelial cells and their secretions in SSc. Additionally, we will investigate the effects of these secretions on SSc and SSc-ILD fibroblasts, obtained from patients.

As the successful candidate, you will join the vibrant pulmonary fibrosis laboratory of Dr Schock where you will learn about cell culture of endothelial cells and fibroblasts, hypoxia exposure, protein analyses (soluble proteins by ELISA, cellular proteins by Western blotting), gene expression (mRNA by qRT-PCR) and functional assays (wound closure). We also run a weekly journal club / Lab meeting where you can present your lab work and identify the role of the endothelium in driving fibrosis.

The work will identify endothelial cell-derived molecular mechanisms leading to activation of fibroblasts. The most pro-fibrotic factors secreted by hypoxia-injured endothelial cells, will be further investigated as therapeutical targets to limit progression of lung fibrosis in SSc.

Project 5: Calcification in the vascular system, a window to Alzheimer's disease, diabetes and macular degeneration

PI: Imre Lengyel

Wet lab project

Summary of the project:

Vascular calcification (VC) occurs when calcium deposits in blood vessels, making them stiffer. This can occur in conditions like Alzheimer's disease, diabetes, and macular degeneration, and it affects major arteries such as those in the heart, brain, and limbs. VC is linked to ageing because older cells often stop dividing and enter a "senescent" state, which alters their function. We still don't fully understand how this process impacts the retina.

In this project, we will study how calcification develops in cells and test whether treatments targeting ageing cells can reduce these changes. We will grow cells in different environments and monitor calcification using fluorescence microscopy, and identify molecular changes using PCR and immunohistochemistry. We will verify the observed changes on tissue sections.

Project 6: Developing Vaccines to Prevent AMR Infections

PI: Beckie Ingram

Wet lab project

Summary of the project:

Antimicrobial-resistant Pseudomonas aeruginosa is a major cause of chronic and life-threatening infections, particularly in patients with underlying lung disease. We are developing a novel vaccine targeting P. aeruginosa, and this summer project will contribute directly to validating these vaccine candidates in clinically relevant bacterial isolates.

The student will culture a panel of P. aeruginosa clinical isolates, gaining hands-on experience in aseptic technique and bacterial handling. Using PCR-based approaches, the student will screen these isolates to confirm the presence of genes encoding our lead vaccine antigens, allowing assessment of how widely conserved the targets are across real-world strains.

If time permits, the project will extend to RNA isolation and quantitative real-time PCR from bacteria grown under infection-relevant conditions. This will allow the student to determine whether vaccine antigens are actively expressed during conditions that mimic infection, an important consideration for vaccine efficacy.

Through this project, the student will develop core microbiology and molecular biology skills, including bacterial culture, DNA/RNA extraction, PCR, qPCR, data analysis, and experimental record-keeping. The work will contribute directly to an active translational vaccine programme addressing antimicrobial resistance, providing the student with insight into how laboratory research supports the development of new therapies for unmet clinical need.

Project 7: Bacterial amphipathic helix crosses two membranes: a novel secretory system blending science with biotechnology

PI: Miguel A. Valvano

Wet lab project

Summary of the project:

Imagine a primordial molecular soup where certain proteins can interact with and cross hydrophobic lipid membranes without any help from other proteins. Our recent discovery sheds new light on this concept that has long fascinated scientists. Studying the Burkholderia lethal factor 1 (BLF1), a bacterial protein toxin secreted by the human pathogen Burkholderia pseudomallei, we discovered a novel protein secretion mechanism driven by a peptide domain that interacts with an anionic phospholipid associated with membrane curvature. Moreover, this novel peptide domain-mediated transport promotes the association of BLF1 and many other different recombinant ("cargo") proteins with secreted membrane vesicles (MVs). The recombinantly made cargo proteins are functional and when delivered to eukaryotic cells, they can modulate cellular functions like actin cytoskeletal rearrangements and cell death.

We are exploiting this newly discovered protein secretion system for multiple applications including vaccines, therapeutics, protein delivery, protein characterisation, antibacterial agents and biosensors, and production and isolation of recombinant proteins. The summer student joining our group will be involved in "hands-on" research to address (i) how the peptide-lipid interaction mediates formation and release of MVs and (ii) to make bacterial mutants that overproduce MVs for applications in vaccines and anti-cancer drugs.

Project 8: Cracking the RNA Code: How Chemical Modifications Control Protein Binding in Cancer

PI: David Simpson

Dry lab project

Summary of the project:

Post-transcriptional RNA modifications such as m^6A, m^5C, and pseudouridine are increasingly recognised as key regulators of gene expression, yet their functional consequences remain poorly understood. This project will therefore investigate how RNA modifications influence RNA-binding proteins (RBPs).

RNA modification sites have already been detected by direct sequencing of a cancer cell line RNA using the Oxford Nanopore platform. This project will apply Structural modelling approaches, including AlphaFold and alternative AI-based tools, to assess the likelihood of specific RNA modifications disrupting or enhancing RBP binding. Modelling the effects of RNA modification on specific RBPs sites across the transcriptome will provide insights into how they shape post-transcriptional gene regulation in cancer.

This project sits at the forefront of the rapidly expanding 'epigenomics' research area and you will contribute to our emerging understanding of RNA-based regulatory mechanisms and associated therapeutic opportunities.

The studentship offers highly desirable training and experience at the intersection of bioinformatics, genomics, and AI-driven biomedical research:

- Integrative data analysis and biological interpretation, including RNA modification and structural prediction tools
- Coding skills (Python/R) and data-visualisation expertise
- Confidence working with large-scale genomic datasets