2020-2021 Hector MacLean Scholarship Projects

Project: A non-cytotoxic approach to reduce ocular fibrosis
Supervised by: Dr Manisha Shah, Dr Elsa Chan & Dr Jennifer Fan Gaskin
Research Group: Ocular Fibrosis Unit

Project Summary: Wound healing is a classical response to any tissue injury repair and this process often leads to scar-forming fibrotic lesions. Scarring response is a major problem that influences the surgical outcome in patients with eye diseases. The post-surgical scarring in the eye causes vision impairment and blindness. There are some non-selective cytotoxic drugs currently being used in the clinic that exerts serious side-effects and leads to a high recurrence rate of fibrosis and surgical failure. Hence there is an immediate need to investigate safer and more effective therapeutic alternatives.

The unit focuses on investigating post-operative ocular scar formation. By understanding the involvement of NADPH oxidase-associated pathways in Reactive Oxygen Species (ROS) production in post-surgical ocular fibrosis, we aim to investigate how to improve long-term success of ocular surgery and prevent/treat post-operative ocular scar formation and vision loss in patients. We use various molecular and cell culture techniques, cell signalling pathway analysis, histological and immunohistochemical analysis and preclinical mouse models of ocular fibrosis to study the various aspects of this project.

Students will have an opportunity to learn techniques such as Western blot, histology and immunohistochemical analysis, microscopy and imaging as well as some aspects of preclinical mouse model of glaucoma filtration surgery. The student will be trained and expected to perform respective techniques and data analysis.

Project: The application of artificial intelligence for retinal hyperspectral image analysis
Supervised by: Dr Xavier Hadoux & A/Prof Peter van Wijngaarden
Research Group: Ophthalmic Neuroscience

Project Summary: Hyperspectral imaging involves the imaging of objects across a wide range of wavelengths of light. Our team is one of the first groups to apply this method to retinal imaging for the detection of biomarkers of eye and central nervous system diseases. A key element of this process is the development and optimisation of data analysis methods using a variety of image processing and artificial intelligence approaches including deep learning. The research candidate will have the opportunity to work with large well labelled image data sets to develop and tune deep learning networks for the detection of a range of disease biomarkers.

Applicants with proficiency in computer programming are encouraged to apply. Prior experience with machine learning is desirable.
Project: Keratoconus-solutions using big data analysis

Supervised by: Dr Srujana Sahebjada & A/Prof Mark Daniell

Research Group: Surgical Research

Project Summary: Keratoconus is a common condition that affects the cornea and despite its increasing prevalence, the cause of keratoconus is largely unknown. The aim of the project is to better understand the underlying molecular causes, clinical characteristics and treatment options of keratoconus to develop strategies that can halt the disease progression. The project also aims at developing machine learning algorithms to identify features that define early subclinical keratoconus that are currently refractory as well as identify a series of features that are involved in a) disease staging, as well as b) risk of progression of Keratoconus. The project involves collection of large datasets from clinical records and images and offers an exciting opportunity to conduct big data analysis and manuscript writing.

Students with a background in either medical, biomedical and computer science, optometry and visual science, or statistics are welcome to apply.
Project: REPAIR OF THE CORNEA TO RESTORE VISION: Translation to Surgical Repair Device

Supervised by: Dr Karl Brown & Prof Greg Dusung

Research Group: Surgical Research

Project Summary: Severe burns and corneal disease leads to vascularisation and ulceration of the corneal surface, which is currently treated by corneal transplants and lifelong anti-rejection drugs. Many countries in the world do not have sufficient donors to meet the increasing demand for this procedure. At CERA we work closely with chemical engineers and veterinary scientists at the University of Melbourne to develop engineered constructs to replace the damaged corneal endothelium. Materials and procedures have been patented, and one is under commercial development.

The current project is to develop a source of corneal endothelium from human induced pluripotent stem cells (iPS cells) and grow these on patented hydrogel films to replace damaged endothelium. Alternatively, the reprogramming of appropriate cells from patient donors direct to corneal endothelium will be explored. Mechanisms of adhesion and proliferation of these cells will be examined, and preclinical transplantation studies will be carried out in sheep in the veterinary facility.

This project would be suitable for medical or biomedical science students with an interest in cell biology, pharmacology or ophthalmology to work towards clinical application of this novel technique with an ophthalmologist, stem cell scientist, veterinary scientists and other cell biologists. A short project as part of this program is available for a Summer vacation student working alongside scientists and clinicians.
Project: Functional vision assessment of bionic eyes in a real world setting

Supervised by: Dr Carla Abbott, Dr Lauren Ayton
A/Prof Penelope Allen

Research Group: Bionic Research

Project Summary: Retinitis pigmentosa (RP) is an inherited disease that causes loss of the light sensitive cells (photoreceptors) in the retina, and hence blindness. RP affects 1.5 million people worldwide and in most cases is not able to be treated. Bionic eyes (retinal prostheses) have been developed for people with late-stage RP, to enable them to regain some central vision. Retinal prostheses work by bypassing the photoreceptors to target stimulation of the retinal cells leading into the optic nerve. At the Centre for Eye Research Australia, there is currently a clinical trial in progress where RP patients with ultra-low vision have been implanted with a second-generation bionic eye device. During the trial, patients are assessed 3-monthly with the Functional Low-Vision Observer Rated Assessment (FLORA) protocol in their home environment.

This project will involve statistical analysis of the FLORA outcomes to demonstrate the impact of the bionic eye and to identify where visual rehabilitation might increase the functional vision skills of the patients. In patients with a bionic eye due to ultra-low vision, assessment of the impact of the prosthesis on their daily activities and navigational ability is a key part of analysing the usefulness of the technology.