THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Professor Alan Rowan

Phone: 3346 4305

Email: alan.rowan@uq.edu.au

Biodegradable filtration membrane

Supervisor: Dr Nasim Amiralian (n.amiralian@uq.edu.au) & Prof Alan Rowan

Single-use plastics, such as those used for filtration, are a significant contributor to the plastic waste problem. Plant-derived nanofibres have many advantages, such as being natural, abundant, biodegradable, and are exceptionally light and strong. These nanofibres are excellent candidates for use as sustainable materials to reduce the use of petroleum-based plastics in the filtration industry. This project aims to design, manufacture and characterise biodegradable based membrane for filtration applications. The project involved the design and production of biodegradable materials and testing their performance for filtration.

Investigation of the processing parameters on the nanocellulose properties

Supervisor: Dr Nasim Amiralian (n.amiralian@uq.edu.au) & Prof Alan Rowan

Nanocellulose is the next generation of renewable materials for the development of high-performance products. While nanocelluloses produced from different extraction methods share a common molecular backbone, their structure, properties, surface chemistry, cost, and practical uses can vary greatly. This project investigates the effect of different processing parameters on the properties of final nanocellulose. The project will involve, design, synthesise and characterisation of materials as well as the production of a library of different types of nanocellulose with known properties for future applications.

Brain mimicry to understand the behaviour of malignant gliomas

Supervisors: Naatasha Isahak (naatasha.isahak@uq.edu.au) & Prof. Alan Rowan

Malignant gliomas are the most common primary brain tumours, among which glioblastomas (GBMs) are the most malignant and highly aggressive. One major cause of treatment failure and tumour recurrence is diffuse invasion of GBM cells into the surrounding brain tissue. Therefore, it is critical to understand the invasion mechanism of GBM cells, to devise an efficient therapeutic strategy. However, the heterogenous cell population observed in GBMs may explain why single-target drugs and therapies might prove inefficient since these tumours could “become” something else and escape drug therapies. This project aims to elucidate the conditions that mimics the human brain and the effects of ECM properties on mechano-transduction of established GBM cell lines for a better understanding of the invasion mechanism of GBM cells.

Studying of cells in microgravity conditions

Supervisors: Naatasha Isahak (naatasha.isahak@uq.edu.au) & Prof. Alan Rowan

Every living organism is affected by gravity. With returning astronauts suffer bone loss of up to 1.5% a month, along with lowered levels of calcium, dysregulated immune systems, and muscle atrophy- it is clear that gravity has a profound effect on cell functions and behaviour. As cells monitor the surrounding mechanical cues from the extracellular matrix, they transmit them through focal adhesion connections to initiate signal pathways that cause reorganization of the cytoskeletal structure. Through the aid of a synthetic hydrogel with regulated sites for focal adhesion, this project will investigate the effects of microgravity on the cytoskeletal structure of the cells and determine how gravity affects differentiation affect cell differentiation.

Measuring the microscale stiffness around cells

Supervisors: Dr Michael Taylor (m.taylor@sbs.uq.edu.au) & Prof Alan Rowan

Cells sense and respond to the stiffness of the surrounding extracellular matrix (ECM) via a process called mechanotransduction. An increasing number of studies show that the mechanical properties of the ECM have a crucial role in determining cellular fate and various different cellular processes in tissues. One confounding effect when studying the influence of ECM stiffness on cell function is that the cell itself modifies the surrounding extracellular matrix, making it very difficult to know what mechanical cues the cell is actually subject to. We have recently developed and built a new type of microscope that uses a phenomena called Brillouin scattering to measure microscale stiffness. This project will use this to quantify how cells influence the mechanical properties directly surrounding them, and relate this to cellular effects of mechanotransduction.

Studying cellular response to external force

Supervisor: Dr Michael Taylor (m.taylor@sbs.uq.edu.au) & Prof Alan Rowan

Cells are able to sense and respond to external mechanical stimuli from their surrounding extracellular matrix (ECM) via a process called mechanotransduction. An increasing number of studies show that the mechanical properties of the ECM have a crucial role in determining cellular fate and various different cellular processes in tissues. However, it remains relatively unknown how forces acting on the ECM influence cells. We are uniquely equipped to study this using a STED confocal–rheometer instrument which allows real-time fluorescent imaging of 3D volumes and the simultaneous application of force to the ECM material while measuring its viscoelastic properties. This multidisciplinary project will specifically aim to test extent to which cells respond similarly to applied forces as compared to changes in material stiffness.

Visualisation of mechanosensing dynamics

Supervisor: Dr Mahdie Mollazade (m.mollazade@uq.edu.au) & Prof Alan Rowan

Cells are constantly exposed to a diverse range of mechanical signals that change over time. Mechanical signals are sensed and converted by cells into biochemical signals; a process known as cell mechanosensing. Cellular mechanosensing is mediated with the involvement of various intracellular structures with high spatiotemporal dynamics, such as caveolae and focal adhesions. Caveolae and focal adhesions are membrane structures that undergo dynamic reorganizations upon

responding to the mechanical signals from the environment. This multidisciplinary project will combine our expertise on the area of cell mechanosensing and super resolution microscopy.

Unveil the drivers of bone fracture healing

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

Wound healing is a dynamic process requiring a coordinated response to repair the damage. This project focuses on a combined therapeutic approach of matrix restoration to provide biophysical cues and specific matrix ligands to mediate the cell based responses to drive repair. This synergistic approach will be employed to study the key regulator of bone repair, the osteocytes, investigating their cellular signalling to promote bone fracture healing in a unique 3D model system.

This project will involve osteocyte cell growth and differentiation, working with 3D culture systems, live confocal imaging, gene expression and immunostaining.

Differentiation of stem cells to repopulate bone forming and resorbing cell population

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

The key effector cells of the bone microenvironment are the osteoblasts (bone forming cells) and the osteoclasts (bone resorbing cells), together driving bone turnover and bone repair. Both these cell types have been shown to only survive for days to weeks, then replenished from local stem cell populations. An imbalance in this process will shift the tightly regulated balance of bone formation and bone resorption. This project will focus on investigating the effect of novel bone cell derived signalling vesicles in controlling the fate of bone mesenchymal stem cells.

This project will involve stem cell and bone cell growth, stem cell differentiation, working with 3D culture systems, live confocal imaging, gene expression and immunostaining.

Bone cell extracellular vesicles, natures ultimate nanoparticles driving cell signalling

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

Extracellular vesicles are nature's way of packaging up precious cargo and delivering it to the intended target site to bring about specific biological responses. Bone cells are known to produce a myriad of signalling molecules to communicate with other bone cells and to communicate with distant tissues through systemic delivery. We have identified a novel population of extracellular vesicles that are produced in response to extracellular matrix changes, containing a key signalling molecule. But there is much more to this story and this project will focus on unravelling this further.

This project will involve osteocyte cell growth, working with 3D culture systems, extracellular vesicle characterisation, extracellular vesicle purification, liquid chromatography with tandem mass spectrometry, live confocal imaging, gene expression, western blotting and immunostaining.

Osteocytes the master regulator of bone formation

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

The cells of the bone are uniquely isolated from other tissues in our body contained within the hard, impermeable hydroxyapatite matrix. Where osteocytes, the master regulators of bone turnover are the longest living of the bone cells and are individually buried in small hydroxyapatite chambers. Employing a unique live 3D model system this project will investigate how the extracellular matrix properties of osteocytes can alter their signalling to the other bone cells, controlling the constant and ongoing turnover of bone to maintain its integrity and health.

This project will involve osteocyte cell growth and differentiation, working with 3D culture systems, live confocal imaging, gene expression, immunostaining and simple chemistry to functionalise biomaterials.

Guiding wound healing through biophysical control

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

Wound healing is a dynamic process requiring a coordinated response to repair the damage. The extracellular matrix assists in providing an interconnected network contributing to both the biochemical and biophysical cues to bring about biological responses in cells/tissues. We have defined natural biomaterials to establish 3D cell model systems to study these activities using live confocal microscopy to investigate the role of matrix signalling.

This project will involve growth of various skin cell types, working with 3D culture systems, live confocal imaging, wound healing assays, gene expression and immunostaining.

Collagen the founding matrix of our bodies but cellular production is not as simple as we might think.

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

Collagen is the most abundant protein in our bodies, contributing to the rich diversity of extracellular matrix proteins. The extracellular matrix assists in providing an interconnected network contributing to both the biochemical and biophysical cues to bring about biological responses in cells/tissues. Collagen does not exist as a single polymeric chain, but self assembles into a highly ordered network of fibres imparting the inherent mechanical properties defined by this architecture. Collagen is the most abundant protein matrix component of bone and the focus of this project is to interrogate the replenishment by bone cells and the regulators of fibre formation employing live 3D model cell systems.

This project will involve bone cell growth, working with 3D culture systems, live confocal imaging, gene expression and immunostaining.

Get creative, make your own synthetic collagen III

Supervisor: Dr Amanda W. Kijas (a.kijas@uq.edu.au) and Prof. Alan Rowan

Collagen is the most abundant protein in our bodies, contributing to the rich diversity of extracellular matrix proteins. The extracellular matrix assists in providing an interconnected network contributing to

both the biochemical and biophysical cues to bring about biological responses in cells/tissues. In the initial stages of wound healing collagen III plays a key role in guiding the initial stages of repair. Here we will employ a defined synthetic collagen III to study how this form of collagen assists to guide these early cellular responses of key skin cell types employing 3D live imaging models.

This project will involve growth of various skin cell types, working with 3D culture systems, live confocal imaging, wound healing assays, gene expression, immunostaining and simple chemistry to functionalise biomaterials.

The influence of extracellular matrix composition on brain diseases

Supervisors: Dr Jan Lauko (j.lauko@uq.edu.au) and Dr Anne Lagendijk

It is known that changes in environmental cues – the extracellular matrix (ECM) can lead to vascular pathologies. Specifically, vessels in the brain are highly specialised and have established a selective and protective blood-brain barrier (BBB), to limit entry of potentially neurotoxic substances and pathogens into the brain. The aim of this project is to elucidate which aspects of brain ECM composition – the mechanical properties, the presence of biological signals contribute to specification of the brain vasculature and how changes in the environment might contribute to vascular disease. This project will focus on the material aspects of this study, the synthesis of novel polymeric materials, their mechanical (rheological) characterisation with the ultimate aim to correlate these characteristics to specific biological responses.

How does the persistence length of polymers influence their biodistribution

Supervisors: Dr Jan Lauko (j.lauko@uq.edu.au), Prof Kris Thurecht and Prof Alan Rowan

Unlike most other polymers, the polyisocyanopeptides (PIC) developed and extensively studied in our group, do not form sphere-like particles, but form relatively stiff, several hundred nm long rod-like particles (Rowan, Nature, 2013). This is because of their helical backbone structure which is stabilised by peptide hydrogen bonds. PIC's essentially do not have a hydrodynamic radius making it both difficult to determine their molecular weight by standard analytical methods used in polymer science, but also making them interesting in terms of their distribution in body. The aim of this project will be to synthesize functionalized PIC polymers, study their mobility in a model system, with the ultimate aim to follow their biodistribution in a mouse model.