QUEEN'S UNIVERSITY BELFAST

Qatar – Projects Booklet

April 2024

Professor Margaret Topping
Pro-Vice Chancellor (Global Engagement)

WELCOME TO QUEEN'S

Thank you for considering Queen's University Belfast for your PhD experience.

At Queen's, we are proud to be a university that is internationally recognised and globally connected.

A member of the Russell Group of research-intensive universities, Queen's is at the forefront of developing new thinking right across the University, and in the QS World Rankings by subject 2024, 19 of Queen's subjects were ranked in the top 200.

With over 25,000 students, including 4,000 international students from over 90 countries, Queen's is a dynamic and diverse institution, a magnet for inward investment, a patron of the arts and a global player in areas ranging from cancer studies to sustainability, and from pharmaceuticals to cyber security.

In recognition of its commitment to producing research that has an impact on society, Queen's is ranked 85 in the world in the Times Higher Education Impact Rankings 2023 and is proud to be in the top 170 universities in the world for graduate prospects.

We are ranked 4th in the world for international outlook but are also a university that is proud to play a key role in its local community. Situated in the heart of one of the capital cities of Europe, Queen's is renowned for its teaching excellence and international research, while Belfast is known for its warm welcome, rich culture, innovation and entrepreneurship.

At Queen's our Strategy 2030 sets out our ambition over the next six years to shape a better world through life-changing education and research. Our vision is that of a global, research-intensive university, coupled with outstanding teaching and learning, focused on the needs of our society, locally and globally.

Our PhD student population is at the heart of those ambitions, and through a partnership between our academic Schools, research institutes, and award-winning Graduate School, we seek to develop future-ready individuals who push beyond conventional boundaries and who will return to their home countries equipped to take on the leadership roles which will respond to the national strategies and ambitions of our partner countries.

Professor Helen McCarthy
Associate Pro-Vice-Chancellor (Academic Business Development)

THE GRADUATE SCHOOL AT QUEEN'S

In addition to training our PhD students as experts in their fields, we also offer a wide range of opportunities for personal and professional development through our Graduate School. By combining subject excellence with high-level training, the Graduate School aims to develop thinkers, communicators, innovators and leaders who are future-ready.

The Graduate School is a world-class intellectual and social hub, connecting students from all disciplines to each other and to mentors and employers within the University and beyond. It is grounded in intellectual challenge beyond disciplinary borders, personal effectiveness and the development of future-facing skills. We aim to enhance the professional experiences with which postgraduates arrive at Queen's University; and our ethos is to nurture a culture of opportunity, innovation and enterprise, and a rich, diverse, inclusive social community.

With emphasis on designing and delivering programmes which spark, encourage and support leadership, innovation and enterprise, Queen's Graduate School is committed to developing economic and social participation and growth by offering programmes underpinned by design thinking, co-creation and entrepreneurial mind-set principles and by focusing on experimentation, prototyping and evidence-gathering as key methods.

We support global leaders to identify opportunities for innovation across a range of sectors and disciplines, and to develop the tools and mindset required to adapt to and ensure relevance in a changing world.

Being a postgraduate student at Queen's is about going beyond current conceptions and categories, redefining and rethinking assumptions and having a perspective that is flexible and adaptive. It's what we call 'What's Next' thinking.

This brochure provides you with a range of PhD projects for which you can apply, as well as information on the range of workshops and training opportunities available to you in our Graduate School. If you would like to discuss an individual project, please contact the supervisor whose details are provided. For general queries about doctoral study at Queen's or the wider University, please contact: Mrs Lynne Spence (l.spence@qub.ac.uk).

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FACULTY AND SCHOOL STRUCTURE

Queen's has three Faculties and a total of 15 Schools, each lead by a Head of School. Where projects are available, the order they appear within this booklet follows this structure.

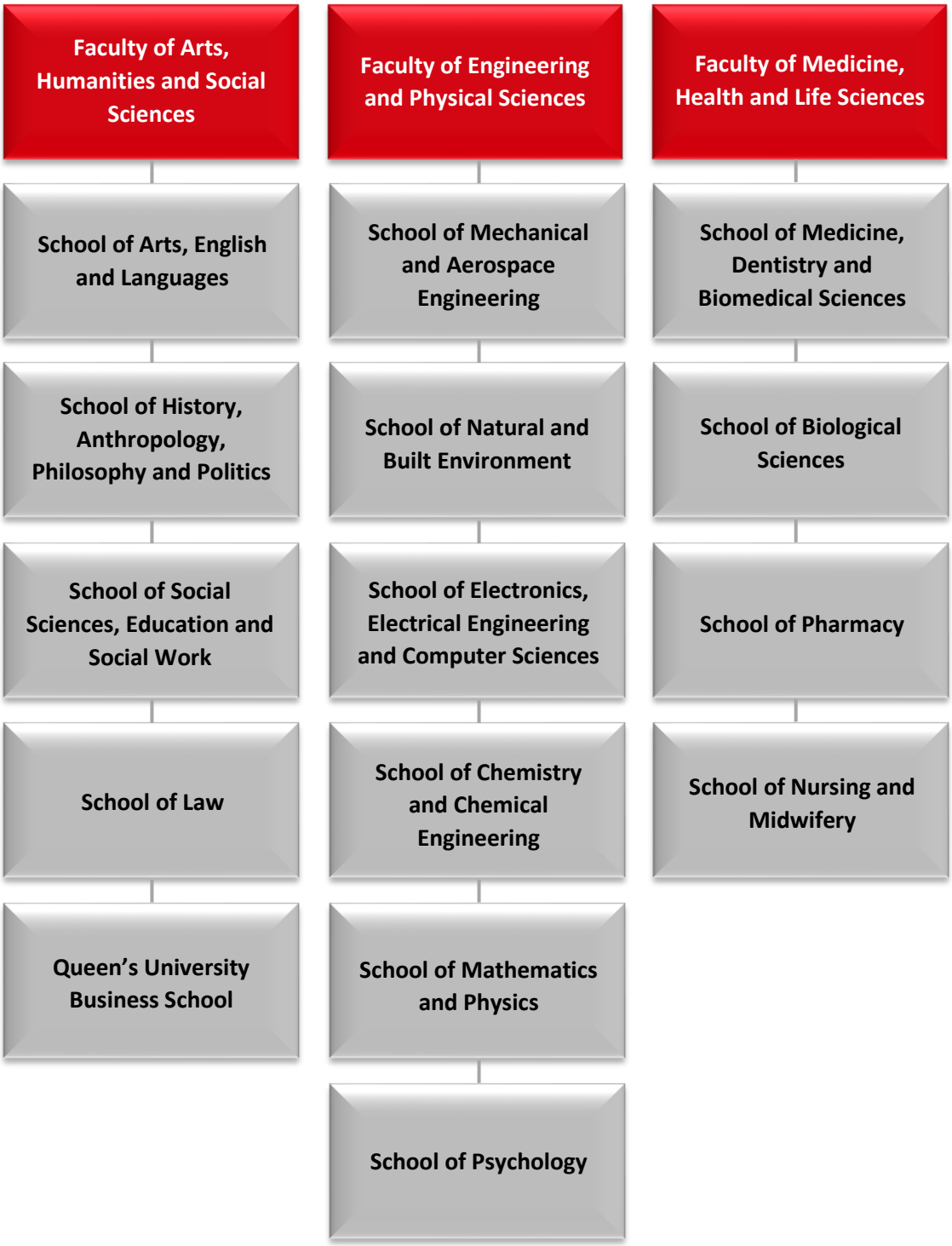
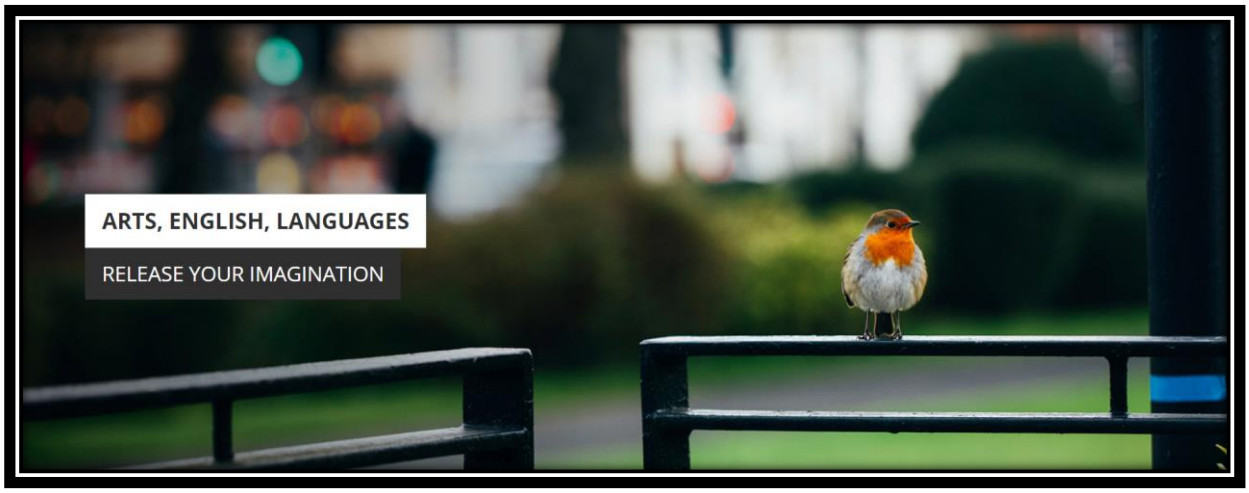


Figure 1: *Faculty and School Structure*

1. FACULTY OF ARTS, HUMANITIES AND SOCIAL SCIENCES

1.1 SCHOOL OF ARTS, ENGLISH AND LANGUAGES



1.1.1 Italian Cinema in the Arab World: Distribution, Remakes, Influences

Supervisor	Professor Stefano Baschiera
Mode of Study	Full time Distance Learning
Project Overview	From Italian genre cinema of the 1960s to recent Arab remake of contemporary film, the project looks at the presence and influence of Italian cinema in the Arab film culture.
Project Description Detailed description of the project	This project explores the impact and legacy of Italian genre cinema from the 1960s on contemporary Arab film culture, considering also a recent Arab remake of Italian film *Perfect Strangers*. By examining the stylistic and thematic influences of Italian cinema on Arab filmmakers and their works, the study aims to uncover how Italian genre conventions, narrative styles, and aesthetic sensibilities have been adapted and integrated into Arab cinema. Additionally, it delves into the distribution and reception of these films, analysing how they were marketed, exhibited, and consumed by Arab audiences. The research will employ a comparative analysis of select Italian films and their Arab counterparts, highlighting the cultural exchange and adaptation processes. Through this lens, the project seeks to contribute to a broader understanding of cross-cultural filmic influences, the global reach of Italian cinema, the dynamics of cultural translation, the preservation of cinematic heritage, and the evolution of film as a medium of intercultural dialogue.
Project Keywords	Italian Cinema; remake; distribution

1.1.2 Qatar and the Circulation of Arabic Literature: The Role of Literary Prizes, Festivals and Book Fairs

Supervisor	Professor Sarah Bowskill and Dr Khalifa Abdel-Wahab
Mode of Study	Full Time Distance Learning or Full Time at QUB
Project Overview	This project analyses the role played by literary prizes and festivals in Qatar. The project is likely to draw on frameworks relating to world literature and the sociology of literature, including, but not limited to, Pierre Bourdieu. Possible case studies include the Katara Prize and the Doha International Book Fair. The project may also examine the way Arabic literature is/has been represented internationally at book fairs especially where Qatar has been a guest of honour. The project can be tailored according to the interests of the student(s) and/or the strategic aims of the Qatari funding body. Students may focus exclusively on literary prizes, literary festivals, or both. Where literary prizes are the subject, the approach may combine textual analysis with approaches from the sociology of literature.
Project Description: Detailed description of the project	The project aims to examine the history of important literary prizes and/or festivals in Qatar with a view to understanding how awarding institutions contribute to the circulation of Qatari/Arabic literature. The applicant(s) may wish to take a particular prize or festival as a case study. The study of world literature and, more specifically, of literary prizes and festivals is gathering pace. Studies of literary prizes in Anglophone and Francophone contexts are most common, but much work remains to be done in relation to individual prizes and other national/linguistic contexts. Both supervisors have published work on literary prizes. Bowskill has published on literary prizes in Spanish-speaking Latin America, and Khalifa has published on prizes for literature in Arabic and especially those that support the translation of Arabic literature into English. They would draw on this expertise to support this project. Aims of the project may include: To understand the role of literary prizes in supporting the circulation of literature in Qatar/the Arab world/beyond by • Analysing media coverage of prize-winners • Analysing the subsequent trajectories of prizewinning authors/texts • Analysing thematic trends in prizewinning texts To understand the role of literary festivals and book fairs in supporting the circulation of literature in Qatar/the Arab world/beyond by • Analysing the role of the state and/or private sponsors in promoting literary culture in Qatar. • Analysing media coverage of literary festivals/book fairs • Analysing the presence of national/regional and international publishers at these events • Analysing which authors are invited to speak at these events

	• Analysing the role of 'invited' countries and the experiences of Qatar/Arab countries abroad as 'guests of honour'/the subject of the 'market focus' e.g., Sharjah at London Book Fair in 2022; Qatar at Amman International Book Fair in 2023 and Sharjah at the Thessaloniki Book Fair in 2024.
Project Keywords	Qatar, Arabic literature, Qatari literature, sociology of literature, world literature, translation, literary prizes, prizes for literature, book fairs, book festivals

1.1.3 Kidlit 2030: Translating children's literature in a changing Qatar

Supervisor	Professor Sue-Ann Harding
Mode of Study	Full Time Distance Learning
Project Overview	This project will examine English-Arabic translation of children's literature in the context of the broad social changes underway in Qatar.
Project Description: Detailed description of the project	Qatar's National Vision 2030 seeks to transform the country socially and economically, with special emphasis in the Vision given to the education of children and young people as key to building a culturally vibrant society. While much has been said about the country's modernising ambitions and engagement with the wider world, there remains a significant lack of research on the extent to which these changes have affected and are affecting translation practices, translation being one of the most significant ways that new ideas cross linguistic and cultural boundaries. From this starting point, this project will focus specifically on the translation of children's literature as both a key part of cultural life in its own right, and a primary mechanism for the introduction of new ways of thinking to young people. Methodologically, it will begin by surveying broad trends in the texts selected for translation in Qatar before moving to a finer grained analysis of the translation approaches adopted in key works. The project will address the following main research question: • To what extent are the changes advocated in the Qatar National Vision 2030 reflected in the translation of children's literature Qatar? Further research questions to be addressed in the course of the project include: • How has the publishing landscape of children's literature developed in response to the National Vision 2030? • What policies and practices have publishing houses developed in response to the National Vision 2030? • Do the texts selected for translation differ from those published previously? If so, in what ways? • To what extent and how have translation practices changed in terms of number of translations published; the commissioning of translations; source text languages and countries; and the authors, titles and themes selected for publication?
Project Keywords	Translation studies; children's literature; publishing; translation policy; cultural flows; Arabic literature

1.1.4 Multimedia Crime Fiction in the Arabic world

Supervisor	Dr Dominique Jeannerod
Mode of Study	Full Time Distance Learning
Project Overview	This Project seeks to address the recent emergence of Crime Fiction in the Arabic World (Arabic Noir) and question the historical and socio-economic conditions of this development in the past decades. The project is a pioneering one, as it deals with an area hitherto entirely neglected in Crime fiction studies. But it will benefit from, and contribute to, a growing awareness of the regional and international significance of this new horizon of the Crime genre. It will look at multi-and transmedia crime narrative productions from the Arabic world (novels, serialisation, films and TV series).
Project Description: Detailed description of the project	This Project will provide a contextual, historical and critical appraisal of the recent emergence of Crime Fiction in the Arabic World and link it with intermedia processes of exchanges and influence in the global circulation of crime narratives. Paying attention to traditional works dealing with crime in the classical period as well as to more recent forms in various Arab speaking countries, including transmedia forms (novels, serialisation, films, TV series) The project is a pioneering one, as it deals with an area hitherto entirely neglected in Crime fiction studies. Very recent publications have started to provide analytical tools for assessing it, and an international conference was organised in Paris in March 2019 at the Inalco and the Institut du Monde Arabe on Arabic crime narratives, which discussed their distinctive features and their conditions of existence and reception in the Arabic world. Thus, the project will benefit from, and contribute to, a growing awareness of the regional and international significance of this new horizon of the Crime genre. It will be conducted under supervision and with the input of scholars members of The International Crime Fiction Research Group, created at Queen's University Belfast has multiple partnerships with Arabic speaking Crime Fiction scholars based worldwide including in the Arabic Work currently starting research in an interest in the genre. Methodologically, it will define this new and international corpus of Crime Fiction in Arabic and from Arab countries both as a local phenomenon connected to space and place and as consequence of globalization. It will assess how crime narratives circulate in and from the Arabic world and investigate the various transnational configuration having an impact on this process; it will probe, based on this corpus concepts such as transculturalism, "cosmopolitan turn", "transmediality" and "glocalisation"
Project Keywords	Crime Fiction; Global Circulation of popular cultures; adaptation and translation/transnational studies/history of publishing and media industries

1.1.5 Music Performance and Inclusion

Supervisor	Professor Franziska Schroeder
Mode of Study	Full Time Distance Learning
Project Overview	The PhD student would be embedded in our research team "Performance without Barriers" (http://performancewithoutbarri ers.com), a team that is committed to research activities that promote: • Social inclusion through creative performance practice • Accessible and enabling technologies • Challenging dominant assumptions or exclusive identities
Project Description: Detailed description of the project	The student would work in partnership with Queen's, our research team and our local charity partner, Drake Music NI. The student would partly be based at the unique Sonic Arts Research Centre, a centre dedicated to cutting-edge initiatives in the creation and delivery of music and audio. The Sonic Laboratory's uniqueness is vested in the degree of flexibility it can provide for experiments in sound diffusion and for ground-breaking compositional and performance work within a purpose-built, variable acoustic space. The researcher would investigate the topic of inclusion in digital music performance, guided by Franziska Schroeder, Professor of Music and Cultures in the School of Arts, English and Languages, and a specialist in the area of social inclusion, improvisation and digital music. Although Drake Music focuses on musicians with disabilities, as it is a charity that facilitates access to independent music making for children and adults with all natures of different abilities, including physical, sensory, intellectual, cognitive and acquired disabilities, the PhD student would be free to interpret the topic of 'inclusion' in a wider sense. The students could potentially research the notion of 'inclusion' in the form of a comparative study of how 'inclusion' is understood and interpreted in Qatar society, in particular in the area of digital music making and / or music improvisation.
Project Keywords	Inclusion, digital music performance, music improvisation, society

1.1.6 Shakespeare and Arab Cultures

Supervisor	Professor Mark Thornton
Mode of Study	Full Time Distance Learning
Project Overview	Shakespeare and Arab Cultures is a PhD project based in the School of Arts, English and Languages. It examines the significance of performances, films and translations of Shakespeare across the Arab world.
Project Description: Detailed description of the project	Shakespeare and Arab Cultures is a broad-based PhD project that examines the place and role of Shakespeare across the Arab world. It explores histories of Shakespeare performance, film, television and translation in Arab cultures and in Arab-speaking countries, in order to reflect on the multiple uses of Shakespeare in a variety of generic forms. Consideration might be given to Shakespeare in festivals, Shakespeare in education, Shakespeare on tour and Shakespeare as a reference point in poetry and literature. Case-studies could centre on such examples as the Yemini film, *Someone is Sleeping in My Pain* (2001), an adaptation of *Macbeth*, the Iraqi production, *Romeo and Juliet in Baghdad* (2012), the touring production, *The Al-Hamlet Summit* (2004), *The Tempest* production (Qatar, 2015), the Egyptian film adaptation of *Romeo and Juliet*, *Hobak Nar* (2004) or similar examples from Saudi Arabia. This is an indicative list only. The content will be devised by the student and supervisor, Prof. Mark Thornton Burnett (QUB), scholar in global Shakespeares, and will be organised around a series of relevant case-studies.
Project Keywords	Film, stage, translation

1.2 SCHOOL OF HISTORY, ANTHROPOLOGY, PHILOSPHY AND POLITICS

1.2.1 The Political Economy of Energy Transition in Oil and Gas Exporting States

Supervisor	Dr Stefan Andreasson
Mode of Study	Full Time Distance Learning
Project Overview	The objective of this project is to understand the key factors shaping oil and gas exporting states' energy transitions in the context of uncertainty about the future of fossil fuels and the consequences of phasing out these sources of energy for countries heavily reliant on revenues from their extraction.
Project Description: Detailed description of the project	States that are heavily reliant on oil and gas export revenues must contend with the global effort to reduce and eventually phase out fossil fuels. The Persian Gulf states' historical role as major producers in a geopolitically contested region makes their approaches to the low-carbon energy transition pivotal. This project aims to identify and understand the implications of the key factors shaping the energy transition in (selected) oil and gas exporting states in the Persian Gulf and the effects of that transition regionally and globally. The project will outline the economic, political and geostrategic opportunities and risks of the energy transition, considering in particular what actors are likely to gain and lose from this transition and what affected oil and gas exporting states can do to maximise opportunity in this process.
Project Keywords	Political economy; energy transition; fossil fuels; oil and gas; resource curse; development; geopolitics

1.3 SCHOOL OF SOCIAL SCIENCES, EDUCATION AND SOCIAL WORK

1.3.1 The Experiences of Participation Within Higher Education of Those From Previously Marginalised or Excluded Groups, Particularly Academic Staff and/or First Generation Students

Supervisor	Professor Dina Belluigi
Mode of Study	Full Time Distance Learning
Project Overview	This project will explore how changes to the academic environment are experienced, with a vision to understanding how different knowledges and ways of being may enrich the future university.
Project Description: Detailed description of the project	Access to university, the highest and most powerful of all institutions of education and knowledge formation, has been a global project within the past forty years which has seen variable uptake, and much scholarship. At the cutting edge of new areas of theorisation, are the questions raised by the participation of staff and students who differ from the previous norms of academia, and the ways in which they can be positioned to enrich and diversify the social formation and knowledge formations of their institutions, societies, and disciplinary communities globally. This project would ask questions such as: • In what ways has access to higher education changed the pipeline of academic success in this context? • In what ways have participation within higher education impacted on institutional, disciplinary and inter-cultural norms? • What can be extrapolated from these insights to inform macro- and meso-level policies and micro-level interventions practices? A project such as this has scope for a range of research strategies. These will be informed by the specific theoretical and analytical lens which the candidate finds most valid, the particular focus of 'difference' to which they focus, in addition to which geographic or institutional contexts the project considers. It will be expected that the study will involve comparative components, whether in the literature review or within the study itself.
Project Keywords	Higher education, University, Educational change, Inclusion

1.3.2 Constructions of Academic Knowledge Within Local Cultures, and Their Relation to the Perceptions and Aspirations of the University's Role Globally

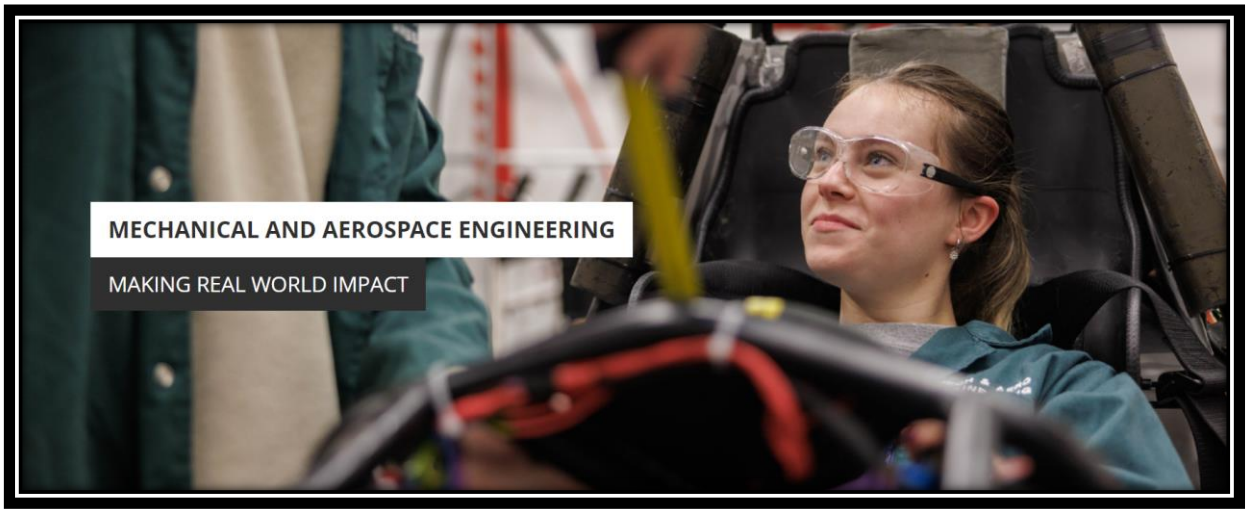
Supervisor	Professor Dina Belluigi
Mode of Study	Full Time Distance Learning
Start Date	Ideally, where it is envisaged that a number of students would be interested in one of the topics above, it would be ideal for them to enrol at the same time so we can create a cohort learning culture.
Project Overview	G/local dynamics and tensions are prevalent in many sectors of society. Internationalisation of higher education is not a new phenomenon, with knowledge exchange and learning a characteristic of the ancient universities to the present day. The rise of the western academy created an impression of universal knowledge and disciplinary canons which were decontextual. In the present day 'knowledge economy' with institutions and publications ranked against each other competitively, there is growing concern that the wealth of diverse knowledge systems and ways of knowing continue to be protected, fostered and enhanced by universities. This project will consider these dynamics at the micro-level, by analysing the constructions of academic knowledge within local cultures and perceptions of the university's role locally and globally.
Project Description: Detailed description of the project	It is broadly contended that higher education performs the role of knowledge formation in society, where education reproduces that which is legitimated. In this project, investigators will analyse the relation of academic knowledges to those which are valued and practiced within local cultures. It will also consider how external discourses and drivers, impact on the perceived role of higher education institutions. Questions related to this topic might include: • In what ways are various knowledges constructed, de/contextualized and de/legitimated within and beyond the academy? • In what ways are international discourses impacting on the fostering of indigenous knowledge systems and the ethics of knowing? • What are the relations between the place and community, within which universities are situated, and their global ambitions? A project such as this has scope for a range of research strategies. These will be informed by the specific theoretical and analytical lens which the candidate finds most valid, the particular focus of 'difference' to which they focus, in addition to which geographic or institutional contexts the project considers. It will be expected that the study will involve comparative components, whether in the literature review or within the study itself.
Project Keywords	Higher education, University, Social change, Internationalisation, Knowledge systems

1.3.3 Professional Development of Academic Staff for Social Justice Within the Academy

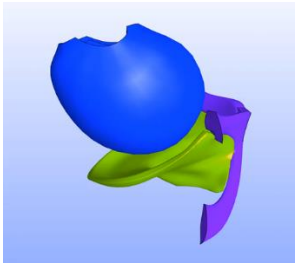
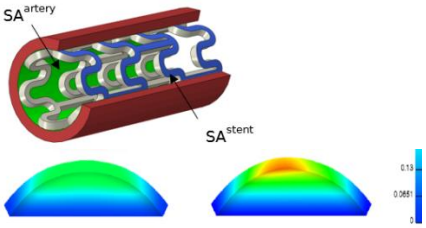
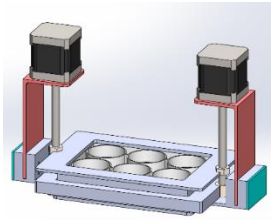
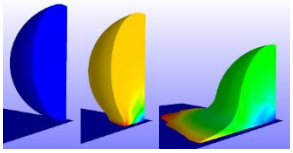
Supervisor	Professor Dina Belluigi
Mode of Study	Full Time Distance Learning
Start Date	Ideally, where it is envisaged that a number of students would be interested in one of the topics above, it would be ideal for them to enrol at the same time so we can create a cohort learning culture.
Project Overview	One of the most debated areas of scholarship, policy and practice across the world is the role of higher education in remedying society's ills. Drawing from scholarship and success in practice across the world, this project hopes to contribute to understanding how institutions in Qatar may enable their academic staff to be fit-for-purpose for social justice in their professional functions.
Project Description: Detailed description of the project	Professional development in higher education (called 'educational development' or 'academic development) is a complex field of practice and scholarship. The theories of change which underpin it are influenced by the intellectual strength of the persons who practice it, in addition to the traditions of quality assurance, management or enhancement at an institutional level. This project looks at the ways in which professional development is fit-for-purpose in preparing academic staff for the social justice role of higher education. Research questions related to this project may be: • In what ways is social justice understood at macro-, meso- and micro-level within universities in Qatar? • In what ways do current professional development initiatives prepare academics for enacting social justice in their teaching and research? • How might contextually-informed social justice academic development be envisioned? A project such as this has scope for a range of research strategies. These will be informed by the specific theoretical and analytical lens which the candidate finds most valid, the particular focus of 'difference' to which they focus, in addition to which geographic or institutional contexts the project considers. It will be expected that the study will involve comparative components, whether in the literature review or within the study itself.
Project Keywords	Professional development, Higher Education, Social Justice, Institutional cultures, The role of the university.

2. FACULTY OF ENGINEERING AND PHYSICAL SCIENCES

2.1 SCHOOL OF MECHANICAL AND AEROSPACE ENGINEERING



2.1.1 Computational Modelling of Soft Tissue Biomechanics

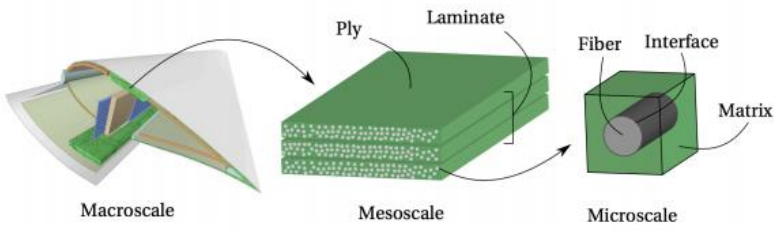
Supervisor	Dr Alex Lennon
Mode of Study	Full Time Distance Learning
Project Overview	Very flexible (soft) materials exist at multiple length scales within the body, from muscle and connective tissue down to the membranes of cells. Understanding their role in disease, injury, and regeneration provides numerous exciting challenges for biomechanics research.
Project Description: Detailed description of the project	**Project description**: One of a range of possible projects in which there has been recent or active research can be pursued within this Ph.D. topic: • investigating properties of pelvic floor muscles to understand injury risk during childbirth (Fig. 1a), • investigating deployment of bioresorbable stents within diseased arteries and their subsequent resorption (Fig. 1b-top), • modelling cornea biomechanics to help understand cornea degradation and/or improve laser eye surgery (Fig. 1b-bottom) • experimental and/or numerical investigation of response of human airway cells to chronic coughing in respiratory disease, • multiphysics modelling to investigate how biological cells interpret mechanical loads induced by their environment, e.g. within deforming muscle tissue or the highly loaded regions of cartilage and bone within our joints (Fig. 1d).  (a) Finite element (FE) model of childbirth  (b) FE models of a stent (top) and healthy and degenerated cornea subjected to normal intraocular pressure (bottom)  (c) Mechanical testing device to exert radial stretching on flexible cell culture plates to simulate airway epithelium stretch experienced during coughing  (d) Passive finite element model of a cell spreading **Figure 1:** Examples of potential activities within suggested research topics

	Other opportunities may exist, depending on the candidate's interests and whether relevant collaborators exist or can be readily identified. **Aims and Objectives:** Depending on the chosen topic a typical project may attempt to • characterise mechanical properties of the tissue of interest, • develop/adapt material models for use in FEA of devices (e.g. stents) and/or surrounding tissues (e.g. arterial tissue), • perform testing and/or develop material models for time-dependent behaviour of biomaterials or tissues (e.g. during device degradation, disease progression, or healing after injury), • develop mathematical models of cell population behaviour and integrate them with either experiments or simulations of cell populations within mechanically loaded environments, • develop multiphysics models of individual cells that link biochemistry with the cell to mechanical loading within the cell's structural elements
Project Keywords	Biomechanics; Mechanobiology; Computational Modelling; Soft Tissue Mechanics; Multiphysics

2.1.2 Evaluating the Non-Market Co-Benefits of Solar Energy

Supervisor	Dr Beatrice Smyth
Mode of Study	Full Time Distance Learning
Project Overview	Solar energy, through transformation to useful electricity and displacement of fossil fuels, creates non-market co-benefits, such as decreased greenhouse gas emissions, improved air quality and scope for localised economic development. However, although solar energy in use is linked with clear environmental and societal benefits, there are concerns over the impacts of the production and manufacturing stages. The issues need to be quantified and detailed analysis into the relative impacts of different solar technologies is required.
Project Description: Detailed description of the project	It is hypothesised that the non-market co-benefits of solar can be modelled using a new approach that combines life cycle analysis techniques from energy engineering with health impact assessment methodologies from the public health discipline and economic value estimations from the field of environmental economics. The novelty of the project is based around two areas: the development of interdisciplinary methodologies and the creation of a new database of non-market co-benefits in the solar sector. The aims of this project are to fully identify and quantify the environmental and societal impacts of solar energy, so as to inform policy-makers of the added potential of the solar economy. The impacts of solar energy will be investigated over the whole life cycle from raw material extraction and manufacturing to final disposal or recycling of the equipment, so that the benefits during the operational phase can be weighed against the overall life cycle impacts.
Project Keywords	Life cycle analysis, solar energy, societal impact, environmental impact

2.1.3 Structural performance of composite structures: A combined finite element and experimental investigation

Supervisor	Dr Zahur Ullah
Mode of Study	Full Time at QUB
Project Overview	 Due to their exceptional chemical and physical properties, fibre-reinforced polymer (FRP) composites are used in a variety of engineering applications including aerospace, automotive, energy, marine, civil structures, and biomedical. During their service lives, composite structures are subjected to static and impact loading which ultimately lead to structural failure. The heterogeneous and multi-scale nature of composite structures requires to understand their structural response at multiple scales including micro, meso and macro, as shown in Figure 1. The failure mechanisms at micro-level constituents including matrix, fibres and their interfaces lead to failure of macro-level structures. This multi-scale finite element method requires the solution of micro-level boundary value problem for each macro-level point of interest. Multi-scale finite element procedure provides accurate computational framework without any assumption of material models for the macro-level structure. On the micro-level, fibres, matrix and their interfaces are modelled explicitly with specialised material models. These material models capture the viscous behaviours of the resin and debonding of the fibre-matrix interfaces. Each micro-level problem involves the solution of nonlinear finite element problem with heterogeneous geometries, complex material models and dense meshes. Therefore, the associated computational cost is very high.  **Figure 1:** Multi-scale nature of composite structures (Rocha, 2019)

Project Description: Detailed description of the project	This project aims to developed and experimentally validate an efficient and accurate multi-scale finite element-based computational framework for the simulation of the structural performance of composite structures subjected to static and impact loading. The objectives of this PhD project are outlined as follows: • Development of multi-scale finite element analysis framework for composite structures. • The utilisation of reduced order models, including proper orthogonal decomposition (POD) and Empirical cubature method (ECM) to enhance the computational efficiency of the multi-scale finite element framework. The POD will reduce the number of degrees of freedom while the ECM will reduce the cost associated with numerical integration. • Implementation of the developed reduced order multi-scale finite element analysis framework in open-source finite element software library MoFEM (Mesh-oriented finite element method). • Optimisation of developed computational framework for the Queen's University high-performance computing cluster, Kelvin. • Simulation of structural mechanics problems subjected to static and impact loading to evaluate the effectiveness of the developed computational framework. • Perform experiments on the same material system to validate results obtained from the finite element simulation. This PhD project will be carried out within the Advanced Composites Research Group at Queen's University Belfast consisting of academics, PhDs and post-doctoral researchers. 
Project Keywords	Finite element analysis, Fibre reinforced polymer (FRP) composites, multi-scale modelling, solid mechanics, continuum mechanics

2.2 SCHOOL OF NATURAL AND BUILT ENVIRONMENT

2.2.1 Applications of 3D-Printed Soils in Geotechnics

Supervisor	Dr Vasileios Angelidakis
Mode of Study	Full Time at QUB
Project Overview	Designing new civil engineering materials is integral to achieving net-zero. The limitations of traditional materials used in construction are well explored, whereas new materials with enhanced properties have the capacity to revolutionise engineering design. When it comes to soils, additive manufacturing techniques such as 3D printing present the opportunity to design artificial materials with prescribed particle size and shape distributions, two key elements when it comes to soil shear strength. This project will employ physical and numerical experiments to explore the properties of 3D-printed soils, where particle shape will be a design parameter, rather than an observed parameter, to produce materials with tailored mechanical and rheological properties. Applying these artificial materials to geotechnical applications has two main advantages: first, materials with fine-tuned properties will result in cutting material waste, as the properties of the artificial material will be less ambiguous compared to natural soils and second, we can design artificial materials with extreme properties not found in nature, which are capable to withstand the increased and rapidly changing demands posed by climate change on your geotechnical assets.
Project Description: Detailed description of the project	This project will explore the properties of artificial soil elements produced via 3D printing. The main aim is to explore the mechanical properties of soils that are either 3D printed to their entirety, or mixtures of natural and artificial soil particles. Objectives: • Explore the effect of particle shape on the shear strength of soils. Collect data from the literature to explore which aspects of particle shape (micro scale) contribute to resistance of the bulk material (macro scale). • Select artificial particle shapes with a wide range of shape characteristics, to analyse their mechanical properties. Particle shape characterisation will be conducted using open-source software. • Analyse physical and numerical granular models made of these particles. The particles in the physical models will be 3D printed and tested in a triaxial compression rig to quantify their shear strength. The particles in the numerical models will be simulated using open-source software using the Level-Set Discrete Element Method (LS-DEM). • Draw comparisons between the mechanical behaviour of real and artificial soils via numerical simulations. Explore the effects of friction and particle softness. Simulate mixtures of real and artificial soils, where the artificial particles are used as a soil improvement solution.
Project Keywords	Artificial soils; 3D printing; shear strength

2.2.2 Co-Location of Offshore Wind Turbines and Floating Solar Structures

Supervisor	Dr Madjid Karimirad
Mode of Study	Full Time at QUB or Full Time Distance Learning Joint Supervision
Project Overview	Floating solar or FPV (Floating photovoltaic), refers to an array of solar panels on a structure that floats. Existing large-scale offshore wind energy farms and their infrastructures developed in the North of Europe could be integrated with floating solar technology. This would not be possible for all the locations due to the very severe weather conditions in parts of the North Sea. However, many locations exist where the wave conditions are moderate, (see for example the numerous sea basins in Holland), and at these locations, integration of the two technologies (floating solar and wind turbine) would be possible. The main objective would be to develop a conceptual design of how floating solar could be integrated into some of the existing wind farms, in particular in areas of sea that have shallow water or that already have existing infrastructures (atolls, sea lagoon, harbour, oil platforms, etc) in place. This should allow for assessing the Levelized Cost of energy in those solutions.
Project Description: Detailed description of the project	To deliver UN Sustainable Development Goals and battle the climate emergency, further renewable energy and better solutions to take advantage of vast resources available offshore should be implemented. Offshore wind has great potential and boomed in the market. One of the challenges is to better and enhance ocean space utilisation. This can be done by using the floating solar platforms added to offshore wind parks to increase the synergy and lower the costs associated with infrastructure, better energy utilisation, and less negative impact on other users. However, such integration should be thoroughly assessed to ensure respect to design, wave and wind loading and the hydrodynamic interaction of the structures. This influences the dynamics of the platform and its integrity as well as power production. The project aims to find a realistic solution for co-locating offshore wind and floating solar. The objectives of the projects are: • Assessment of the dynamics of the offshore wind and floating solar • Hydrodynamic analysis of the interactions between floating solar and offshore wind turbines • Design of suitable hybrid concepts for co-location • Testing the floating solar and offshore wind in the hydraulics lab Numerical simulations to assess the design and validation of the numerical simulation versus experiments
Project Keywords	Offshore Wind, Floating Solar, Marine Dynamics, Wave loads, Wind loading

2.2.3 Repurposing Limestone Quarry Fine Clays and Sewage Sludge Ash as Low Strength Construction Material

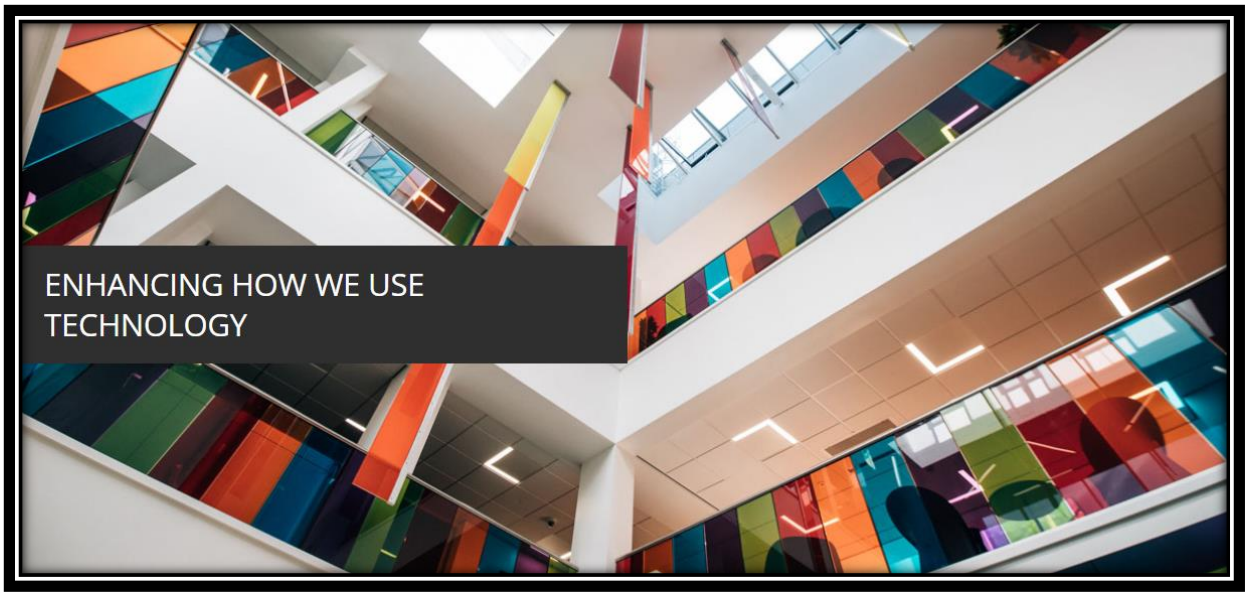
Supervisor	Dr Sree Nanukuttan
Mode of Study	This project will work as distance learning as well as full-time at QUB. We would encourage students to be trained at QUB laboratory for up to 2 months in the first year of the work. There is an existing project with IRD Qatar and Ministry of Environment and Climate change at Qatar. The student will benefit from liaising with these two Qatari entities.
Project Overview	Qatar has a construction material scarcity, and this project combines the two materials left over after limestone extraction and sewage treatment process to be converted into low strength construction material. Viability has been proven through prior laboratory work, but applications need established and performance data need generated to convince industry and clients.
Project Description: Detailed description of the project	This project will set out a route for the development of innovative and low-cost construction products, aligned to the principles of circular economy. The new products would utilise solid wastes accumulated in landfills, reduce reliance on imported materials, and consequent energy/carbon/cost savings. The project primarily concentrates on two materials (1) inter-limestone clay layers – left over from limestone quarrying and (2) sewage sludge ash – left over from the municipal sewage treatment process. These two waste materials have minerals that when calcined can react with calcium hydroxide to form stable, strength giving new minerals. The aim is to utilise this thread to develop low strength construction materials for domestic use in Qatar. The objectives are to determine the reactivity of these materials in isolation and as a combined resource and determine ideal mix design for achieving required strength and performance properties. Further validation of the product through performance testing, gathering essential data for convincing users/clients. Calcination temperature and resources needed for processing the materials already exists in Qatar and has been validated through prior testing, thereby creating a rapid start of the project.
Project Keywords	Waste materials, Calcined clays, Reactivity, low strength cement, performance testing

2.2.4 Improving the Shrinkage Behaviour and Efflorescence Formation of Low Carbon Geopolymer Concrete

Supervisor	Professor Wei Sha
Mode of Study	No Preference. However, Distance Learning is only possible if the student will have local access to concrete and materials characterisation lab facilities. It is not feasible for the student to travel to Belfast to use the labs in the University while living in an overseas country. The project will require lab use every week.
Project Overview	Previous ESPRC grants have developed technology for environmentally friendly geopolymer concrete. The LowCoPreCon project culminated in the production of full scale precast geopolymer concrete units including stairs, wall panels, floor panels and building blocks. This was a significant step forward towards more widescale use of low carbon concrete. Overall, the trials were largely successful and demonstrated that geopolymer technology can be used in the production of precast concrete elements. However, the trials also highlighted some remaining issues which still need to be addressed to allow and encourage greater uptake of geopolymer concrete by industry. There were two main issues identified. Firstly, there were microcracks on the surface of concrete elements. These are likely related to early age drying shrinkage. Further research is needed to assess the early age drying shrinkage of the geopolymer concrete. Modifications need to be made to the binder composition to assess if a reduction in drying shrinkage is observed. There are a number of possible ways to adjust the composition of geopolymer concrete. One promising option is the addition of MgO which hydrates to form $Mg(OH)_2$, an expansive mineral. The addition of MgO in small quantities and the subsequent formation of $Mg(OH)_2$ may offset early age drying shrinkage and eliminate the microcracks observed on the concrete surface. The second issue identified during the factory trials was efflorescence on the surface of geopolymer building blocks. The geopolymer building blocks produced in the factory trials were competitive and often superior to conventional building blocks in every aspect including cost, mechanical properties and environmental impact. The only problem they exhibited, was the formation of white deposits on their surface known as efflorescence. Recent studies have also identified the issue of efflorescence as a knowledge gap in geopolymer concrete technology. It may be possible to reduce the issue of efflorescence through altering the mix proportions, modifying the curing conditions or by using additives that can reduce the mobility of alkalis in the geopolymer matrix. This project will aim to address these issues, thereby eliminating remaining obstacles hindering the uptake of low carbon geopolymer concrete.
Project Description: Detailed description of the project	Initially a literature review will be carried out to review the latest developments with regards to both shrinkage and efflorescence formation in geopolymer concrete. In particular, the review will focus on the very latest developments and appropriate test methods for assessing shrinkage and efflorescence formation. Experimental investigations will begin by assessing the effect of binder composition and curing conditions on the shrinkage of geopolymer concrete. The various geopolymer components will be adjusted with particular attention to the content of alkaline

	activators. Then, MgO will be added to geopolymer concrete mixes in varying proportions and the effect on shrinkage will be assessed. This study will investigate the effect of binder composition, curing conditions and MgO content on the shrinkage of geopolymer concrete. It is anticipated that either one or a combination of these factors will significantly improve the shrinkage behaviour. This will reduce the microcracks observed on the surface of precast geopolymer concrete. Effect of binder composition and curing conditions on efflorescence formation will also be assessed. The use of alumina rich additives that can reduce the mobility of alkalis in the geopolymer matrix will also be trialled and their suitability investigated. Alongside these experimental activities, a series of publications based on this work will be drafted and finalised. Additionally, a review paper will be submitted.
Project Keywords	Geopolymer

2.3 SCHOOL OF ELECTRONICS, ELECTRICAL ENGINEERING AND COMPUTER SCIENCE



2.3.1 Advance Millimetre-Wave Antenna Beamforming

Supervisor	Dr Muhammad Ali Babar Abbasi
Mode of Study	Full Time Distance Learning
Project Overview	First stage of 5G deployment will be concluded by the end of year 2020. Vodafone Qatar began made its 5G NR n78 (3500 MHz) network commercially active on 27th August 2018 providing peak data rates in excess of 1 Gbps. Vodafone Qatar's spectrum licences were officially updated in January 2019 to permit the operation of a 100 MHz channel within the 3500 to 3800 MHz frequency band. Even this data rate is not enough to fulfil growing demand for higher throughput in future wireless systems. Advanced communications techniques based on multicarrier modulations, multiple antenna systems (MIMO) and their extension to massive MIMO, powerful coding schemes or interference coordination could be combined. An alternative but complementary way to increase throughput is to deploy communication systems operating in millimetre-wave (mmWave) bands, e.g. 28 GHz, 38 GHz, 60 GHz etc. In such a context, multiple antenna systems with dozens of radiating elements at the access point are extremely attractive solutions to achieve very high data rates (multi-gigabit / sec) for multiple users sharing the same spectrum at the same time, with low power consumption, thanks to the use of beamforming with analogue/digital precoding techniques. Moreover, any effective hardware implementation of such systems must rely on a realistic knowledge of hardware impairments and mmWave propagation / antenna characteristics, especially for outdoor and mobile communications for which the data available in the most recent literature are very limited.
Project Description: Detailed description of the project	The objective of the PhD project is to study advanced antennas and beamforming technology suitable for base-station antenna solution in mmWave spectrum. The main objective of this work is to design and realize mmWave antenna operating at Qatar's approved frequency spectrum for mmWave 5G cellular. To achieve this goal, advanced antenna beamformer configuration is first required to be designed and tested for all path loss and blockage scenarios in a full-wave electromagnetic numerical solver like Computer Simulation Technology (CST) microwave studio or High Frequency Structure Simulator (HFSS). Antenna diversity approach is required to then mitigate the EM wave blockages occurring due to presence of obstacles. Comprehensive study is required to ensure over 99% signal coverage in all scenarios of holding a handset. The proposed PhD thesis will be carried out in part in the Centre for Wireless Innovation (CWI), located in the University's Institute of Electronics, Communications and Information Technology (ECIT). The centre hosts a suite of advanced measurement equipment that will allow the doctoral candidate to thoroughly characterize the beamforming solution. **Objectives** 1. Understand the operation of 5G cellular wireless technologies and investigate the frequency and power ranges of mmWave 5G radios in future cities.

	2. Develop antenna unit-cells and beamformers with an emphasis on mutual coupling and antenna efficiency. 3. The optimization of interconnection between antennas and active radio components (amplifier, mixer etc.). 4. Establish measurement campaign to test the mmWave link reliability in urban scenarios. 5. Study and optimization of a beamformer radiation characteristics to achieve the highest throughput This project is best suited to a student interested in practical application of electrical engineering in future smart cities. Student should be motivated to learn basic principles of electromagnetic wave propagation, high frequency electronics and mmWave 5G wireless systems. **Learning Outcomes** Upon completion of the project you will expect to have: 1. Key design features for RF front-end system design 2. A comprehensive knowledge and understanding of high frequency electronics 3. Insight on RF engineering in future cities
Project Keywords	Antenna, array, beamformer, 5G, millimetre-wave, microwave, radio frequency, optimization, 3D-printing, phantom, metamaterial

2.3.2 Precision Location of Tooling Using Wireless Methods

Supervisor	Dr Muhammad Ali Babar Abbasi
Mode of Study	Full Time Distance Learning
Project Overview	Mechanical tools involved in industrial machining require accurate and precise location identification. Before machining process, tools are properly calibrated; however, this calibration deviates as the machining process begins. Re-calibration or manual re-configuration often require excessive time and cost, eventually affecting the overall productivity. In such a context, multiple antenna systems with dozens of radiating elements at the machining heads are extremely attractive solutions to aid in very precise tooling. Moreover, any effective hardware implementation of such systems must rely on a realistic knowledge of hardware impairments and radio propagation / antenna characteristics, especially for difficult environments for which the data available in the most recent literature are very limited.
Project Description: Detailed description of the project	This project aims to design and develop high-precision location monitoring for industrial tooling using small-scale localized microwave antennas. The technique involves active/passive antennas co-located with the machine head, sensing critical variables like size and gaps during the machining and tool-changing processes. Antennas also operate as wireless sensor nodes, making real-time feedback system that enhances the location precision. This project integrates the latest aspects of information and communication technology (ICT) with the classical industrial manufacturing processes to enhance the machining accuracy and productivity. The proposed PhD thesis will be carried out in part in the Centre for Wireless Innovation (CWI), located in the University's Institute of Electronics, Communications and Information Technology (ECIT). The centre hosts a suite of advanced measurement equipment that will allow the doctoral candidate to thoroughly characterize the beamforming solution. **Objectives** 1. Understanding the classifications and operations of wireless technologies 2. Investigating the frequency and power ranges of sensor antenna nodes 3. Understanding the industrial machining standards 4. Investigating precision location methods using antenna(s)/array antenna and performs experiments 5. Investigating the common communication protocol between wireless nodes and tooling system 6. Developing feed-back control system and integrate with the tooling 7. Completing field-trials This project is best suited to a student interested in practical application of electrical engineering in future industries. Student should be motivated to learn basic principles of electromagnetic wave propagation, high frequency electronics and mmWave 5G wireless systems.

	Learning Outcomes Upon completion of the project, you will expect to have: 1. Key design features for RF front-end system design 2. A comprehensive knowledge and understanding of high frequency electronics 3. Insight on RF engineering in future industries
Project Keywords	Antenna, array, beamformer, Industry 4.0, millimetre-wave, microwave, radio frequency, optimization, 3D-printing, metamaterial, mechanical tooling

2.3.3 Leveraging Ambient Energy for Remote Sensing Technologies

Supervisor	Dr Stylianos Asimonis
Mode of Study	Full Time Distance Learning
Project Overview	Envision a situation where monitoring temperature, humidity, movement, and various other parameters becomes seamless through the deployment of hundreds of affordable sensors. These sensors could be distributed across remote locations, for example, dropped from an aircraft, and their collected data could be transmitted to a nearby reader device, potentially attached to a drone, from a distance of hundreds of meters away. The entire system would operate on energy harvested from the environment (like solar or RF energy). The advent of new technologies in low power transmission protocols holds significant promise for establishing large-scale, energy-efficient wireless sensor networks (WSNs). This presents an economical and environmentally friendly alternative to the energy-intensive radio systems traditionally used.
Project Description: Detailed description of the project	This project aims to revolutionize wireless sensor networks (WSNs) by developing an innovative, energy-autonomous system that harnesses solar and RF energy. Utilizing cutting-edge solar panels and RF harvesting techniques, the project will power battery-free sensor nodes capable of monitoring vital signs and environmental conditions. By integrating highly efficient, flexible solar panels and advanced RF energy harvesting systems, alongside superdirective antennas and low-power communication protocols, the project seeks to achieve high sensitivity and energy efficiency. These sensor nodes will be capable of real-time data transmission over long distances without relying on conventional power sources, making them ideal for remote health monitoring and environmental sensing applications. This approach promises to significantly reduce the reliance on battery power, offering a sustainable and cost-effective solution for deploying large-scale sensor networks in diverse settings. **Objectives:** 1. Develop affordable, self-powered sensors for environmental sensing. 2. Create a scalable, energy-efficient data transmission protocol. 3. Utilize solar and RF energy to sustain sensor operations. 4. Innovate superdirective antenna design for enhanced long-range communication and energy efficiency in sensor networks. 5. Demonstrate sensors in hard-to-reach areas with low upkeep, focusing on applications in environmental sensing.
Project Keywords	Wireless Sensor Networks (WSNs), Superdirective Antennas, Environmental Monitoring, Low-Power Communication, Solar-Powered Sensors

2.3.4 Automated Engineering of the Architecture of Mobile Apps for the Fog

Supervisor	Dr Dionysis Athanasopoulos
Mode of Study	Full Time Distance Learning
Project Overview	How could we automate the restructuring of existing mobile back-ends (that are deployable on the Cloud) to microservices that are deployable on resource-constrained devices of the Fog? Could we do it at development-time and/or run-time of apps?
Project Description: Detailed description of the project	While the Cloud offers powerful machines for efficient data-processing, the latency may make the usage of the Cloud a less efficient solution when data are frequently sent to the Cloud. Instead of moving data to the Cloud, we envision the execution of (parts of the) the back-ends of mobile apps close to the end-users' machines, a.k.a., on the Fog. However, it may not be feasible to deploy back-ends with heavy computation requirements on resource constrained machines. In this case, we explore solutions that decompose back-ends into light-weight cohesive loose-coupled components (a.k.a. micro-services) that are deployable on Fog machines. The restructuring of the mobile back-ends could be performed at the development time and/or the runtime of apps. **Tasks:** The project involves the systematic literature review, the identification of the main research gaps in the literature, the (co-)authoring of research papers, the development and the empirical evaluation of the proposed decomposition approach. **Skills**: The skills to be learned in this project are the employment of design principles for software decomposition, the understanding of software quality, the usage of micro-services and RESTful APIs, and the understanding of the Fog/Cloud computing.
Project Keywords	Fog/Cloud computing, microservices, mobile apps, back-ends, software, architecture, design principles, and software restructuring

2.3.5 Serverless Fog Computing: From Microservices to Nanoservices

Supervisors	Dr Dionysis Athanasopoulos
Mode of Study	Full Time Distance Learning
Project Overview	Fog computing can support services with fast response time and low bandwidth usage by moving computation from the cloud to edge devices. However, existing fog computing frameworks do not support dynamic data-oriented service composition. On the contrary, the design and the deployment of services is bound to specific edge devices. This approach requires service developers to statically define which service modules should be deployed on which type of edge devices. However, different service modules may need to get triggered dynamically according to the exchanged data.
Project Description: Detailed description of the project	**Function-as-a-Service** (FaaS) is a promising programming model for fog computing to offer dynamic service composition based on **nanoservices**. The challenge in this project is to offer automated mechanisms that design/redesign existing software into nanoservices that follow the FaaS Model. **Useful Readings:** 1. Bin Cheng, Jonathan Fürst, Gürkan Solmaz, Takuya Sanada: Fog Function: Serverless Fog Computing for Data Intensive IoT Services. SCC 2019: 28-35 2. Google Serverless Computing (https://cloud.google.com/serverless/) 3. AWS Lambda (https://aws.amazon.com/lambda/) **Objectives:** 1. A systematic literature review of the research domains of serverless computing, nanoservices and the FaaS model 2. Identify the main gaps in the research on the above domains 3. Propose automated mechanisms for the design/redesign of software suitable for the serverless fog and the dynamic nanoservice composition 4. Employ/extend existing serverless platforms to deploy the constructed nanoservices and to coordinate the dynamic composition 5. Conduct empirical evaluation of the constructed nanoservices
Project Keywords	Fog computing, nanoservices, serverless computing

2.3.6 Empirical Elasticity in the Hybrid Cloud

Supervisors	Dr Dionysis Athanasopoulos
Mode of Study	Full Time Distance Learning
Project Overview	Over the last few years, Infrastructure as a Service (IaaS) has become widely available with service provides such as Amazon, Microsoft and Google. These IaaS providers allow you to deploy services where your users get the best quality of service. However, IaaS providers can be expensive, and many companies still have powerful computing and storage resources from before clouds popularity growth. These resources are usually located close or at the edge of the network (a.k.a. at the Fog).
Project Description: Detailed description of the project	The cloud providers currently offer platforms for the elastic orchestration of containers (e.g. **Kubernetes**). However, those platforms do offer empirical/predictive (proactive) promotion and demotion of the ephemeral (reactive) elastic deployments at runtime between the **Fog** and the **Cloud**. The challenge in this project is to extend the Kubernetes platform (esp. **KubeEdge**) to offer empirical algorithmic and platform elasticity at runtime for the hybrid cloud. **Useful Readings:** 1. Emiliano Casalicchio: A study on performance measures for auto-scaling CPU-intensive containerized applications. Cluster Computing 22(3): 995-1006 (2019) 2. Kubernetes – Scheduling Future at Cloud Scale (https://ai.google/research/pubs/pub43826) 3. KubeEdge, a Kubernetes Native Edge Computing Framework (https://kubernetes.io/blog/2019/03/19/kubeedge-k8s-based-edge-intro/) **Objectives:** 1. A systematic literature review of the fog and cloud elasticity, along with the orchestration of containers 2. Identify the main gaps in the research on the runtime elasticity for the hybrid cloud 3. Establish a predictive model (e.g. mathematical or machine-learning model) for runtime predictions 4. Implement mechanisms that realise the empirical promotion and demotion of the ephemeral elastic deployments between the Fog and the Cloud. 5. Extend the Kubernetes and the KubeEdge platforms to offer the empirical elasticity 6. Conduct empirical evaluation of the constructed model and mechanisms.
Project Keywords	Hybrid cloud, elasticity, Fog computing, software deployment, Kubernetes

2.3.7 Antenna Designs for the Space Solar Satellite

Supervisors	Dr Neil Buchanan
Mode of Study	Full Time at QUB
Project Overview	The Space Solar Satellite promises to offer 24/7 clean energy by harvesting the sun's energy via a satellite in space and beaming down to earth using microwaves. Government studies have shown the system to be viable, yet a considerable research is needed to make it a reality. In particular novel antenna designs are needed for the antenna arrays on the satellite and the rectifying antennas on the earth.
Project Description: Detailed description of the project	Project Description: • Investigate suitable antenna elements that could be used as part of a space based solar power phased array. These elements need to exhibit low mutual coupling when operated as an array. They could also be electronically reconfigurable for different beam shapes, or frequency ranges. • Investigate suitable beam forming circuits that can allow electronic steering of the antenna array with a high degree of accuracy. Trade off between using analogue beamformers versus software defined radios. • The antenna arrays will be simulated using software such as CST microwave studio and Matlab. • Practical demonstrators will be built of the selected antenna options which will be measured in the anechoic chamber at Centre for Wireless Innovation, titanic Quarter. • Other aspects of the PhD could include design of the rectifying antennas on the earth which are used to convert the microwave power into DC power.
Project Keywords	Antenna Arrays, Space Based Solar Power

2.3.8 Deep Learning Approaches to High Dimensional Image Compression in Digital Pathology

Supervisors	Dr Richard Gault (EEECS) & Professor Iain Styles (EEECS)
Mode of Study	Full Time Distance Learning
Project Overview:	Deep generative models provide the framework for data driven feature representation and the extraction of the fundamental building blocks of high dimensional data. These modelling approaches create a mapping between real world data, such as images, to feature representations whilst maintaining an algorithmic way to translate between the two domains with high fidelity. This approach has been exploited to address the data compression challenge. In areas such as digital pathology, huge volumes of data are amassed quickly and are computationally challenging to process. This project aims to develop novel computational models to address the increasing problem of data size in the digital pathology sector.
Project Description: Detailed description of the project.	The advances, and increasing adoption, in whole slide and multiplex Immunohistochemistry/Immunofluorescence imaging technologies has resulted in very large data storage requirements for the digital pathology sector. A single whole slide image may generate 25GB data. The collection of multiple images per patient followed by multiple stages of analysis means that the volume and computational demands rapidly increase. Deep learning approaches have shown potential for decomposing large data files into fundamental feature representations which can be stored as a minimalist record of the data. Deep generative models, such as Generative Adversarial Networks (GANs) or auto encoders, can learn an appropriate feature representation for a given domain. This can be beneficial for domain specific tasks but limit the potential for cross domain generalisation. The successful candidate will have the opportunity to develop skills in state-of-the-art high performance computing including the utilisation of the UK national Tier 2 System at QUB (NI-HPC, Kelvin 2) and later the UK national Tier 1 facilities for big data analytics. This project aims to exploit the characteristics of digital pathology image data to create novel solutions to the image compression problem using unsupervised deep learning methods. This will involve undertaking research in the area of artificial intelligence and demonstrating the efficacy of the resulting research in the digital pathology domain. **Objectives**: The focus of the project will be to develop novel artificial intelligence methods with the following specific objectives: • Develop a novel image compression approach to handle high dimensional images generated from multiplex immunohistochemistry/ Immunofluorescence. • Extend the developed model to account for inter-domain variability (e.g. inter-scanner variability, variations in lab protocols).

	• Exploit the compressed feature representation of the data to enable efficient analysis of multiplex immunohistochemistry/ Immunofluorescence images. **References:** S. Ma, X. Zhang, C. Jia, Z. Zhao, S. Wang and S. Wang, "Image and Video Compression With Neural Networks: A Review," in IEEE Transactions on Circuits and Systems for Video Technology, vol. 30, no. 6, pp. 1683-1698, June 2020, doi: 10.1109/TCSVT.2019.2910119. D. Jiménez-Sánchez, M. Ariz and C. Ortiz-de-Solórzano, "Unsupervised Learning of Contextual Information in Multiplex Immunofluorescence Tissue Cytometry," 2020 IEEE 17th International Symposium on Biomedical Imaging (ISBI), Iowa City, IA, USA, 2020, pp. 1275-1279, doi: 10.1109/ISBI45749.2020.9098352.
Project Keywords:	Deep learning, unsupervised learning, computer vision, Digital Histopathology, image compression

2.3.9 A Common Approach to the Mining of Software Repository Data

Supervisors	Dr David Cutting and Dr Des Greer
Mode of Study	Full Time Distance Learning
Project Overview:	Software repositories contain significant amounts of information about the evolution of a software project, including changes to code (and intermediate versions) as well as extensive metadata such as who made such changes, when, and what reason they gave. The mining of software repositories (MSR) is an established approach to gain insight into systems by gathering and analysing data about their evolution contained in such repositories. However, limiting adoption of MSR is that each repository system stores data in a different format and the formats of output are not designed for easy machine readability. The Common Language Of Software Evolution in Repositories (CLOSER) aims to address these issues through the creation, implementation, testing and validation of a common format to store evolutionary meta data from repositories, lowering the barriers to MSR and allowing multiple repository formats to be used in a common analysis.
Project Description: Detailed description of the project.	The Common Language Of Software Evolution in Repositories (CLOSER) aims to address several open issues in the field of historic software analysis. While there has been significant work undertaken in using the large amount of data stored in software repositories (aka version control systems) the reproducibility and general applicability is often undermined by the different repository technologies used. Two implemented approaches that target different repository technologies simply cannot be used on the same project for complimentary or comparison purposes. At the same time significant effort is often put into parsing the textual repository information for each implemented approach leading to a lot of effort "reinventing the wheel". The first stage of this project will be to build on existing work at QUB and continue to analyse the most commonly used repository technologies and refine the unified framework able to represent metadata from different repository technologies into an extensible common domain-wide form, identifying which elements are common and which additional technology-specific elements will need to be persisted but not part of the common set. A number of language implementations and proof-of-concept parsers will be created to demonstrate this technology and implemented with existing solutions available for repository analysis. Once CLOSER has been improved and fully implemented the approach will be used to further develop existing approaches to utilising metadata from repositories to identify semantic links between software elements using concepts such as co-committal inference (the possibility that elements which are often changed together are somehow linked). These semantic links will be combined with other available data sources, for example from static and dynamic analysis of the code with industry-standard tools, to

	gain a combined nuanced model of the relationship of elements within a software system from a variety of perspectives. This relationship model will be applied in the domain of change impact analysis (CIA) with the goal of further improving CIA techniques using multiple information sources. The rich picture formed from multi-source relationship mapping can also be used to analyse code quality identifying highly-coupled elements which are not obvious from code alone and to make better evolutionary visualisation projections. Numerous other opportunities exist to use such a model including prediction of change-prone areas of code and code quality metrics. This project will be in collaboration with BT Research who will provide industrial guidance and case studies. They will also host the PhD candidate on collaboration visits to their Martlesham headquarters as required. The project will be co-supervised at QUB by Dr David Cutting and Dr Des Greer, with external input from Dr Joost Noppen of BT Research. **Objectives** 1. Refine CLOSER a. Based on existing CLOSER implementation, analyse common repository technologies (including git, SVN, and CVS) to identify their metamodel concepts and overlaps between them (the common model) to validate the model. b. Generate an ontology of the common model and additional technology-specific elements. c. Update the proof-of-concept CLOSER parser and model representation as required. 2. Demonstrate CLOSER on existing repository analysis tools provided a. Augment tools to support CLOSER b. Demonstrate and benchmark tools working on their existing technology with CLOSER representation c. Demonstrate and benchmark tools working on an alternative technology through CLOSER representation d. Evaluate the CLOSER model and improve as required 3. Investigate if the CLOSER model (using tool support) can be used to give useful results in Change Impact Analysis using industrial data 4. Expand change impact analysis approaches a. Include a generic framework for third-party analysis b. Include dynamic source analysis c. Evaluate the approach 5. Determine if the model can be used to predict code and project qualities 6. Implement demonstrations of the relationship model (for example through visualisation)
Project Keywords:	Software Engineering, Software Evolution, Mining of Source Code Repositories, MSR

2.3.10 Software Engineering for Artificial Intelligence and/or Machine Learning (SE4AI/ML)

Supervisor	Dr Zheng Li
Mode of Study	Full Time at QUB
Project Overview	Despite the advance of high-performance parallel hardware like GPUs and FPGAs, artificial intelligence (AI) and machine learning (ML) systems are mainly software systems with functionalities enabled by one or more AI/ML components. Although sometimes AI is considered to be directly embedded in hardware devices (e.g., robots, cars, drones, etc.), it is essentially the "soft" algorithms, data, and programs that drive the bare-metal devices to work, not to mention that many AI/ML systems "can be purely software-based, acting in the virtual world (e.g., voice assistants, image analysis software, search engines, speech and face recognition systems)" [1]. However, it is evident that a disproportionately larger amount of effort is being invested in the hardware infrastructure development over the software stack development in the AI/ML domain. The imbalance between efforts on hardware and on software has been estimated to be as high as 80:20, while such a bias is clearly irrational, for their both fundamental impacts on AI/ML jobs. Worse still, such a bias might indicate the existence of software crisis brewing in the AI/ML ecosystem, not to mention that gigantic hardware resources could unexpectedly cause gigantic software problems [2]. Therefore, it is crucial and valuable to investigate software engineering best practices, patterns, principles, and theories for developing and deploying high-quality AI/ML systems.
Project Description: Detailed description of the project	This project will focus on one or more software aspects of development and evolution of AI system, to advance the emerging discipline software engineering for AI (or AI engineering). The specific research topic will be further discussed and determined based on the student's interests and knowledge base. For example, the potential research questions include but not limited to: • How can correctness or usefulness of a system with an AI component be specified or evaluated? • How to collect requirements for AI-enabled systems? • How to analyse and mitigate wrong results and how to design robust systems? • How to properly modularise AI systems and/or further modularise the AI components of an AI system? • How and where to deploy models, how and when to update models, and what telemetry to collect? • How to design learning and evaluation infrastructure that scales? • How to compose multiple AI components within a system and detect feedback loops? • What does software architecture for AI-enabled systems look like? • How to detect poor data quality, poor model quality, and data drift? • What would unit testing for data look like?

	• How to assure quality of an AI-enabled system? • How would test automation look like to test correctness of infrastructure or models? • How to assure fairness and privacy of AI-enabled systems? **References:** [1] European Commission, "A definition of AI: Main capabilities and scientific disciplines". Available online: https://ec.europa.eu/futurium/en/system/files/ged/ai_hleg_definition_of_ai_18_december_1.pdf [2] Ebert C (2018) "50 years of software engineering: progress and perils". IEEE Softw 35(5):94–101.
Project Keywords	Software Engineering, Artificial Intelligence, Machine Learning, Design Pattern, Architectural Tactics

2.3.11 IoT-Native Software Engineering

Supervisor	Dr Zheng Li
Mode of Study	Full Time at QUB
Project Overview	The Internet of Things (IoT) is widely recognised as the third technological revolution (after the Industrial and Internet Revolutions) [1] or as part of the fourth industrial revolution (after the Steam, Electricity, and Digital Revolutions) [2]. Particularly, the European Commission places IoT to be at the centre of the digitisation of the world economy [3], and the US National Intelligence Council lists IoT as one of six breakthrough technologies that have significant impacts on the US interests [4]. Considering that software is defining everything and dominating the world [5], software systems play a key role in the IoT revolution and its future evolution. On the other hand, the tremendous challenges of blending the physical and virtual worlds in turn affect the development of supporting software systems to IoT. As such, it has been identified that IoT "is pulling software engineering further and further from the comfort zone of principles and techniques that have prevailed for many decades" [6]. This can be discussed more specifically by using the "4+1" view model of software architecture [7]. For example, IoT software systems encounter a new Physical View. The physical view is concerned with the deployment of software components as well as the physical connections between these components, which can be further distinguished between two perspectives in the context of IoT. From a single software component's perspective, individual IoT devices generally have limited compute, storage, and network capabilities. From a whole software system's perspective, IoT involves non-scalable integration of heterogeneous technologies produced by different manufacturers. Unfortunately, the literature regarding the engineering of IoT software systems is still sparse. Compared to the IoT-native research and practice in the database community [9], the IoT-oriented efforts on software engineering seem to have left behind. Therefore, we promote "IoT-native Software Engineering" to indicate the unique needs and the dedicated development of software engineering in the age of IoT.
Project Description: Detailed description of the project	This project will mainly focus on the innovation of IoT-native software engineering from the Development View of the "4+1" view model. The development view is concerned with the software implementation, (module) organisation, and management. In fact, it has been identified that dedicated efforts, techniques, and theories are needed for engineering IoT software systems. And there are already some promising research directions pointed out in the community. For example, a just-for-me principle would be worth following to break the monolithic orchestration mechanism of both development methods [1] and software components [8]; mixing and matching various development methods would become an innovative way to deliver suitable IoT solutions [1]; and brand-new protocols for discovering, accessing, and coordinating things and the relevant software components would be crucial and valuable [6]. Please note that the specific research topic of this project will be further discussed

	and determined based on the student's interests and knowledge base. So, please feel free to open your mind and identify/propose more specific research problems along this research direction. **References:** [1] I. Jacobson, I. Spence, and P.-W. Ng, "Is there a single method for the Internet of Things? essence can keep software development for the IoT from becoming unwieldy." Queue, vol. 15, no. 3, pp. 25–51, May-June 2017. [Online]. Available: https://doi.org/10.1145/3121437.3123501 [2] P. Ross and K. Maynard, "Towards a 4th industrial revolution," Intelligent Buildings International, vol. 13, no. 3, pp. 159–161, 2021. [Online]. Available: https://doi.org/10.1080/17508975.2021.1873625 [3] European Commission, "The next generation Internet of Things," https://digital-strategy.ec.europa.eu/en/policies/next-generation-internetthings, 3 January 2023. [4] US National Intelligence Council, "Disruptive civil technologies: Six technologies with potential impacts on us interests out to 2025," https://apps.dtic.mil/sti/citations/ADA519715, 1 April 2008. [5] X. Zhu, B. Song, Y. Ni, Y. Ren, and R. Li, "Software defined anything–from software-defined hardware to software defined anything," in Business Trends in the Digital Era. Singapore: Springer, June 2016, ch. 5, pp. 83–103. [6] J. L¨u, D. S. Rosenblum, T. Bultan, V. Issarny, S. Dustdar, M.-A. Storey, and D. Zhang, "Roundtable: The future of software engineering for internet computing," IEEE Software, vol. 32, no. 1, pp. 91–97, Jan.-Feb. 2015. [7] P. B. Kruchten, "The 4+1 view model of architecture," IEEE Software, vol. 12, no. 6, pp. 42–50, November 1995. [8] Z. Li and R. Ranjan, "Just enough, just in time, just for "me"': Fundamental principles for engineering IoT-native software systems," in Proceedings of the ACM/IEEE 44th International Conference on Software Engineering: New Ideas and Emerging Results (ICSE-NIER 2022). Pittsburgh, Pennsylvania, USA: Association for Computing Machinery, 2022, pp. 56–60. [Online]. Available: https://doi.org/10.1145/3510455.3512785 [9] The Apache Software Foundation, "Apache IoTDB: Databse for Internet of Things," https://iotdb.apache.org/, 2023.
Project Keywords	Software Engineering, Internet of Things, "4+1" View Model

2.3.12 Big Data Gravity and Friction Management

Supervisor	Dr Zheng Li
Mode of Study	Full Time at QUB
Project Overview	The emerging age of big data is leading us to an innovative way of understanding our world and making decisions. As the name suggests, this "big data" age comes with a stunning and continuous data growth. For example, it has been estimated that 2.5 quintillion bytes of data are produced by humans every day (there are 18 zeros in a quintillion), and 463 exabytes of data will be generated each day by humans as of 2025. Such a data growth brings tremendous challenges to data management that plays a prerequisite role in business intelligence and big data analytics (BDA). It is worth noting that when implementing BDA, there are inevitably more challenges than traditional data analytical scenarios. On one hand, big data itself can cause significant performance problems in application programs in general, especially when involving databases. On the other hand, following the No-Free-Lunch theorem, various data types and analytical demands might require completely different BDA applications involving different time and space complexities. For example, de facto BDA workload characteristics extremely vary, and the typical ones include batch processing for offline analytical jobs, stream processing for real-time processing of data, query-processing with transactional features, and even a combination of them. Driven by the needs and challenges of BDA (that essentially reveals the potential values of datasets and completes the value chain of big data), it is crucial and valuable to investigate effective and efficient techniques, strategies, patterns, and theories of big data management.
Project Description: Detailed description of the project	Big data management is the organisation, administration, and governance of large volumes of both structured and unstructured data. This project will mainly focus on the "data gravity" and "data friction" to investigate big data management. Data gravity refers to the tendency of data to accumulate and attract further data and applications, which may trigger difficulty and extra cost when moving data away from its storage. Data friction is a resistance that impedes the transfer of data between systems, which may result in processing delays, increased costs, and higher energy consumption. Despite their disadvantages, different levels of data gravity and data friction would be needed when dealing with different types and/or techniques of BDA jobs. For example, the privacy-critical BDA scenarios will require a high level of data friction, while the quantum computing-based BDA solutions will favour heavy data gravity. Note that the specific research topic of this project will be further discussed and determined based on the student's interests and knowledge base. For example, you may want to develop a generic big data management framework that considers all kinds of BDA logic; or you may focus on a specific BDA scenario to manage and/or optimise data gravity and friction, e.g., for a hybrid BDA job that involves both Edge computing and Quantum

	computing. So, please feel free to open your mind and have your specific proposal(s) along this research direction.
Project Keywords	Big data analytics, big data management, data gravity, data friction, quantum computing, software engineering

2.3.13 On Sociopsychological Software Engineering

Supervisor	Dr Zheng Li
Mode of Study	Full Time at QUB
Project Overview	This is an interdisciplinary project recently proposed by the researchers from School of EEECS and School of Psychology. The motive of such a project is to address the gap in the current software engineering research, i.e., the "WHY" is largely missing in the empirical software engineering lessons. This can be observed even by the relevant definitions of empirical software engineering: • Empirical Software Engineering is a subfield of software engineering (SE) research that uses empirical research methods to study and evaluate an SE phenomenon of interest. • Evidence-Based Software Engineering is concerned with using findings from empirical research (based on observation and experimentation) to determine WHAT software engineering practices, tools and standards work, and the situations WHEN and WHERE they work. • Considering the human-intensive nature of software engineering, the answers to WHY behind many software engineering lessons can be obtained within the psychology domain. For example: 1. Why is Agile more successful? Because tighten feedback loops increase all the stakeholders' confidence in the software projects. 2. Why should we limit the to-do items in every iteration? Because a long to-do list will make us feel tired even before we do anything yet. 3. What software design makes TikTok addictive? Many reasons are related to the (weaknesses of) human nature, e.g., the curiosity will drive users to wonder what is next. Why do developers tend not to shut down their computers overnight? Because context switching can be psychologically disturbing.
Project Description: Detailed description of the project	This project aims to understand and explain the current practices (in addition to knowing them via empirical studies) of, reveal insightful and sociopsychological lessons of, and strengthen and enrich the fundamentals of, software engineering. Driven by this aim, there are roughly six objectives: 1. Characterise and clarify "sociopsychological aspects of software engineering" (against, e.g., behavioural software engineering). 2. Examine different software processes and identify software engineering practices where sociopsychology may apply. 3. Build a hierarchical reference model to classify and organise the identified software engineering practices for sociopsychological investigation. 4. Develop a dedicated research methodology for sociopsychological software engineering. 5. Explore the existing social and/or psychological theories to try explaining the relevant software engineering practices. 6. Use the previously defined methodology to guide empirical studies to prove/confirm/deny the explanation trials.

	Please note that this project is still at an early stage, and thus the term "sociopsychological software engineering" could be replaced with another proper name after the first objective is achieved.
Project Keywords	Human aspects of software engineering, psychology, sociopsychology, empirical software engineering

2.3.14 Space-Time Coding Arrays for THz Communications

Supervisor	Dr Mohammad Neshat
Mode of Study	Full time at QUB or Distance Learning
Project Overview	**Overview** Future generation of wireless communications, also known as 6G, will rely on THz bands, which offers unprecedented possibilities. Current front-end architectures are not mainly suitable for THz band applications, as they would be either too expensive or impractical. Space-time coding arrays are one of the concepts that can be exploited to mitigate the complexity and cost of the front-end architecture in THz band. Space-time coding arrays enable different adjustments in 4 dimensions, namely space and time, on the waves that interact with the array, depending on the particular communications or sensing application.
Project Description: Detailed description of the project	This project aims to design, fabricate and test of a coding meta-surface that can be dynamically controlled in space and time. The goal is to use such meta-surface as part of a transmitter front-end to modulate/steer an interacting THz carrier wave for sending data. **Objectives** • Developing a fast switching scheme that can be integrated into the unit cells of the meta-surface • Designing unit cells with changing state to affect phase/amplitude of the interacting wave • Design, fabrication and test of the whole meta-surface and the associated state control unit • Establishing a point-to-point connection to transmit data from the meta-surface to a receiver, and examining the received signals • Improving the entire system to achieve the optimal performance in data rate and beam steering capability
Project Keywords	Terahertz, Communications, Space-Time Coding, 6G

2.3.15 EnhancerNet: AI for Predicting Gene Enhancer Functionality

Supervisor	Dr Reza Rafiee (EEECS) & Dr Yaser Atlasi (MDBS)
Mode of Study	Full time at QUB
Project Overview	This PhD project develops EnhancerNet, an AI model to predict enhancer functionality from DNA sequences, similar to language model training. It aims to improve understanding of gene regulation and support targeted treatments by accurately identifying and explaining enhancer activities in various cell types, leveraging intricate data patterns.
Project Description: Detailed description of the project	Gene enhancers are crucial DNA sequences that control when and where genes are activated in cells. Despite ongoing research, accurately identifying enhancers just from DNA sequences remains challenging. This PhD project aims to explore and create an AI model, EnhancerNet, to predict enhancer functionality effectively. Similar to how language models like GPT-3.5 work, EnhancerNet will be trained on a dataset of enhancer sequences and their activities in specific cell types. By learning from this data, EnhancerNet will comprehensively understand the intricate patterns found within enhancer sequences and their functional roles. We will fine-tune the model to boost its accuracy and ability to generalise. Once trained, EnhancerNet can predict the activity of new enhancer sequences in different cell types, prioritise enhancers for lab tests, and explain how genetic changes in enhancers affect gene regulation. This AI model has the potential to deepen our understanding of gene regulation and aid in developing targeted treatments in genetics and molecular biology. **References:** askiran, I.I., Spanier, K.I., Dickmänken, H. et al. Cell-type-directed design of synthetic enhancers. Nature 626, 212–220 (2024). https://doi.org/10.1038/s41586-023-06936-2 de Almeida, B.P., Schaub, C., Pagani, M. et al. Targeted design of synthetic enhancers for selected tissues in the Drosophila embryo. Nature 626, 207–211 (2024). https://doi.org/10.1038/s41586-023-06905-9 Wolfe, J.C., Mikheeva, L.A., Hagras, H. et al. An explainable artificial intelligence approach for decoding the enhancer histone modifications code and identification of novel enhancers in Drosophila. Genome Biol 22, 308 (2021). https://doi.org/10.1186/s13059-021-02532-7 de Almeida, B.P., Reiter, F., Pagani, M. et al. DeepSTARR predicts enhancer activity from DNA sequence and enables the de novo design of synthetic enhancers. Nat Genet 54, 613–624 (2022). https://doi.org/10.1038/s41588-022-01048-5
Project Keywords	EnhancerNet, Gene Enhancer Functionality, AI Model Prediction, Gene Regulation, Molecular Biology

2.3.16 Efficient Machine Learning on Encrypted Data via Arithmetic Optimizations

Supervisor	Dr Amir Sabbagh Molahosseini
Mode of Study	Full time at QUB or Full Time Distance Learning
Project Overview	This project aims to develop an efficient implementation of Fully Homomorphic Encryption (FHE) to enable secure machine learning (ML) on encrypted data. Leveraging arithmetic optimizations and innovative techniques, it seeks to enhance the speed and accuracy of ML computations while ensuring data privacy and security.
Project Description: Detailed description of the project	In today's era of pervasive computing, protecting sensitive information has gained paramount importance. Fully Homomorphic Encryption emerges as a promising cryptographic approach to tackle this crucial challenge. FHE enables data to remain encrypted while supporting arithmetic computations, allowing users or low-end Internet-of-Things (IoT) devices to encrypt data and then transmit it to a third party or cloud server for secure machine learning computations. Subsequently, the computation results can be sent back to authorized parties for decryption. This process facilitates privacy-preserving and secure data analytics. However, conducting ML on encrypted data remains significantly slower than performing ML on unencrypted data by several orders of magnitude. Thus, the efficient implementation is pivotal to the practical use of FHE for encrypted ML. The objective of this project is to achieve an efficient implementation of FHE by employing arithmetic optimizations. This implementation aims to enable both efficiency and accuracy in machine learning on encrypted data. Throughout this project, a variety of techniques, including approximate computing, software-defined arithmetic, and residue number systems, will be utilized to realize high-performance and practical implementations of FHE for machine learning on encrypted data.
Project Keywords	Homomorphic Encryption, Machine Learning, Computer Arithmetic

2.3.17 Condition Monitoring of Civil Structures Using Sensor Network

Supervisor	Dr Hamza Shakeel
Mode of Study	Full time at QUB
Project Overview	This project aims to develop advanced techniques for condition monitoring of civil structures such as buildings using inertial sensors like accelerometers and gyroscopes. The research will focus on real-time data analysis and machine learning algorithms to detect and predict structural health issues for timely maintenance interventions.
Project Description: Detailed description of the project	In this project, the student will deploy relatively low-cost inertial sensors strategically across the structure to capture comprehensive data on structural dynamics. The student will implement a real-time monitoring system integrated with appropriate machine learning based algorithms for continuous assessment of structural health. The project will develop predictive maintenance strategies based on the detected anomalies and degradation trends to optimize maintenance scheduling and minimize downtime.
Project Keywords	Condition Monitoring, IoT, Sensors, Machine Learning

2.3.18 Artificial Intelligence Enhanced Safety Critical Control for Trustworthy Autonomous Systems

Supervisor	Dr Mien Van
Mode of Study	Full Time Distance Learning
Project Overview	Unmanned Autonomous Vehicles (UAVs) (incl. ground, aerial, underwater and surface vehicles) and teams of UAVs are being extensively applied for many practical applications that are too dangerous or unsuitable for humans, such as environmental monitoring, security surveillance, search-and-rescue missions, etc. The challenge with UAV systems, however, is that they (i) consist of many interdependent components, (ii) operate in highly uncertain environments and (iii) exhibit complex dynamics. This complex interdependency introduces new vulnerabilities within AV systems that are sometimes impossible to predict. As such, a single undetected fault in actuators, sensors or the communication network can lead to catastrophic events, including physical system damage and/or intelligence leakage, endangering human lives. Therefore, safety critical control is very important to guarantee the safe operation of UAVs during manoeuvring.
Project Description: Detailed description of the project	Unmanned Autonomous vehicles (UAVs) have been extensively applied for many practical applications. It is thus necessary to develop a new theory of safety critical control for UAVs to guarantee resilience and safety against errors, uncertainties and disturbances. In this project, a new theory of learning-based safety critical control will be developed to mitigate or even eliminate the effects of the errors and disturbances during autonomous operations. The safety critical control is employed to guarantee that the UAV will always operate within the designed safe zones during manoeuvring. Meanwhile, learning algorithms will be explored to model the uncertainty sources and integrate them within the safety critical control. This will enhance the precision of the tracking control system and the safety of UAVs during manoeuvring. The objective of the project is as follows: • To design a safety critical control algorithm based on Barrier Lyapunov function or Control Barrier Functions theory. • To design a machine learning technique, for example Bayesian learning method, to learn model uncertainty and integrate with safety critical control • To analyse the stability and performance of the system.
Project Keywords	Safety critical control, Safety critical systems, learning-based safety critical control, autonomous vehicles, tracking stability

2.3.19 Online Performance Optimisation Through Algorithmic Choice

Supervisor	Professor Hans Vandierendonck
Mode of Study	Full Time at QUB
Project Overview	To investigate the challenges and opportunities for machine-learning based online performance optimisation, and designing novel algorithms and systems software that addresses these challenges.
Project Description: Detailed description of the project	Problems in computer science tend to be solved by multiple algorithms that have best performance under different circumstances. Which algorithm exhibits the shortest execution time often depends on a number of factors, including data set characteristics such as their size, algorithmic parameters, and the processor and memory organisation. A common example is sorting, where the optimal choice between merge sort, quicksort and radix sort varies with the length of the sorted array. When it is desired to develop fast code, the lack of clarity on the best algorithm leads to sub-optimal choices. This project will pursue a novel approach based on online unsupervised learning, to determine which algorithmic variant is most efficient during the execution of a program. Each time an algorithm needs to be invoked, online performance data is collected, which can be used to train a machine learning model online. Some of the challenges include: (i) unsupervised learning to avoid performance losses associated to collecting ground truth data; (ii) extremely fast training and inference to cater for microsecond-scale algorithms; (iii) automatically identifying relevant features to train the predictor. The purpose of this PhD project is to explore open issues in this domain and demonstrate performance improvements, performance portability and adaptiveness to changes in data sets and algorithm implementations.
Project Keywords	High-performance computing, transprecise computing, algorithmic choice, online machine learning and performance optimisation

2.3.20 High-Performance Graph Processing

Supervisor	Professor Hans Vandierendonck
Mode of Study	Full Time at QUB
Project Overview	To investigate key performance and scalability issues of computing analytics on large-scale graph-structured data sets, and designing novel algorithms and systems software to address those challenges.
Project Description: Detailed description of the project	Many disciplines rely heavily on the efficient analysis of graph-structured data, e.g., bio-informatics and computational genomics, cybersecurity, epidemiology, biology, and social sciences. Graphs can become very large, prompting the use of clusters of computers to achieve fast turn-around times. However, clusters pose multiple challenges to efficient computation, in particular for graph analytics. Very often, graphs have skewed degree distributions, making it hard to partition them properly across the nodes of the cluster. Poor partitioning inflates network communication volume, increases workload imbalance and potentially results in redundant work. Graph analytics are very often communication-bound and spend significant time waiting on network communication to complete. The aim of this PhD project is to analyse and design efficient algorithms for NP hard graph analytics problems, such as subgraph isomorphisms, clique and cover problems. The project will investigate novel algorithms and their implementation on distributed graph processing systems, paying attention to both (theoretical) algorithmic techniques and their efficient implementation. Hereto, it can build on our prior research on graph processing, including the GraphGrind, LaganLighter and Graptor graph processing systems, and research results on clique and graph isomorphism problems.
Project Keywords	High-performance computing, graph processing

2.3.21 Confidence, Predictivity and Biomarker Detection to Enhance the Usability of Breast Cancer Computer Aided Diagnosis

Supervisor	Professor Hui Wang
Mode of Study	Full Time Distance Learning
Project Overview	Computer-aided diagnosis (CAD) is a computerized procedure for medical image analysis to provide a second objective opinion in interpretation of medical images to aid medical decision-making. CAD has the potential to save time and/or as a tool to provide an objective second opinion, although this potential has not been fully realized due largely to the usability problem. Two reasons for the problem can be identified. One is that CAD systems lack a reliable confidence measure for its prediction. Machine learning models usually output a confidence score for any prediction, but the correlation between the confidence and the probability of the prediction being true is generally low; in other words, the predictivity of the confidence score is low. Therefore, the availability of the confidence score does not increase the usability of CAD. Another reason for the usability problem is that the machine learning model for a CAD system is typically not a model of the biomarker of a disease, thus the model may only work well in the closed world implied by the data used to train the model.
Project Description: Detailed description of the project	This project will tackle this usability problem with a deep learning framework. We will research how to measure confidence of individual predictions and how to measure predictivity of the confidence in order to obtain a highly predictive confidence measure through optimisation. We will also research how to build machine learning models for biomarkers. Based on the research findings we will develop a breast cancer CAD system and validate it in collaboration with partners in a Northern Ireland hospital. **Objectives:** 1. Design of a confidence measure. Contextual probability will be considered. 2. Design of a predictivity measure, which can be incorporated into the loss function of deep learning. 3. Development of deep learning architecture that can learn models for disease biomarkers. 4. Demonstration of research findings in a research prototype for computer aided diagnosis. **Note**: this PhD project is a continuation of an EU Horizon 2020 project on breast cancer image analysis. **References**: 1. Decision Support and Information Management System for Breast Cancer (DESIREE). H2020 PHC-30-2015, 1 Feb 2016 – 31 July 2019. http://desiree-project.eu 2. Andrik Rampun, Hui Wang, Reyer Zwiggelaar, Bryan Scotney, Philip Morrow (2018). Confidence Analysis for Breast Mass Image Classification. IEEE International Conference on Image Processing 2018. 3. Andrik Rampun, Philip J. Morrow, Bryan W. Scotney, Hui Wang (2020). Breast density classification in mammograms: An investigation of

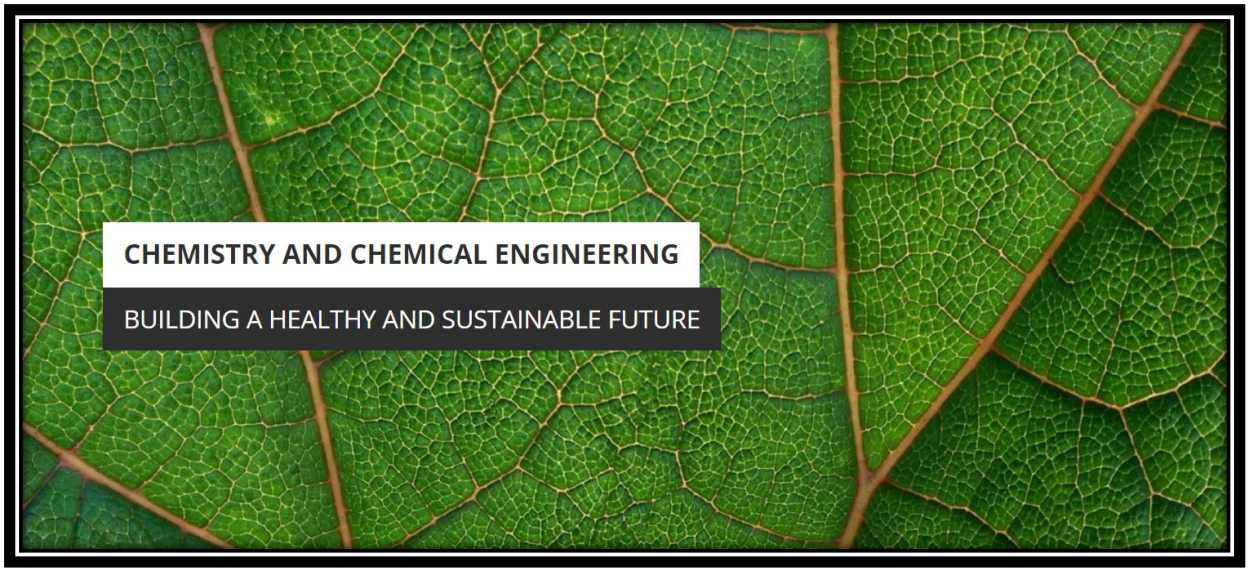
	encoding techniques in binary-based local patterns, Computers in Biology and Medicine, 122:103842
Project Keywords	Machine learning, medical image analysis, computer aided diagnosis, confidence, predictivity, biomarker detection

2.3.22 AI-Assisted Accelerator Design for FPGA Technologies

Supervisor	Dr Yun Wu
Mode of Study	Full time at QUB
Project Overview	FPGA targets are of high interest for acceleration of tasks where processed data is composed of numbers with reduced quantification or with custom representation (such as highly-parallel and quantized AI tasks, approximate computing, etc.). This opens new opportunity to re-think how micro-architectures can be efficiently synthesized for FPGA technologies, in particular how base blocks of arithmetic/algebra accelerator can be designed, scaled and adapted to various FPGA technologies. The challenge consists in the design of micro-architectures that can be assembled in a scalable way to compose large accelerator block. Dedicated works involving a lot of human time and brain have been done, targeting specific FPGA technologies of interest at that time. However, these efforts can only cover a limited part of the combinations of current and future applications and of target FPGA technologies. Additionally, specific human design brings no guarantee that interesting solutions have been explored for a single technology. The general trend in raising the level of abstraction of design languages for digital circuits and FPGA hardware acceleration (from VHDL and Verilog to C, C++, OpenCL, etc.) also mandates that synthesis tools are expected to produce optimized implementations (if not optimal) for the targeted FPGA technology. **References:** [1] J. Mandebi Mbongue, D. Tchuinkou Kwadjo and C. Bobda, "Automatic Generation of Application-Specific FPGA Overlays with RapidWright," 2019 International Conference on Field-Programmable Technology (ICFPT), Tianjin, China, 2019, pp. 303-306, doi: 10.1109/ICFPT47387.2019.00053. [2] Chris Lavin and Alireza Kaviani. 2019. Build Your Own Domain-specific Solutions with RapidWright: Invited Tutorial. In Proceedings of the 2019 ACM/SIGDA International Symposium on Field-Programmable Gate Arrays (FPGA '19). Association for Computing Machinery, New York, NY, USA, 14–22. https://doi.org/10.1145/3289602.3293928 [3] L. Liu, J. Weng and N. Kapre, "RapidRoute: Fast Assembly of Communication Structures for FPGA Overlays," 2019 IEEE 27th Annual International Symposium on Field-Programmable Custom Computing Machines (FCCM), San Diego, CA, USA, 2019, pp. 61-64, doi: 10.1109/FCCM.2019.00018.
Project Description: Detailed description of the project	The subject consists of exploring how AI technologies can help exploring and discovering pertinent implementation solutions of accelerators for various FPGA technologies, taking into account the architectural specificities and constraints of these technologies (size/number of LUTs, placement of carry chains, number of inputs/outputs per logic slice, routability, etc.), and considering variants to signed inputs and more specific representations such as unum posit. A more specific interest exists for basic micro-architecture blocks with regular distribution of inputs, because such blocks enable to easily and

	quickly instantiate reasonably-optimized accelerators with usual HDL languages, instead of involving complex ILP solvers and HDL generators for each accelerators instance in a design.
Project Keywords	Filed Programmable Gate Array, Artificial Intelligence, High Level Synthesis, Embedded Systems, Computer Architecture

2.4 SCHOOL OF CHEMISTRY AND CHEMICAL ENGINEERING



2.4.1 Biochar: Towards Sustainable Wastewater Treatment

Supervisor	Dr Jehad Abu-Dahrieh
Mode of Study	Full Time at QUB or Full Time Distance Learning
Project Overview	Ammonia is a common pollutant in wastewater that can be harmful to aquatic life and human health if left untreated. The potential impact of using biochar for ammonia removal from wastewater is significant. By removing ammonia from the water, biochar can reduce the environmental impact of wastewater discharge and improve the quality of the water. This can have a positive impact on aquatic life, as well as on human health and well-being. Additionally, the use of biochar in wastewater treatment can provide a sustainable and cost-effective solution for ammonia removal. This project will aid in the development of solutions which could provide sustainable utilisation of biomass residues. The development of a circular bio-economy in this regard could develop the viable use and reuse of materials which are currently contributing to pollution of water, air and soil. The project offers several benefits including carbon sequestration, energy savings and potential nitrogen fertiliser. Moreover, using biochar technology to adsorb pollutants in air and wastewater can reduce the need for energy-intensive treatment processes and reduce greenhouse gas emissions toward clean energy.
Project Description: Detailed description of the project	This project **aims** to develop and test an enhanced adsorbent material to address the significant environmental concern of ammonia pollution in wastewater and agriculture runoff. The conventional methods of ammonia removal are costly, energy-intensive, and may produce secondary pollutants. Biochar, a carbon-rich material produced by valorisation (by pyrolysis) of organic waste materials such as biomass waste/residue, which is considered one of many valuable bioenergy and bioproducts produced, has been proposed as an alternative material for ammonia removal due to its high adsorption capacity, low cost, and sustainability. However, to enhance its efficiency and selectivity for ammonia removal, functionalization of biochar with various functional groups has been proposed. Functionalization of biochar involves modifying its surface with chemical groups to improve or create new functional groups such as oxygen-enriched functional groups, carboxyl, and hydroxyl, which enhances its affinity towards targeted pollutants. The modification and functionalization of biochar can be achieved through physical or chemical treatment to alter its surface properties. The proposed project aims to evidence biochar can be tailored to removal ammonium from wastewater. In order to achieve this the work will be focused on the following specific objectives: 1. Building on existing knowledge for the biochar production and characterization from biomass waste 2. functionalize and characterize biochar with suitable functional groups for ammonia removal.

	3. Optimize the synthesis and functionalization of biochar for improved ammonia removal efficiency. 4. Evaluate the stability and reusability of functionalized biochar for ammonia removal.
Project Keywords	Biochar, pyrolysis, adsorbent, carbon sequestration, wastewater, pollution, ammonia

2.4.2 Carbon Dioxide Capture by Sustainable Biochar

Supervisor	Dr Jehad Abu-Dahrieh
Mode of Study	Full Time at QUB or Full Time Distance Learning
Project Overview	Biochar, a carbon-rich material produced by valorisation (by pyrolysis) of organic waste materials such as biomass waste/residue has the potential to capture approximately one gigaton of greenhouse gases annually, contributing to nearly 10% of global emissions reduction if used for carbon neutrality. Biochar is a carbon-neutral negative material with the ability to fix carbon for long period of time, and it has nearly no negative environmental impact. One prerequisite for CO_2 trapping and capturing is the porosity of biochar, and it is commonly acknowledged that micropores affect how well biochar can take CO_2. To that effect tailoring and functionalizing biochar with suitable properties to capture CO_2 is proposed here. This project will aid in the development of solutions which could provide sustainable utilisation of biomass residues. The development of a circular bio-economy in this regard could develop the viable use and reuse of materials which are currently contributing to CO_2 Capture. The project offers several benefits including carbon sequestration. Moreover, using biochar technology to capture CO_2 can reduce the need for energy-intensive treatment processes and reduce greenhouse gas emissions toward clean and net-zero energy.
Project Description: Detailed description of the project	Greenhouse gas emissions, particularly carbon dioxide (CO_2), and the surging global demand for clean energy sources represent the dual, urgent challenges of our era. To address both challenges carbon dioxide can be captured from various industrial processes such as power plants, cement manufacturing, or directly from the atmosphere. This project **aims** to develop and test an enhanced adsorbent material to address the significant environmental concern of CO_2 emissions. Biochar which is considered one of many valuable bioenergy and bioproducts produced, has been proposed as material for CO_2 capture due to its high adsorption capacity, low cost, and sustainability. However, to enhance its efficiency and selectivity for CO_2 capture, functionalization of biochar with various functional groups has been proposed. Functionalization of biochar involves modifying its surface with chemical groups to improve or create new functional groups such as oxygen-enriched functional groups, carboxyl, and hydroxyl, which enhances its affinity towards targeted pollutants. The modification and functionalization of biochar can be achieved through physical or chemical treatment to alter its surface properties. The proposed project aims to evidence biochar can be tailored to CO_2 capture. In order to achieve this the work will be focused on the following specific objectives:

	1. Building on existing knowledge for the biochar production and characterization from biomass waste 2. functionalize and characterize biochar with suitable functional groups for CO_2 Capture. 3. Optimize the synthesis and functionalization of biochar for improved CO_2 Capture. 4. Evaluate the stability and reusability of functionalized biochar for CO_2 Capture.
Project Keywords	Biochar, pyrolysis, adsorbent, carbon sequestration, CO_2 Capture, porosity greenhouse gases

2.4.3 Production and Characterization of Biobased Materials from Food/Biomass Waste and Their Applications

Supervisor	Dr Jehad Abu-Dahrieh
Mode of Study	Full Time at QUB or Full Time Distance Learning
Project Overview	Human population is estimated to increase from 7.7 billion in 2019 to 9.7 billion in 2050. This will boost food production for the growing population, which led to increase food waste that can be harmful to human health and exacerbate climate change. The biomass/food waste that cause a problematic if it not treated can be used for production of high- value materials if treated. There are different ways of utilizing this waste by using thermochemical conversion processes such as pyrolysis. The products of pyrolysis encompass a range, including bio-oils suitable for fuel or chemical use, gases with significant heating potential and char, which serves as both fuel and feedstock. Among these, activated carbon stands out as a feedstock, leading to the production of carbon nanotubes through pyrolysis, which is the main focus of this study. Herein, the application of the new added value materials in removing pollutants from the water, reduce the environmental impact of wastewater discharge and improve the quality of the water will be investigated. This project will aid in the development of solutions which could provide sustainable utilisation of food/biomass residues. The development of a circular economy in this regard could develop the viable use and reuse of materials which are currently contributing to pollution of water, air and soil.
Project Description: Detailed description of the project	This project **aims** to develop and test an enhanced adsorbent material to address the significant environmental concern of water pollution in wastewater. These adsorbent materials will be prepared by using pyrolysis which is a process that involves heating matter in an inert atmosphere to produce useful products, with the product properties depending upon various factors. As mentioned above there are a range, different potential product from pyrolysis such as including the char/ activated carbon. Herein different treatment method, chemical and physical, will be used to activate the produced material from the pyrolysis process. In order to achieve this the work will be focused on the following specific objectives: 1. Study the composition of the food/biomass waste by means of proximate and ultimate analyses. Elemental (C, H and N) analysis 2. Optimize the reaction condition of the pyrolysis process such as temperature, heat rate, space velocity. 3. Characterization of the produced materials by studying the morphology by Powder X-ray diffraction (XRD), Brunauer-Emmett-Teller (BET) analysis, Scanning electron microscopy (SEM). Thermal stability by Thermogravimetric analysis (TGA). The static contact angle of the prepared material to study the material hydrophobicity.

	4. Evaluate the stability and reusability of produced material for wastewater treatment.
Project Keywords	Food/biomass waste, activated carbon, pyrolysis, adsorbent, wastewater, pollution

2.4.4 Breaking BaD

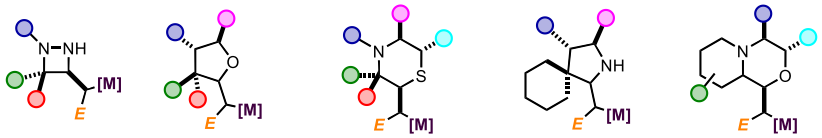
Supervisor	Dr Ian Lane
Mode of Study	Full Time at QUB
Project Overview	The aim of this product is to develop the theoretical model to describe the production of an ultracold gas (less than a microkelvin) of deuterium atoms via the fragmentation of laser cooled molecules. This is the simplest atomic gas that behaves according to the rules of the Exclusion Principle but direct cooling with lasers is problematic. Choosing a parent molecule, such as BaD, that can be cooled and then breaking it in two, we can create cold atoms of elements that so far have resisted attempts to reach absolute zero.
Project Description: Detailed description of the project	In recent years it has become possible to produce gases of atoms at unimaginable temperatures close to absolute zero or zero degrees Kelvin, the lowest temperature allowed by the laws of physics. Oddly, this is often achieved by using lasers that cool the atoms to temperatures around 100 nanokelvin, a tiny fraction of a degree – there are in fact as many nanokelvin in one degree as there are seconds in a period of 30 years. Alas some elements are still difficult to cool in this way, mainly because of a lack of suitable lasers or the cooling process is compromised. Hydrogen is particularly difficult but fortunately we have potentially found a unique way of creating a very, very cold gas of hydrogen atoms. The trick is to actually use the lasers to cool something else, a tiny molecule consisting of two atoms, one of which is the hydrogen required. There are a number of hydrogen containing molecules that can be laser cooled, so the idea is to then gently remove the hydrogen atom from its partner using tweezers of light. Curiously, we have shown that the mass of the companion atom in the molecule influences the final temperature of the hydrogen atoms produced, with a heavier partner leading to a colder gas of hydrogen. Consequently, we wish to study diatomic hydrides such as CaH (40-fold lowering in temperature) and BaH (over 2 orders of magnitude drop). One exciting application is the creation of a **quantum gas of hydrogen atoms** called a Bose-Einstein Condensate from the fragmentation of diatomic molecules that are themselves not cold enough to form such as gas. This would allow the creation of this unique phase of matter on demand with nanosecond or greater precision, an ability not usually possible with phase changes. A particular focus will be the production of the heavier isotope deuterium by the fragmentation of BaD as such atoms have so far resisted all attempts to cajole them into a quantum gas by current means. This would create the lightest **degenerate Fermi gas** ever created, a world first. Such a cold gas of hydrogen could have a number of applications, including probing H-bonding and other long-range forces, testing whether the physical constants of the Universe are really constants after all and as a delicate probe of material surfaces, such as the components of electronic circuits.

Project Keywords	Quantum technology and engineering; quantum computation, ultracold science, laser cooling

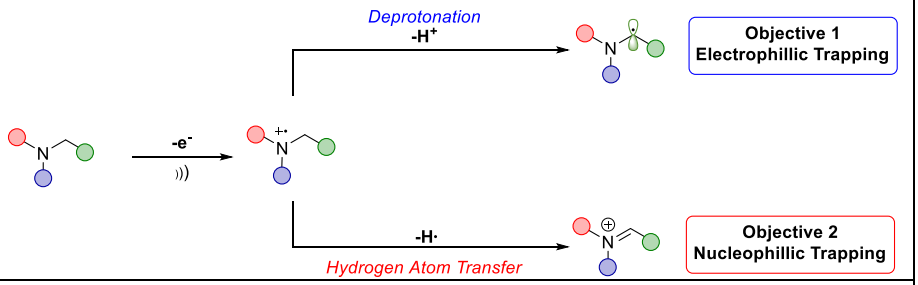
2.4.5 Novel Functional Monomers for Polymer-Based Receptors: A Computational Approach

Supervisor	Professor Panagiotis Manesiotis
Mode of Study	Full Time Distance Learning
Project Overview	Aim of the project will be to use modern molecular modelling packages and computational chemistry to design and optimise novel functional monomers for use in polymer-based receptors, such as molecularly imprinted polymers.
Project Description: Detailed description of the project	Recent years have seen a rapid expansion in the applications of smart functional materials in bioanalysis, environmental remediation, sensors, medical devices and beyond. The development of these materials is a costly and time-consuming undertaking, which often results in innovation bottlenecks. However, recent developments in computational chemistry and the wider availability of high-power computing clusters, has enabled accurate modelling or increasingly complex structures, starting from small molecules and ranging to proteins, polymers and composite materials. In this project, we will focus on the use of such computational packages to model the performance of small molecule polymerisable receptors for anionic species, in particular phosphate and sulphate ions, based on the urea and squaramide functionality. The most promising candidates will be taken forward as part of a complementary project that will evaluate the performance of these receptors in the recognition of anions in aqueous samples. Depending on progress on the project, the modelling of an actual imprinted polymer binding site will also be attempted, in order to propose suitable cross-linking and co-monomers for optimum target binding.
Project Keywords	Supramolecular chemistry, molecular recognition, molecular imprinting, computational chemistry, molecular modelling

2.4.6 General Access to Diverse 3D Heterocyclic Scaffolds

Supervisor	Dr Mark McLaughlin
Mode of Study	Full Time at QUB
Project Overview	Over the past two years, the McLaughlin group have pioneered a novel approach to access small ring heterocycles from readily accessible alkyne starting materials. Given this proof-of-concept work, we now wish to apply our strategy towards the synthesis of more complex 3D heterocyclic structures. We envisage that this methodology can be used to make four to six (and potentially larger) rings including spiro- and fused moieties.
Project Description: Detailed description of the project	Through a robust hydrometallation/cyclisation strategy this project will work to produce high value, 3D-rich heterocycles from easily accessible functionalised alkynes. The project has three key aims 1) Synthesis of underexplored small ring heterocycles 2) Synthesis of highly functionalised five membered ring systems and 3) Access to six membered ring scaffolds bearing multiple heteroatoms and will culminate in the development of a universal approach to a wide range of medicinally relevant structural motifs as shown below.  Diazetidines THFs Thiomorpholines Spiro Fused
Project Keywords	Synthetic organic chemistry, catalysis, ultrasound, single electron transfer

2.4.7 Employing Ultrasound as an Enabling Technology in Organic Synthesis

Supervisor	Dr Mark McLaughlin
Mode of Study	Full Time at QUB
Project Overview	This project will work to provide proof of concept that ultrasonic activation of piezoelectric materials e.g., BaTIO3, can mediate SET processes and thus provide new avenues for reaction methodology. In particular, this project will focus on developing robust protocols to enable direct □-functionalisation of saturated cyclic and acylic amines, providing synthetic routes to a wide range of products.
Project Description: Detailed description of the project	The key objective of this project is to establish that ultrasound piezoredox activation is achievable and thus provide the synthetic community a new tool to allow late-stage diversification of a single motif. An important part of this work will be the development of traditional and umpolung reactivity of the parent amine, allowing for the formation of both nucleophilic a-amino radicals (Objective 1) and electrophilic iminium ions (Objective 2). 
Project Keywords	Synthetic organic chemistry, catalysis, ultrasound, single electron transfer

2.4.8 Sustainable Porous Liquids

Supervisor	Dr Leila Moura
Mode of Study	Full Time at QUB
Project Overview	**This project targets materials tailored for gas capture and separation**, namely CO_2, providing cheap, resilient and low-impact gas purification technologies, with the goal of providing relevant facilities retrofitting options at reduced initial investment. This project will develop **new porous liquids**, use **dedicated testing equipment,** and a **high-throughput screening methodology to fast-track the design and discovery of promising materials.**
Project Description: Detailed description of the project	**Carbon capture and hydrogen storage** are, globally, two of the most discussed research and policy topics, due to their energetic and environmental importance. Material development for these applications follow the lead, with porous liquids being one of the most popular and recent options, with publications reaching over 3000/year, with commercially available examples for gas capture, owing to their high sorption capacity and separation abilities. Porous liquid porosity derives from the presence of porogen materials, ranging from free discrete molecular cages up to colloidal particles, dispersed in a liquid. They combine the permanent porosity of porous solids and the mobility of liquids, making them more competitive for commercialisation and retrofitting than solid sorbents, eg. in CO_2 capture via amine plants. Current porogens include metal organic frameworks (MOFs), zeolites, covalent organic frameworks (COFs) and few other purely organic materials. The formation of porous liquids implies that the cavities of the pores are not affected by the presence of the solvent molecules, either by size-exclusion or by hydrophobic effects. We aim to develop fully biobased porous liquids (PLs) that are inexpensive, biodegradable and nontoxic, with high gas uptake capacities and selectivities, making them attractive for commercialisation. This project will combine **microporous solids (MPs) from biobased polymers** with a non-volatile media based on sustainable **liquid low melting mixtures (LMMs)** as carriers in the formulation of PLs. This proposal aims to change the complex synthesis processes or the use of metal centres in the formulation of porous liquids by combining low melting mixtures as liquids carriers with microporous polymer solids as porogens, all from sustainable, biobased, waste or commercial sources. Our final aim is to produce a **customisable sorbent**, producing a PL that can be **adapted to changing gas stream compositions**. Promising materials will be investigated under realistic conditions of temperature, pressure and with complex gas mixtures.
Project Keywords	CO2 capture; porous liquids, hydrogen storage, low melting mixtures, deep eutectic solvents, ionic liquids, gas separation

2.4.9 Where Next for Biomass Conversion?

Supervisor	Dr Christopher Murnaghan
Mode of Study	Full Time at QUB
Project Overview	Investigations into catalytic conversion of biomass sources for hydrogen and value-added functionalised monoaromatic compounds
Project Description: Detailed description of the project	The use of many different catalytic systems for the valorisation of raw biomass towards hydrogen, carbohydrates and aromatics is an area which has been explored much throughout the last few decades. However, where does it leave the scientific community? There are more unanswered questions that there are answered and this project will examine some of those questions in detail. Chief among which being the best catalytic system, two will examined within this work; enzymatic and photocatalytic. The employment of numerous naturally occurring enzymes (MnP, LiP, Laccase, VP) already found in a wide range of biomass sources can be employed for the destruction of biomass. Both commercial and synthetic photocatalysts which are known to be very effective at cleaving certain bonds within biomass but always have a shortcoming:- they have to be operated under aqueous conditions typically. This work will look at the optimisation of these catalytic systems for the production of functionalised monoaromatics and also hydrogen from raw biomass sources. The ultimate goal of the project is the development of a hybrid system which will have the aforementioned catalysts working together for the valorisation of raw biomass within a single reactor unit.
Project Keywords	Biomass, lignin, cellulose, photocatalyst, enzyme

2.4.10 Formation and Cleavage of C-C Bonds by Employing UV Irradiation

Supervisor	Dr Christopher Murnaghan
Mode of Study	Full Time at QUB
Project Overview	Employing reactive intermediates for the synthesis of useful molecules
Project Description: Detailed description of the project	The use of light to initiate reactions has been studied for nearly 100 years, much is known about the intermediates and how they might react. However the phenyl cation intermediate is one which possesses huge synthetic utility in replacing some traditional, stoichiometric reactions like the Friedel-Crafts acylation. Employing UV irradiation of a suitable wavelength will result in the formation of a phenyl cation which will readily react with a suitable electron rich donor species and create a new C-C bond. Another class of photoinitiated reactions which will be studied in this project will be the Norrish reactions and their use in lignin degradation. As it stands lignin as an entity is in a largely reduced form bearing very few carbonyl functionalities, however, simple oxidation with TEMPO will result in benzylic oxidation. Subsequent irradiation of this benzylic carbonyl group should result in bond cleavage and also bond formation as cyclisation reactions are expected to occur also.
Project Keywords	UV Irradiation, Photoreaction, Lignin, Norrish, Phenyl Cation

2.4.11 Development of a Supported Catalyst for Reductive Catalytic Fractionation (RCF)

Supervisor	Dr Christopher Murnaghan
Mode of Study	Full Time at QUB
Project Overview	Development of more sustainable catalytic surfaces for RCF
Project Description: Detailed description of the project	As it stands, the RCF reaction which is done typically in a high pressure hydrogenolysis reactor employs powdered catalyst which is stirred during the reaction. When the reaction ceases, the catalyst as well as any solid material from the reaction is filtered off together and the separation process of used noble metal catalyst and substrate is time, energy intensive and in some cases impossible. Therefore the development of a solid structure which is inert to the highly reductive nature of the reaction medium but also has catalyst impregnated on the surface and therefore will catalyse the reaction occurring. The difference will be when the reaction is stopped; the simple removal of the solid support will leave behind the unused substrate and the remainder of the reaction solution. The process of developing a supported catalyst for this purpose will not only greatly reduce the waste following RCF reactions but may aid in mass transfer issues previously seen with powdered catalyst which is prone to clumping.
Project Keywords	Reductive Catalytic Fractionation, Noble Metal Catalysis, Chemical Engineering

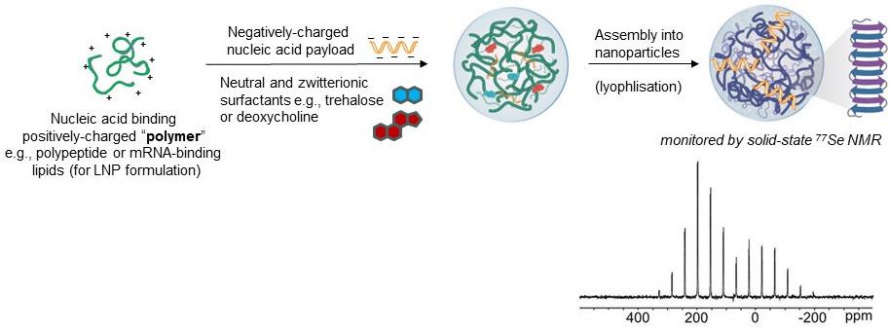
2.4.12 Recovery of Critical Elements from E-Waste

Supervisor	Professor Małgorzata (Gosia) Swadźba-Kwaśny and Professor Peter Nockemann
Mode of Study	Full Time at QUB
Project Overview	The aim of the project is to recover critical elements, in particular indium, from electronic waste, to enable their circular processing. This will be achieved using a custom-designed, environmentally-benign deep eutectic solvents.
Project Description: Detailed description of the project	Volume of electronic waste has increased exponentially over the past decade. When stored in landfields, they pose serious threat of contamination to soil and water. However, when treated, they can be a valuable secondary source of critical elements, such as gallium, indium and lanthanides. Currently, there are no establish methods of e-waste valorisation. Conventional hydrometallurgical processes often rely on harsh chemicals, such as strong mineral acids, and pose their own set of problems. Our group developed a family of hydrophobic deep eutectic solvents based on phosphine oxide (***ACS Sustainable Chem. Eng.***, 2018, **6**, 12, 17323; ***Phys. Chem. Chem. Phys.***, 2020, **22**, 24744) that are benign, based on inexpensive and low-toxicity materials, and can be tuned for selective extraction. Recently, we have successfully developed a process for selective separation of gallium. Building on this knowledge, this PhD project will focus on leaching and selective separation of indium from e-waste. The aim will be to develop and optimise a system for selective separation of indium. Firstly, deep eutectic solvents tailored for indium coordination will be prepared and tested, by spectroscopic studies (NMR, FT-IR, Raman) and thermal analysis (DSC, TGA). Subsequently, extractions from model e-waste leachate will be carried out, followed by leaching e-waste samples and then separating metals. Coordination environment of indium at each stage will be tested (Raman, EXAFS) and efficiency of extraction will be probed by ICP and XRF. From this, an understanding of structure-property relationship will lead to improved solvent system for the separation of indium.
Project Keywords	Critical elements, deep eutectic solvents

2.4.13 Carbon Dioxide Capture and Reaction to Net Zero Fuels

Supervisor	Dr Jillian Thompson, Professor Stuart James and Dr Chunfei Wu
Mode of Study	Full Time at QUB
Project Overview	Reduction of greenhouse gases in the atmosphere to limit the effects of global warming is a pressing global need and presents a key challenge for today's scientists and engineers. Capture of CO_2 is one way to achieve this, and novel porous liquid materials, have been demonstrated to be a groundbreaking technology for this application. The project will use porous liquids for the first time in an integrated carbon capture and utilisation process to absorb the carbon dioxide and to develop a process whereby the porous liquid absorbent is regenerated alongside upgrading of the absorbed carbon to a net zero fuel.
Project Description: Detailed description of the project	Porous liquids, combine the porosity of microporous solids with the ease of handling of liquids, and are a new and extremely promising class of absorbent material. The permanent porosity present in the liquid combined with their tuneable properties allows a high and selective uptake of gaseous species. Application of this innovative and exciting technology to CO_2 capture has already shown excellent results and this project will extend the function of the porous liquid from carbon capture to utilisation. For the first time, we will examine porous liquids in an integrated carbon capture and utilisation setting to establish the viability of simultaneous regeneration of the porous liquid and conversion of the absorbed carbon dioxide, through hydrogenation to net zero fuels such as methane or methanol. A range of porous liquids will be prepared and tested for their uptake of CO_2, with optimisation of conditions. Upgrading the absorbed CO_2 will be facilitated over heterogeneous catalysts, and again optimisation of the reaction parameters will be carried out. A balance between conditions needed for absorption and reaction processes will be considered as well as the effects of longer-term use of the porous liquid. The technoeconomic aspects of the process will be assessed. A range of valuable technical training opportunities will be taken from preparation of materials; measuring gas uptake; preparation, characterisation and testing of heterogeneous catalysts; evaluating mass and energy balances in the process; technoeconomic evaluation of the process.
Project Keywords	CO_2 capture, Net Zero, Heterogeneous Catalysis

2.4.14 Monitoring the Formulation and Transfection Efficiency of Nucleotide Prodrug Cargoes in Nanoparticles Using NMR

Supervisor	Dr Joseph S Vyle and Professor Helen McCarthy
Mode of Study	Blended QUB
Project Overview	Both Queen's (Pharmacy) and Weill-Cornell Qatar (Medicine), have demonstrated expertise in the delivery of nucleic acid API cargoes in vivo. Through this project, we will demonstrate NMR methods (solid-state and solution phase) available in Queen's CCE for monitoring the association of labelled cargoes with pharmaceutically-relevant delivery vehicles using cationic lipids or amphipathic polypeptides. This will both decrease the time and resource expenditure required for optimising the formulation of mRNA vaccines and act as a proof-of-principle demonstration of the ability to monitor in vivo formation of nucleic acid coacervates as seen in viral infection, mRNA transport, localisation and also degradation.
Project Description: Detailed description of the project	Following the population-wide deployment of the anti-SARS CoV2 mRNA vaccine formulated into lipid nanoparticles (LNPs) by Biontech, there has been considerable interest in the process by which the LNPs form complex coacervates as the formulation of such LNPs involves microfluidic mixing of an aqueous solution of the mRNA vaccine (which can have upto 11,000 negative charges) and a solution of non-water soluble lipid and related components which are dissolved in ethanol.[1] In order to achieve homogeneity and stability, typicall, arduous and time-consuming trial-and-error searches are required for both mixing / lyophilisation. Although alternative, water-soluble vehicles, such as the amphipathic peptide RALA,[2] overcome ethanol / water mixing issues, there is still a need for a method for online monitoring of the association and condensation of the nanoparticles derived from this mixing. During this project, formulation of negatively-charged, ^{77}Se- or ^{19}F labelled nucleic acid cargoes with pharmaceutically-relevant delivery vehicles which promote coacervation will be monitored using NMR. An example would use Queen's recently acquired solid state machine and would give a proposed output illustrated in **Figure 1** (recently used to delivery an anticancer Se-modified prodrug developed by McCarthy and Vyle)[2].  **Figure 1.** Proposed example of MAS-ssNMR output from formulation of nanoparticles containing Se-labelled nucleotide prodrug. During the current study, novel model mRNA cap analogues will be prepared in QUB CCE, formulated either in QUB Pharmacy or W-C Medicine (proposed e.g. [4]) and the effect of these modifications upon stability,

	transcription and translation properties examined [e.g., 5]. For those materials exhibiting relevant biological activity, in vivo demonstrations will be performed with specific emphasis on the biochemically- and chemically-fragile part of an mRNA vaccine which leads to cold chain issues for global roll out of such pandemic-defeating materials representing the first proof-of-principle demonstration of the ability to monitor processing transport, localisation and also degradation with a single label. **References** [1] Maeki, M.; Uno, S.; Niwa, A.; Okada, Y.; Tokeshi, M., Microfluidic technologies and devices for lipid nanoparticle-based RNA delivery. *JCR* **2022,** *344*, 80-96. [2] Loughran, S. P.; McCrudden, C. M.; McCarthy, H. O., Designer peptide delivery systems for gene therapy. *Eur. J. Nanomed.* **2015,** *7*, 85-96. [3] Wilson, J. J.; Bennie, L.; Eguaogie, O.; Elkashif, A.; Conlon, P. F.; Jena, L.; McErlean, E.; Buckley, N.; Englert, K.; Dunne, N. J.; Tucker, J. H. R.; Vyle, J. S.; McCarthy, H. O., Synthesis and characterisation of a nucleotide based pro-drug formulated with a peptide into a nano-chemotherapy for colorectal cancer. *JCR* **2024,** *369*, 63-74. [4] Parvizi-Bahktar, P.; Mendez-Campos, J.; Raju, L.; Khalique, N. A.; Jubeli, E.; Larsen, H.; Nicholson, D.; Pungente, M. D.; Fyles, T. M., Structure–activity correlation in transfection promoted by pyridinium cationic lipids. *Org. Biomol. Chem.* **2016,** *14*, 3080-3090. [5] Warminski, M.; Mamot, A.; Depaix, A.; Kowalska, J.; Jemielity, J., Chemical Modifications of mRNA Ends for Therapeutic Applications. *Acc.Chem. Res.* **2023,** *56*, 2814-2826.
Project Keywords	mRNA vaccines, nanoparticles, NMR, anticancer agents

2.5 SCHOOL OF PSYCHOLOGY (BEHAVIOURAL SCIENCES)

2.5.1 Identifying Psychological Mechanisms Which Promote Resilience Post-Trauma

Supervisor	Professor Cherie Armour
Mode of Study	Full Time at QUB or Full Time Distance Learning
Project Overview:	This PhD project will explore the mechanisms between the trauma and resilience relationship. We are interested in the process of flexible self-regulation, which is a multi-component concept consisting of proficiency in context sensitivity, emotional regulation and having a flexible mindset (see Bonanno et al., 2004; Bonanno & Burton, 2013; Cheng, Lau, & Chan, 2014; Kashdan & Rottenberg, 2010).
Project Description: Detailed description of the project.	This PhD project will explore the mechanisms between the trauma and resilience relationship. We are interested in the process of flexible self-regulation, which is a multi-component concept consisting of proficiency in context sensitivity, emotional regulation and having a flexible mindset (see Bonanno et al., 2004; Bonanno & Burton, 2013; Cheng, Lau, & Chan, 2014; Kashdan & Rottenberg, 2010). The population of interest is those who have experienced traumatic events and remained resilient, for example those who have worked as critical care nurses during the COVID-19 pandemic or those who have experienced occupational related traumas such as emergency responders, police, fire, and/or military. Prospective students can specify their choice of population in their proposal in addition to outlining a plan for access to the population. This will be a mixed methods study requiring a systematic review of the literature, and qualitative and quantitative studies. Posttraumatic stress disorder was incorporated into the DSM-3 in 1982. An extensive body of literature has since focused on trauma experiences and their corresponding human responses. Of note, the predominant focus has been on negative psychological outcomes post-trauma including post-traumatic stress disorder (PTSD) but also a range of other, often comorbid, psychopathological disorders such as depression and anxiety. The key question being: why is it that when people experience negative life events, they become psychologically unwell? This is an interesting focus given that population estimates of trauma exposure are exceptionally high in comparison to those who go on to develop a posttraumatic stress outcome. Conversely, epidemiological surveys have reported that even when we consider countries with the highest rate of PTSD within the population, this rate equates to approximately 8.8% (this is the rate of PTSD in NI as recorded by the Northern Ireland Study for Health and Stress which was part of the World Mental Health Consortium). So in reality more people who experience trauma remain psychologically well than those who become psychologically unwell. This is referred to as resilience. This concept has arguably received less attention in the academic literature compared to PTSD. In fact, as recent as the early nighties the concept was ignored, denied or at best regarded as a rare form of 'exceptional emotional strength' (Casella & Motta, 1990; Shedler, Mayman, & Manis, 1993). However, as the research on posttraumatic responding broadened alongside the development and application of advanced statistical modelling techniques,

	the trauma field started to uncover genuine resilience in the form of a proportion of people reporting stable, healthy levels of psychological functioning in the aftermath of traumatic events (Bonanno, 2004, 2005). In a review of 67 unique trajectory studies of psychological responding posttrauma, Galatzer-Levy, Huang, and Bonanno, (2018) confirmed that the majority outcome, with two-thirds of participants falling into this category, is indeed one of resilience. This, therefore, changes the question from: 'Why is it that when people experience negative life events, they become psychologically unwell?' to 'Why is it that most people who experience traumatic life events cope so well?'
Project Keywords:	Resilience; Trauma; Adversity; Psychological Wellbeing; Mental health; Mechanisms; Coping; Emotion Regulation

2.5.2 Two Halves Make a Whole: Exploring the Role of the Families in Caring for Police Officers with Occupational Related Psychological Distress

Supervisor	Professor Cherie Armour
Mode of Study	Full Time at QUB
Project Overview:	This PhD project will focus on spouses / intimate partners who have cared for police officers with occupational related psychological distress. Through survey data collection and in depth interviews we will gain a better understanding of the role of the family and how caring for those with psychological distress has impacted on them and their children. This project will be a mixed methods project utilising both quantitative (survey methodology) and qualitative (respondent interviews) data collection methods.
Project Description: Detailed description of the project.	A wealth of literature has focused on the psychosocial determinants of health and well-being in first responder populations such as police officers. The focus has been placed on these populations as they are often at an increased risk for exposures to traumatic incidents through the nature of their occupational roles and therefore are also at an increased risk of developing adverse posttraumatic outcomes. Less attention has been given in the research literature to the impact that this has on the families of police officers and the caring responsibilities that family members face in times of the development of post-trauma difficulties. Police officers often work in environments which are fast-paced, may require long and sometimes unexpected hours, and which may place them in direct danger. This can disrupt family schedules, upset children, and cause worry and distress in spouses / intimate partners. When psychological difficulties present in police officers due to occupational traumas it is often the family who first notice and have to attend to the distress. They have to care for the police officer and navigate situations which minimise family disruption and at times minimise the potential impact on children.
Project Keywords:	Families; Police Officers; Trauma; Resilience; Mental Health; Mixed Methods

2.5.3 Training Goalkeepers to Improve Performance in Stopping Penalties

Supervisor	Dr Joost Dessing
Mode of Study	Full Time at QUB
Project Overview:	In this project, we aim to examine whether and how goalkeepers can be trained to improve their performance in penalty series, with a focus on the use of virtual reality (VR).
Project Description: Detailed description of the project.	Penalties are an important aspect of football matches. In this project we will examine whether and how we can use virtual reality to train goalkeepers to improve their performance in penalty scenarios. Penalties are an important component of football matches. For tournament football this importance is amplified due to the use of penalty series to decide matched in the knock-out stages. Goalkeepers are pushed to their limits during penalties, because well-taken penalties are near-impossible to stop. The goalkeeper is faced with the choice of moving earlier to be able to cover the entire goal – at the cost of moving based on seeing the kicker for less time – or waiting longer to see more of the kicker (and ball) movements – at the cost of not having enough time to cover the entire goal. The time constraints for goalkeepers during penalties are extremely tight and their decisions/movements must be based on advance knowledge (or guessing) as well as kinematic information (i.e., exactly how the kicker moves); waiting for the ball to start moving means there is not enough time to reach the edge of the goal. In this project, we aim to examine whether and how goalkeepers can be trained to improve their performance in penalty series, with a focus on the use of virtual reality (VR). To create a VR simulator, a database of kicking motions will be created; this will concern so-called independent penalties, in which the kicker does not alter their movement based on how the goalkeeper moves. This simulator will be used in different training studies focusing on guiding the goalkeeper's attention to the relevant body parts of the kicker (those most predictive of the direction of the shot) and influencing the timing of their decision. For dependent penalties – in which the kicker alters their kicking direction based on how the goalkeeper moves, we will examine how interactively kicker and goalkeeper adjust their movements to assess how goalkeepers may change their movements to negatively influence the kicker. This project uses fundamental science and methods to examine a practical scenario and should be expected to yield both scientific and practical insights.
Project Keywords:	Human Movement Science, Football, Virtual Reality, Motion Tracking, Training Simulator

3. FACULTY OF MEDICINE, HEALTH AND LIFE SCIENCES

3.1 SCHOOL OF MEDICINE, DENTISTRY AND BIOMEDICAL SCIENCES

3.1.1 Investigating the Epigenetic Basis of Chemotherapy Resistance in Colorectal Cancer

Supervisor	Dr Yaser Atlasi
Mode of Study	Full Time at QUB
Project Overview:	Treatment with 5-fluorouracil (5FU)-based chemotherapy is the main option for most colorectal cancer (CRC) patients. However, chemotherapy resistance remains a major hurdle in CRC treatment. Recent discoveries highlight a remarkable similarity between chemo-resistant cancer cells and cells found in the early embryo, suggesting that cancer cells can hijack a range of stem, and embryonic programmes to enter a dormant state that enables them to survive treatment. This drug resistance-persistence state is associated with reversible epigenetic reprogramming allowing cells to reinitiate tumour growth upon drug release. In this project, we aim to identify the reversible epigenetic changes underpinning cell plasticity in response to 5FU treatment, with a particular focus on epigenetic changes. Better understanding of these epigenetic mechanisms will provide new therapeutic approaches to prevent or overcome drug resistance in cancer.
Project Description: Detailed description of the project.	We have recently conducted multiple genomics approaches to understand the epigenetic basis of drug resistance in CRC. Through this research, we have identified several candidate epigenetic regulators that may play key roles in this process. In this project, the PhD student will utilize state-of-the-art CRISPR/Cas9 and genomics approaches to study the role of these candidate epigenetic regulators identified in our genomics screens. All proposed experiments are standard molecular biology approaches that have been used before by the lead PIs, mitigating the feasibility concerns. Furthermore, this project does not have a pre-defined outcome and both positive and negative results regarding identified epigenetic candidates will be important findings that shed light on the role of epigenetic regulation in drug resistance. The candidate PhD student will receive training in multi-disciplinary approaches combining genome-wide technologies, stem cell biology (including organoid culture) and various molecular biology techniques. The PhD candidate will also gain experience in computational biology for analysis of genome wide data. **Biography:** Dr. Yaser Atlasi worked in the stem cell and cancer field since 2006. During his MSc, he studied the role of OCT4 in pluripotent and cancer cells. During his PhD with Prof Riccardo Fodde, Erasmus Medical Centre Netherlands, he studied the role of WNT-signalling in pluripotent cells and colorectal cancer. During his postdoctoral-training at Prof. Henk Stunnenberg lab at Radboud University Netherlands, he gained expertise in genome-wide technologies and studied mechanisms of epigenetic regulation and 3D chromatin organization in stem cells. In June 2020, Yaser joint Queen's University Belfast as a Vice Chancellor's Illuminate fellow and established his lab at Patrick G Johnston centre for cancer research. Research in Atlasi lab is focused on stem cell and cancer epigenetics.
Project Keywords:	Epigenetics, chemotherapy resistance, colorectal cancer, bioinformatics

3.1.2 Mechanisms and Models of Gremlin1 Signalling in Diabetic Kidney Disease

Supervisor	Dr Derek Brazil
Mode of Study	Full Time at QUB
Project Overview:	This PhD project will investigate how high levels of Gremlin1 protein cause damage and scarring in diabetic kidney disease. The project will employ a molecular cell biology/in vivo mouse model approach to define the mechanisms of Gremlin1-mediated kidney damage, as well as exploring novel Gremlin1 small molecule inhibitors as potential novel therapeutics for diabetic kidney disease.
Project Description: Detailed description of the project.	**Background** Gremlin1 (GREM1) is a secreted protein antagonist of bone morphogenetic proteins that regulates embryonic processes such as limb and kidney development. Diabetic kidney disease (diabetic nephropathy, DN) is the leading cause of end-stage renal failure worldwide. In healthy kidney, levels of GREM1 are low, but in patients with diabetes, GREM1 levels are massively upregulated, particularly in the kidney tubular epithelial cells. The Brazil group were the first to show that mice with lower levels of GREM1 are protected from early damage in diabetes (1). In addition, we demonstrated that mice lacking GREM1 in kidney tubular epithelial cells were protected from acute kidney injury (2). The Brazil group has identified several novel biological pathways that may contribute to GREM1 signalling in diabetic kidney disease, as well as other diseases such as colorectal cancer (3). This project will unravel the mechanisms of GREM1 upregulation in the diabetic kidney, as well as identifying how high levels of GREM1 cause damage to kidney epithelial and other cells, leading to reduced kidney function. Finally, the Brazil lab has developed a panel of novel small molecule antagonists of GREM1 that will be assessed for their ability to inhibit GREM1 activity and reduce the severity of DN in vivo. **Project Aims** 1. Identify transcriptional mechanisms of GREM1 upregulation in diabetic kidney disease, using cell biology and bioinformatic approaches. 2. Elucidate the signal transduction mechanisms of GREM1 in kidney cells exposed to a diabetic milieu. 3. Identify changes in GREM1 expression and signalling in biopsies from human DN kidneys. **Outputs and Deliverables** At the end of this 3-year PhD project, the student can expect to have achieved the following: 1. In-depth training in experimental design and planning, note-keeping and data analysis 2. Hands-on experience in cell culture, RNA and Q-PCR analysis, Western blotting, Luciferase assays, confocal microscopy, ELISA and bioinformatic analysis 3. Novel results and data that will be formatted for publication in high-impact international journals

	4. Opportunities for demonstrating and teaching undergraduate student in biomedical science and medicine 5. Training and skills in science communication, data presentation and scientific writing This project is ideal for an ambitious, hard-working graduate who wishes to challenge themselves at postgraduate PhD level. The successful PhD student will be embedded in the Brazil group and be assigned a senior PhD student who will provide training on all methods and techniques in the project. The PhD student will attend weekly Brazil group meetings and present each week with other team members. The PhD student will have the opportunity to publish both review/opinion articles as well as contribute to research articles during their project. As part of the All-Ireland research partnership, the MSc student will have the opportunity to travel to Dublin and other cities to meet collaborators and improve their network. The PhD student will be able to attend at least 1 international conference during their PhD to present their data and meet leaders in the diabetes field. The PhD student will also be able to attend weekly WWIEM seminars, as well as other scientific and social events such as the Christmas party and summer BBQ. The PhD programme here in WWIEM will offer a range of additional modules and courses in a range of scientific and transferrable skills (e.g. science communication, entrepreneurship etc.) that the PhD student can undertake In summary, this PhD project is ideally suited to an ambitious candidate who wishes to build a strong platform for a career in academic science or industry in the field of diabetes and diabetic complications. **References** 1. Roxburgh SA, Kattla JJ, Curran SP, O'Meara YM, Pollock CA, Goldschmeding R, Godson C, Martin F, Brazil DP. Allelic depletion of grem1 attenuates diabetic kidney disease. Diabetes. 2009 Jul;58(7):1641-50. 2. Church RH, Ali I, Tate M, Lavin D, Krishnakumar A, Kok HM, Hombrebueno JR, Dunne PD, Bingham V, Goldschmeding R, Martin F, Brazil DP. Gremlin1 plays a key role in kidney development and renal fibrosis. Am J Physiol Renal Physiol. 2017 Jun 1;312(6):F1141-F1157. 3. Dutton LR, Hoare OP, McCorry AMB, Redmond KL, Adam NE, Canamara S, Bingham V, Mullan PB, Lawler M, Dunne PD, Brazil DP. Fibroblast-derived Gremlin1 localises to epithelial cells at the base of the intestinal crypt. Oncotarget. 2019 Jul 23;10(45):4630-4639. 4. Ali IH, Brazil DP. Bone morphogenetic proteins and their antagonists: current and emerging clinical uses. Br J Pharmacol. 2014 Aug;171(15):3620-32. 5. Brazil DP, Church RH, Surae S, Godson C, Martin F. BMP signalling: agony and antagony in the family. Trends Cell Biol. 2015 May;25(5):249-64. 6. Walsh DW, Godson C, Brazil DP, Martin F. Extracellular BMP-antagonist regulation in development and disease: tied up in knots. Trends Cell Biol. 2010 May;20(5):244-56.
Project Keywords:	Diabetes, Gremlin1, bone morphogenetic proteins, transcription factors, bioinformatics, kidney fibrosis, TGFbeta, drug discovery

3.1.3 Molecular Mechanisms of Bacterial Competition in the Gut Microbiome and Their Influence on Chronic Intestinal Inflammation and Colorectal Cancer

Supervisor	Dr David A Cisneros
Mode of Study	Full time at QUB
Project Overview:	The gut microbiome is composed by trillions of bacteria that inhabit the human intestine. These microorganisms generate metabolites from diet and the environment, which directly regulate physiological states. Therefore, manipulation of the microbiome is a research area with great potential to directly change disease prevention and treatment. In most cases, bacteria in the intestine contribute to digestion and intestinal health. However, some strains of bacteria are linked to chronic inflammation and colorectal cancer and in this project, we want to study this link using state-of the-art genetic techniques to study an inflammation model.
Project Description: Detailed description of the project.	**About the lab:** The Cisneros lab is a brand-new team at Queen's University Belfast (QUB). We have fresh ideas to study the gut microbiome and how it influences human health. Our goal is to integrate the newest technologies with classical molecular genetics to understand how the gut microbiome is established and how it can cause disease when this process goes wrong. Our team is based on a people-centric view of research. To help these aims, the Wellcome-Wolfson institute for Experimental Medicine counts with state-of-the-art facilities, with an integrative view of health. Moreover, QUB excels on equality and diversity charters. Get more detailed information about the lab here: www.cisneros-lab.org **About the project:** Trillions of bacteria comprise the gut microbiome and contribute to human health by producing metabolites that regulate intestinal health and contribute to human metabolism and homeaostasis. Therefore, the microbiome represents an innovative approach to develop new therapies. Our team studies how bacterial competition for nutrients and space shapes the biodiversity of the gut. This is important because gut biodiversity is a determinant of human health. Moreover, few key species can affect biodiversity, by direct competition with other bacteria. Most microbiome bacteria contribute to homeostasis and contribute to reduce inflammation in the gut. However, like Dr Jekyll and Mr Hyde, some species called pathobionts have strains associated with cancer and chronic inflammation. Moreover, modern lifestyles contribute to dysregulation of the gut microbiome and establish vicious circles contributing to various metabolic diseases, obesity, and cancer. In this project, we will study genes that allow pathobiont bacterial species to stably colonize the intestinal environment in the first place using state-of-the-art techniques such as microbiome sequencing and CRISPR–Cas9 gene editing. Furthermore, we will study how do they affect acute and

	chronic inflammation in a colitis model. The results of this research will contribute to design strategies to manipulate the microbiome to reduce digestive tract cancer incidence, which in the UK represents ~40,000 new cases per year with an economic cost of £17.1 billion. The successful candidate will acquire training in cell biology, microbiology, genome editing and high-throughput sequencing. The project should provide experience to pursue industrial or academic R&D in the new field of microbiome therapeutic biologicals, synthetic biology, or biotechnology.
Project Keywords:	Microbiome, CRISPR-Cas9, colorectal cancer, intestinal homeostasis

3.1.4 Unravelling the Essential Host Factors in Influenza Virus Trafficking

Supervisor	Dr David Courtney
Mode of Study	Full Time at QUB
Project Overview:	Influenza A virus (IAV) is a highly relevant human pathogen with obvious pandemic potential. While current influenza vaccine strategies exhibit varying levels of effectiveness from year-to-year, the development of more potent and universal IAV antivirals is essential for pandemic-preparedness moving forward. This may be through targeting essential viral factors with small molecule inhibitors, such as has been exploited in the development of Oseltamivir or Baloxavir. Or small molecules may be designed targeting host factors found to be essential for IAV replication. Only by acquiring a thorough understanding of the complexities of viral replication may we rationally design more effective and universal influenza virus inhibitors. This research proposal aims to refine our current understanding of one of the final steps in influenza A virus replication, namely vRNP egress through the cytosol prior to packaging.
Project Description: Detailed description of the project.	The trafficking of IAV vRNPs is an important step in viral replication. The current consensus is that this is the step where influenza reassortment occurs, where segments from 2 different viruses can assemble during a co-infection and generate hybrid viruses. This is particularly pertinent as it is how every human influenza pandemic that we know of has arisen. We are already aware that this step consists of the trafficking of vRNPs on mature Rab11+ vesicles from the ER to the plasma membrane, seemingly fusing together along the way to generate bigger vesicles containing larger numbers of different vRNPs. However, little is known as to which cellular co-factors may be present within these remodelled trafficking vesicles. By immunoprecipitation of the vRNP interactome we seek to identify host determinants of trafficking. With this data in hand, we hypothesise that we will uncover essential co-factors for Rab11-mediated vRNP trafficking to the cellular membrane. On completion of this project, we will have addresses 3 fundamental research aims with regard to influenza virus trafficking, namely: 1. Identify which host co-factors are present within influenza vRNP trafficking vesicles. 2. Characterise these host proteins and their potential pro-viral role in influenza vRNP trafficking. 3. Track the incorporation of these host proteins into trafficking vesicles by live cell imaging to determine the dynamics of vRNP bundling and packaging. A better fundamental understanding of the processes by which IAV vRNA segments coalesce on trafficking vesicles as they approach the cellular membrane is vital to understanding reassortment. This is the process by which every IAV pandemic over the last century has arisen, through co-infection of 2 distinct IAV viruses and the production of a hybrid strain. Through a more complete understanding of how vRNAs are sorted prior to packaging we can aim to intelligently design likely universal inhibitors to interrupt this process and block IAV replication at this pivotal step.
Project Keywords:	Influenza, virus, respiratory, molecular, trafficking

3.1.5 Generational Differences in Risk and Protective Factors for Dementia

Supervisor	Dr Emma Cunningham
Mode of Study	Full Time Distance Learning
Project Overview:	Potentially modifiable risk and protective factors for dementia have been identified, for example education and social interaction. This information is shaping public health initiatives. This project will investigate the differences in these potentially modifiable risk factors between older people of today and the older people of subsequent generations.
Project Description: Detailed description of the project.	A wealth of ongoing research is revealing potentially modifiable risk and protective factors for dementia, for example education and social interaction. This information is being used to shape public health initiatives. It is not, however, clear to what extent the research into these factors in the currently older age generation reflects the relative importance these factors will play for the older generations of the future. The student will: Use globally publicly available data to compare incidence and details of identified modifiable risk and protective factors for dementia in older and younger populations Use globally publicly available data to compare incidence and details of relevant lifestyle differences in older and younger populations Use data from global life course studies to compare modifiable risk and protective factors for dementia and relevant lifestyle differences between younger and older participants This PhD project will provide policy makers with information necessary to translate evidence gleaned from the older people of today into policies appropriate for the older people of subsequent generations.
Project Keywords:	biopolymers, agri-food, waste streams, green technologies, sustainable, food structure, functional properties.

3.1.6 A Novel Non-Antibiotic-Based Approach to Eliminate *P Aeruginosa* in CF Airways: Proof of Principle with the Histamine Two Receptor Antagonist Famotidine

Supervisor	Dr Karim Dib, Professor Cliff Taggart and Professor Damian Downey
Mode of Study	Full Time at QUB
Project Overview:	Cystic fibrosis (CF) is a genetic disease caused by mutations in the gene which codes for a protein called the cystic fibrosis transmembrane conductance regulator (CFTR). CFTR modulators are a new therapy that corrects the malfunctioning CFTR protein responsible for causing CF. Although CFTR modulators provide clinical benefits, *P. aeruginosa* airways infection persists in CF individuals. Once the airways are colonized by this bacteria, lung function declines rapidly. *P. aeruginosa* infection is treated with antibiotics delivered to the airways. However, there are several limitations with this treatment. **First**, elimination of *P. aeruginosa* by antibiotics does not occur in all CF individuals. **Second**, antibiotics trigger development of antibiotic resistant bacteria. **Third**, *P. aeruginosa* form building structures resembling "fortresses" which are resistant to antibiotics. **Fourth**, antibiotics do not reduce bacterial burden after *P. aeruginosa* colonization. Therefore, antibiotics treatments prepare the ground for future persistent colonization of the airways. It is therefore critical to design novel **non-antibiotic based** therapeutics to reduce *P. aeruginosa* in CF airways. This is what our proposal aims at delivering. Our original idea is to boost the capacity of airways neutrophils to kill bacteria. Neutrophils are abundant immune cells in the CF airways, but for unknown reasons, they are unable to kill *P. aeruginosa*. We hypothesised that neutrophils are disabled by a substance called **histamine**, which is produced by bacteria colonizing the CF airways, including *P. aeruginosa*. We believe that histamine binds to a histamine receptor in neutrophils, called the histamine two receptor (H_2R), such binding prevents neutrophils to capture and kill *P. aeruginosa.* Therefore blocking the H_2R with the drug **Famotidine** would restore the killing capacity of neutrophils disabled by histamine. Famotidine is used to treat gastroesophageal reflux disease, is safe, low-cost, well tolerated, and blocks the H_2R in neutrophils circulating in the blood and airways. We then propose that oral administration of Famotidine to CF individuals may restore the ability of airways neutrophils to kill *P. aeruginosa.* Our new idea is based on our findings showing that neutrophils capture and kill *P. aeruginosa* in a test tube. This is prevented by histamine and restored by Famotidine.

	Before using Famotidine in CF people, we need to demonstrate that: (i) Histamine and bacteria producing histamine are abundant in CF airways. (ii) Famotidine improves clearance of *P. aeruginosa* in mice airways.
Project Description: Detailed description of the project.	**Background and Rationale:** A well-established clinical paradox in CF is the persistence of respiratory bacterial infections despite the abundance of neutrophils in the lungs. Neutrophils are expected to kill bacteria but they fail to do so. The impaired capacity of neutrophils to kill airways pathogens may be attributed, at least in part, to the milieu of the CF lung. The population of microorganisms in CF airways is complex. It is conceivable that bacterial metabolism may result in products that lead to dysregulation of neutrophil anti-microbial functions. One of these molecules is **histamine**. Indeed, certain respiratory tract bacteria, including *P. aeruginosa*, a Gram-negative bacterium that is a significant CF pathogen, synthesise clinically important amounts of histamine. Therefore, bacterially produced histamine could represent a previously unappreciated evolutionarily conserved molecular dialogue between bacteria and the host, whereby production of histamine would help infecting bacteria to counteract neutrophil functions. **We then hypothesize that bacteria target histamine receptors in neutrophils** to block their anti-bacterial functions. There are two pharmacologically distinct histamine receptors in neutrophils: the histamine-2 receptor (H_2R) and the histamine-4 receptor (H_4R). We recently showed that activation of the H_2R by histamine in neutrophils delayed the capture of *E. coli* by these immune cells. **Our main hypothesis** is that histamine produced in CF individuals by bacteria colonizing the airways blocks the capacity of airways neutrophils to capture and kill these pathogens by engaging the H_2R. Therefore, blocking the H_2R with the H_2R antagonist Famotidine, may be a novel therapeutic approach to boost microbial clearance by neutrophils in the CF airways. Despite CFTR modulators, the airways of people with CF become infected and colonized with *P. aeruginosa*. This is largely responsible for the damage to lung tissues leading to respiratory failure, the main cause of death. Aggressive antibiotic treatments reduce *P. aeruginosa* burden in CF airways, but they also trigger development of *P. aeruginosa* strains and biofilms resistant to antibiotics. There is a real challenge in developing new antibiotics. In this context, it is urgent to develop novel **non-antibiotic-based** therapeutics aimed at reducing *P. aeruginosa* burden in the airways, such therapeutics could be used in combination with CFTR modulators and current antibiotic regimes in an ageing CF population with complex infections. The main benefits of Famotidine is that it is a **safe and low-cost** molecule. It is used for the treatment of gastric reflux symptoms and acute inflammation in COVID-19 patients. The oral uptake of famotidine (80 mg, 3 times daily)

	in adults results in high levels of famotidine in the blood and inhibition of the H_2R in blood and airways neutrophils. **Specific aims:** **1- Measure histamine concentration in sputa of CF individuals**. Histamine concentration will be measured by ELISA[2]. In parallel, we will measure granule markers (lactoferrin, MMP-9, elastase) by ELISA to assess neutrophil degranulation. Presence of histamine-producing bacteria (*P. aeruginosa, H. parainfluenzae, B. catarrhalis*) will be identified by q-RT-PCR. The samples will be collected from The Northern Ireland regional Adult CF centre, Belfast City Hospital. **Outcome**: We may prove association between high histamine levels in CF sputa, disease severity, and high rate of neutrophil degranulation which illustrates inhibition of phagocytosis. **2- Investigate the role of Famotidine in the capture and killing of respiratory bacteria by neutrophils:** We aim at proving that histamine, by engaging the H_2R in neutrophils, blocks the capture and the killing of *P. aeruginosa* and other respiratory pathogens found in the CF airways including the Gram-positive bacteria *S. aureus*. Bacterial capture and killing by neutrophils *in vitro* will be measured as shown by us and by recording the uptake of fluorescent labelled bacteria. **Outcome:** We will validate Famotidine as a drug boosting neutrophil phagocytosis when histamine is present (a situation which may prevail in the CF airways). **3- To investigate the effect of Famotidine on pathogen clearance in mice lungs:** We will use a mouse model of chronic *P. aeruginosa* lung infection mimicking CF in humans (Fig. 2). Mice will receive oral Famotidine or placebo. Famotidine blocks the H_2R in mice. Thereafter, mice will be sacrificed, lung bacteriology, and histopathological studies will be performed. **Outcome:** We may prove that oral Famotidine ameliorates *P. aeruginosa* airways clearance and lung function in mice.
Project Keywords:	Cystic fibrosis, famotidine, P. aeruginosa, airways infection

3.1.7 Developing an Injury Surveillance System in the Different Disciplines of Cycling in Order to Design and Implement Injury Prevention Programmes

Supervisor	Dr Neil Heron
Mode of Study	Full Time Distance Learning
Project Overview	**Aim** – The primary aim is to establish a prospective injury surveillance system in collaboration with the National Qatar cycling teams. Our secondary aim is to analyse the injury data that the surveillance system will generate in order to design and implement injury prevention programmes and monitor and evaluate their effectiveness. **Please note – the partners in Qatar would be expected to facilitate the contacts with the National Cycling Teams of their own country.** **Background -** Cycling is widely regarded as a form of physical activity with a range of health benefits. As well as providing an effective source of aerobic exercise, it has been demonstrated that cycling can improve cognitive function and well-being in adults (1)(2) as well as being relatively cheap to participate in. For this reason, participation in road cycling continues to grow and UK traffic counts suggest that the number of miles cycled in 2017 surpasses that in 1997 by 29%, (https://www.gov.uk/government/collections/road-traffic-statistics) as well as organised recreational bicycle tours continuing to increase in number (3). Whilst the popularity of cycling continues to grow, maintaining participation in a sport can be affected by injuries sustained whilst participating in road cycling. Several studies have examined the most common types of injuries experienced by amateur cyclists (4)(5) but these studies are heterogenous and of poor methodological quality. No previous authors have undertaken a prospective injury surveillance programme within road cycling. Acute injuries reported to occur in road cycling are abrasions, lacerations, contusions, fractures and dislocations, and sprains. Similarly, common overuse injuries include chronic knee pain due to patellofemoral knee syndrome (PFP) and chronic groin/buttock pain (5)(6). If a prospective injury surveillance programme is undertaken of road cycling injuries and illnesses, then optimal treatment as well as preventative measures can be proposed, helping to maintain people's participation in road cycling. Injuries sustained during cycling also prevent progression and success at an elite level. Studies focusing specifically on the injuries in professional cyclists have reported a high incidence of traumatic injuries such as fractures and overuse injuries affecting the knee and lower back (7)(8). Elite athletes are particularly susceptible to injury due to high speeds, minimal protective equipment and adverse weather conditions (9). Indeed, it has been reported that 16% of cyclists withdraw from the Tour de France annually due to injury (10).

	Despite the reported risks of injury during road cycling, studies reporting the incidence and prevalence of these injuries are limited (11) and no previous authors have undertaken a prospective injury and illness surveillance programme in road cycling. Knowledge of the incidence and prevalence of the most common injuries that occur during road cycling would facilitate implementation of preventative measures that reduce injury occurrence and thus increase participation and facilitate better performance by the road cyclists.
Project Description: Detailed description of the project	**Methods** – The 3-year PhD project will start by establishing the variables which can be monitored in National-level cyclists of all disciplines, e.g. road, BMX, mountain bike, competing for the National Qatar teams. Examples of the variables that will be used include hours cycling per week (in training and competition phases), hours spent undertaking other sporting activities each week (e.g. gym-based activities), details about injuries and how they occurred and the 'cost' of an injury (eg time loss). The prospective injury surveillance system will be tested and refined during the piloting phase of the PhD project. Next, the injury surveillance system will be implemented and set up to monitor the elite cycling squads including following the riders for a full 2 seasons. A review and analysis of the injury surveillance data will be undertaken by the PhD student with the guidance of the supervisory team at the specific intervals of 6, 12 and (time permitting) 24 months. The results of the analysis will be used to identify common injuries in the different disciplines of cycling and combined with sports medicine theories and relevant research evidence, draft injury prevention programmes will be designed. The programmes will be refined in focus group discussions with riders, coaches and support staff. This iterative approach to injury prevention programmes may include video analysis of common injuries within a multi-disciplinary team, including medicine, sport scientists, physiotherapy, and biomechanics. Following implementation of the injury prevention programmes, time permitting, we will continue injury surveillance monitoring and, therefore, be able to assess the extent to which these interventions reduce injuries within road cycling. Proposed publications and time-lines for the project: • Establish a prospective injury surveillance programme in collaboration with the National cycling team squads and continue to monitor this for 2 years. This data will lead to at least 2 publications at the end of year 1 and 2 of monitoring. Month 3 to 27. • Qualitative work with riders, coaches and support staff involved in the different cycling disciplines around potential injury prevention programmes that could be introduced into cycling and publication of results. • Development and implementation of injury prevention programmes within the different disciplines of cycling and then reviewing the injury surveillance data to see if this has produced an injury reduction. Potential publications include the development of injury prevention programmes as well as assessment of their performance in affecting injuries.

	This proposed PhD work will involve partnership work with National Qatari cycling squads and the Qatari partners would therefore be expected to facilitate this relationship with the National cycling squads. **References:** 1. Oja P, Titze S, Bauman A, de Geus B, Krenn P, Reger-Nash B, et al. Health benefits of cycling: a systematic review. Scand J Med Sci Sports. 2011;21(4):496-509. 2. Leyland LA, Spencer B, Beale N, Jones T, van Reekum CM. The effect of cycling on cognitive function and well-being in older adults. PLoS One. 2019;14(2):e0211779. 3. Pucher J, Buehler R, Seinen M. Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research Part A: Policy and Practice. 2011;45(6):451-75. 4. Mellion MB. Common cycling injuries. Management and prevention. Sports Med. 1991;11(1):52-70. 5. Schwellnus MP, Derman EW. Common injuries in cycling: Prevention, diagnosis and management. South African Family Practice. 2005;47(7):14-9. 6. Weiss BD. Non-traumatic injuries in amateur long distance bicyclists. The American Journal of Sports Medicine. 1985;13(3):187-92. 7. Clarsen B, Krosshaug T, Bahr R. Overuse injuries in professional road cyclists. Am J Sports Med. 2010;38(12):2494-501. 8. De Bernardo N, Barrios C, Vera P, Laiz C, Hadala M. Incidence and risk for traumatic and overuse injuries in top-level road cyclists. J Sports Sci. 2012;30(10):1047-53. 9. Decock M, De Wilde L, Vanden Bossche L, Steyaert A, Van Tongel A. Incidence and aetiology of acute injuries during competitive road cycling. Br J Sports Med. 2016;50(11):669-72. 10. Haeberle HS, Navarro SM, Power EJ, Schickendantz MS, Farrow LD, Ramkumar PN. Prevalence and Epidemiology of Injuries Among Elite Cyclists in the Tour de France. Orthop J Sports Med. 2018;6(9):2325967118793392. 11. Barrios C, Bernardo ND, Vera P, Laiz C, Hadala M. Changes in sports injuries incidence over time in world-class road cyclists. Int J Sports Med. 2015;36(3):241-8.
Project Keywords	Injury surveillance, Cycling, Physical activity promotion, Medicine, Injury prevention

3.1.8 Developing App/mHealth Based Rehabilitation for use in the Acute Period Following a TIA and/or 'Minor' Stroke

Supervisor	Dr Neil Heron
Mode of Study	Full Time Distance Learning
Project Overview	**Background** Mobile or mHealth interventions aimed at modifying cardiovascular risk factors such as hypertension and reduced physical activity levels might be effective for secondary prevention after a TIA or minor stroke but their effectiveness is uncertain. There is also a need to examine how such interventions might be implemented, prior to definitive randomised controlled trials (RCTs) to determine effectiveness. **Objectives** The 'Brain-Fit' app has been developed, extensively user tested, and refined as part of previous funded work. The aim of this proposed study is to assess the efficacy of 'Brain-Fit', an mHealth intervention designed to support physical activity and dietary-based lifestyle change in the early phase after TIA or minor stroke. **Methods** Thirty participants will be recruited within 1 month of attending a rapid access TIA clinic. Participants will be allocated using permuted block randomisation to a usual care control group or an intervention group who will be provided with access to the app-based intervention. Outcomes will be recorded at baseline (prior to group allocation) and following the 12-week intervention phase. Objectives will be to assess recruitment and retention rates, explore acceptability of procedures and intervention delivery, explore intervention efficacy, and determine a sample size estimate for a future RCT. **Discussion** Findings from this pilot will be used to make a decision on progression to, and inform the subsequent design of a definitive RCT testing the effectiveness of the intervention on reducing cardiovascular risk after TIA or minor stroke.
Project Description: Detailed description of the project	**Background and Rationale** Stroke is a leading cause of disability and mortality, for which a previous transient ischaemic attack (TIA) is a significant predictive factor [1,2]. An approximate 20% risk of a stroke event occurring within 90 days has been reported following a TIA, and early secondary preventative approaches are therefore recommended [3]. While these approaches include interventions targeted at reducing modifiable cardiovascular risk factors such as arterial hypertension and physical inactivity [4], individuals with higher cardiac risk frequently do not meet secondary prevention guidelines [5]. Early rehabilitative needs post TIA or minor stroke can also be complex [6,7], meaning it is uncertain how to best implement secondary preventative approaches in these populations.

	In a recent systematic review examining aerobic and resistance exercise programs post TIA [8], of eight included trials, three reported change in time spent in moderate-to-vigorous physical activity, but only one showed significant increases in activity. While supervised aerobic exercise programmes have been associated with reductions in blood pressure following a TIA [9], such interventions are relatively time and resource intensive, and may not be feasible or cost effective in current healthcare system settings. Poor uptake and attendance, particularly among some groups, including older adults, can also limit their efficacy [10–12]. Mobile or mHealth-based apps may represent an accessible and cost-effective method for the delivery of lifestyle modification interventions post-TIA and stroke [13], particularly during the COVID-19 pandemic when social distancing is mandated [14]. These interventions can incorporate goal setting and pacing techniques [15], incentive and reward systems [16–18], and use of self-entered or automated data entry [19,20]. Adaptive elements such as tailored reminders or prompts [21], motivational messages [22] and responsive content [23] have also been explored. Despite this, there is comparatively little data on the core intervention components associated with engagement and usage needed for sustained behavioural change [24,25]. Many individuals discontinue use of mHealth interventions because of usability issues, or due to viewing them as irrelevant to their needs [26,27]. The proposed pilot trial will assess a previously developed digital lifestyle modification intervention for use in the early phases following a TIA or minor stroke (the 'Brain-Fit' app). The development and usability testing of the app was completed as part of previously funded work. This previous work was based on the person-based approach [28,29] and was informed by an analysis of the theoretical underpinning of the intervention and its likely mechanisms of effect. This app was modelled on the 'The Healthy Brain Rehabilitation Manual' [30], a paper-based tool (developed by study team members) for cardiovascular risk reduction following a TIA or minor stroke and developed following the MRC guidelines for developing complex health service interventions as part of a NIHR-funded PhD. In a randomised pilot feasibility trial, the tool was shown to be feasible, with potential for improvements in blood pressure and physical activity but qualitative data suggested that a digital version might improve accessibility and longer-term use [31]. We then carried out a study to develop, and explore perceptions on usability and relevance of a digital version of the intervention (the 'Brain-Fit' app) in order to first, maximise user engagement and sustainability in TIA or minor stroke populations [32]. As part of this work, a scoping review, focus group, and think aloud interviews (including n=32 participants) were used to produce guiding principles (See Figure 1), a behavioural analysis and explanatory logic model for the intervention, and to explore perspectives on content and usability of a prototype app. Overall, thematic analysis highlighted uncertainty about increasing physical activity and concerns that fatigue might limit participation. Realistic goals and progressive increases in activity were seen as important to improving self-confidence and personal control. The app was seen as a useful and flexible resource. Participant feedback was used to make modifications to the app to maximise

engagement, including simplification of the goal setting and daily data entry sections.

Figure 1. Guiding principles for the Brain-Fit intervention

	Design Objectives	Key Intervention Features
1	Increase confidence and self-efficacy for making behavioural change and address barriers to lifestyle change Barriers addressed: 1, 2, 3, 4, 5, 6, 7, 8 *	- Promote changes in behaviour including gradual, progressive increase physical activity. - Provide a range of goal setting examples. - Include use of goal setting techniques and step data entry (from manual pedometer or a pedometer app). - Include patient stories detailing experiences of recovery after a TIA or minor stroke. - Include information on benefits of healthy behaviours with minimal reference to risk avoidance. - Include additional support from a healthcare professional (telephone calls) to reinforce key messages and provide further reassurance.
2	Ensure ease of use and good intervention acceptability Barriers addressed: 9, 10, 13 *	- Provide different levels of detail including short summaries of each section as well as longer, more detailed sections. - Include health professional telephone support as part of intervention.
3	Provide accessible, brief information and support that can be viewed easily on mobile devices (promoting frequent/daily use) Barriers addressed: 1, 8, 9, 11, 12 *	- Include simple, clear information and language. - Provide advice on integrating the app into a daily routine. - Use of visual aids, graphics and media.
4	Promote self-management and longer-term behavioural change Barriers addressed: 1, 2, 5, 11 *	- Include motivational messages and prompts. - Include a diary/notes section. - Promote choice through self-selection of additional target behaviours (e., diet, smoking, stress management, medication) - Include links to additional sources of support and localised resources (both digital and non-digital resources) - Include references to support/involvement of family/friends in recovery.

* Barriers identified during scoping review and focus groups. 1. Lack of information on cardiovascular conditions including causes/risk factors. 2. Concern that TIA is an 'invisible' condition and others including health professionals perceive effects as minor. 3. Fatigue. 4. Pain/mobility limitations. 5. Lack of confidence or 'self-belief'. 6. Focus on other aspects of care and recovery. 7. Anxiety about recurrence. 8. Uncertainty how to adopt/ maintain a healthy diet. 9. Limited access to digital interventions. 10. Unfamiliarity with digital technologies/smartphones. 11. Family/partner role (perceived 'protective' role). 12. Poor weather or lack of places to be active. 13. Effect on memory or cognition.

In summary, access to well-developed, evidence-informed digital interventions in the early stages after a TIA may represent an effective secondary preventative and rehabilitative approach to reduce cardiovascular risk. It is critical that apps provide accurate clinical information, and include features to ensure they have good usability, are engaging, and include effective behavioural components. Following these development and optimisation processes, the findings of a randomised controlled feasibility trial will be used to make any additional modifications needed to the 'Brain-Fit' app, prior to conducting a fully powered randomised controlled trial to examine intervention efficacy and cost effectiveness.

Objectives

The objectives of the proposed pilot trial will be:

- To evaluate whether the 'Brain-Fit' mobile app can be used as part of a home-based rehabilitation programme for patients with a recent transient ischaemic attack or 'minor' stroke.
- To assess rates of recruitment (defined as the percentage of eligible patients who agree to participate) and retention (defined as the percentage of participants completing follow-up assessments).
- To explore the acceptability of recruitment and randomisation methods, outcome measurement procedures and fidelity of intervention delivery (including content and format).
- To explore quantitative data on intervention usage and engagement.

- To explore qualitative data on participant perspectives in order to inform interpretation of overall study findings and to further develop and optimise the intervention.
- To explore response variability to help determine a primary outcome and sample size estimate for a randomised controlled trial.

Methods

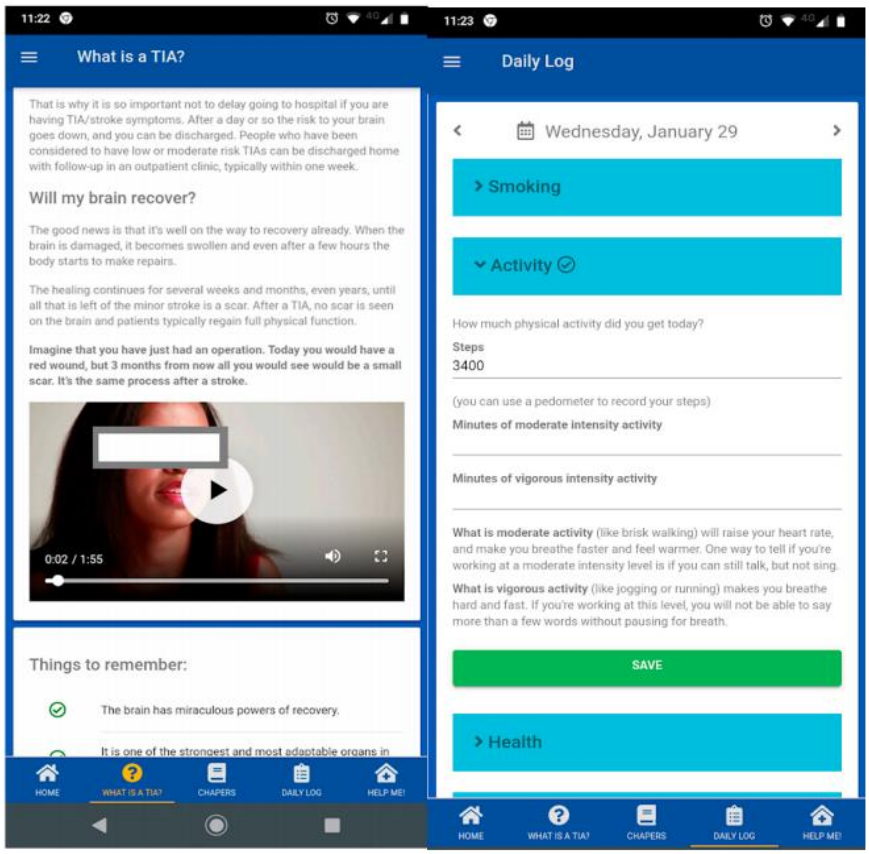
Study design and setting

This study will use a two-arm, assessor blind, parallel group, randomised controlled pilot trial design with a nested qualitative component exploring participant beliefs and behaviours and a process evaluation. The study will be conducted in collaboration between Queen's University Belfast and the local healthcare system. Eligible participants will be randomly allocated to a usual care control group or to an intervention group provided with access to a mobile app (The 'Brain-Fit' app). Outcome measures will be recorded at baseline (immediately prior to group allocation) and at 12-week follow-up. Recommendations of the SPIRIT checklist for trial development and the TIDieR guidelines for describing intervention content were followed when developing this protocol.

Control group

Participants in the control group will receive standard care from the TIA clinic.

Figure 2. Brain-Fit app screen shots



	Outcome measures As a pilot study, no primary or secondary outcomes will be selected. The following measurements will be recorded at the baseline (prior to randomisation) and at follow-up assessment (week 12). • Accelerometer data recorded over seven days using an Actigraph GT3x activity monitor used to provide a blinded assessment of physical activity levels (with data capture at 10-s Epoch intervals recording and time in moderate to vigorous physical activity and step counts included in the analysis). • Two-minute walk test (recording mean distance in metres) performed twice with a 1-minute rest period between trials. • Timed up and go test. • Self-reported physical activity levels recorded using the International Physical Activity Questionnaire (IPAQ). • Dietary intake using a modified Dietary Instrument for Nutrition Education (DINE). • Hospital Anxiety and Depression scale (HADs). • General Self-efficacy scale (GSE). • Modified Rankin scale to measure level of functional disability. • Ability to complete daily activities (SF-12 scale). • Fatigue assessment scale (FAS). • Montreal Cognitive Assessment tool (MoCA). • Overall health status using the EQ5D-5L. **Process evaluation** In line with MRC guidance, this pilot will include a process evaluation appropriate for the feasibility testing stage of the development evaluation-implementation process. This process evaluation will allow for the exploration of the uptake (recruitment) and retention, participant engagement, fidelity of intervention delivery and participant perspectives on the intervention. Purposive sampling will be used to select at least 10 participants from the intervention arm and 5 from the control group to evaluate the perspectives and experiences of participants using semi-structured interviews and focus groups. The feasibility, acceptability and usability of both intervention arms will be assessed, with findings used to further refine and optimise the intervention and trial procedures, including acceptability. Qualitative methods will also be used to explore perceived barriers and facilitators to implementation of the intervention. All interviews and focus group meetings will be tape-recorded, transcribed verbatim and analysed using a thematic content analysis. An exit questionnaire will also be completed at the end of the study including questions on allocation preference and acceptability of treatment, as well as trial procedures, including the questionnaires. Usage data from the 'Brain-Fit' app will also be analysed and summarised descriptively. **Systematic Review** A systematic review will also be conducted over the study duration period to examine the effectiveness of digital interventions for secondary prevention in people with increased cardiovascular risk factors. The review is indicated following the recent completion of a scoping review in this area, carried out as part of a previously funded project, that highlighted

	important gaps in evidence in this area. The protocol for the review will be published and registered with PROSPERO. The review will follow the PRISMA recommendations and will be managed using appropriate review management software (COVIDENCE). **Data management and trial monitoring** A trial steering committee will be established. All data will be stored securely in accordance with General Data Protection Regulations and only members of the trial team will have access to the trial data. Anonymity will be maintained and unique identifiers will be removed in any subsequent outputs. This trial will also be subject to audit from the study sponsor, who has the power to terminate the trial if necessary. Trial results will be submitted for publication and in a relevant peer reviewed journal. It is critical that usability or acceptability issues are explored in detail and addressed in future re-designs of the intervention. It is also important to promote engagement since intention to use mHealth interventions is mediated by perceived ease of use, usefulness as well as social determinants. Increased engagement may be related to demographic characteristics including previous experience of using mHealth interventions, and the inclusion of common behaviour change techniques such as provision of information on health consequences, social support, use of reminders and self-monitoring or use of goal setting. This pilot study will provide preliminary data on the efficacy of the 'Brain-Fit' intervention in the early period after a TIA or 'minor' stroke. Findings will be used to make a decision on progression to a definitive randomised controlled trial and will also be used to inform the subsequent design of a trial aimed at determining the effectiveness of the intervention on reducing cardiovascular risk.
Project Keywords	Stroke; TIA; transient ischaemic attack; rehabilitation; secondary prevention; cardiovascular prevention; App; mHealth

3.1.9 Identifying Novel Biomarkers and Risk Factors for Age-Related Eye Disease

Supervisor	Dr Ruth Hogg
Mode of Study	Full Time at QUB or Full Time Distance Learning
Project Overview:	The Northern Ireland Cohort for the Longitudinal Study of Aging is an ongoing population-based epidemiological study that has recruited 8,500 participants from across Northern Ireland. They have been followed up for nearly a decade. At baseline and wave 3 they underwent multi-modal retinal imaging as well as other health assessments including cardiovascular, cognitive, respiratory and anthropometric. This data combined with the medical history, lifestyle, demographic, genetic and blood-based biochemistry provides a very rich dataset to explore the development and progression of age-related eye diseases such as age-related macular degeneration, diabetic retinopathy. We have strong links with EEECS Computer Vision group who can supervise students in the development of novel imaging biomarkers or Artificial Intelligence/Machine Learning approaches. This provides the opportunity to craft a project to a student's interest and also potentially develop a project that includes a comparative component from the student's own country.
Project Description: Detailed description of the project.	**Background:** Age-related eye disease is a significant contributor to disability and reduced quality of life in older age. Multi-disciplinary longitudinal epidemiological studies provide the opportunity to explore risk factors for development or progression of disease and the development of novel biomarkers to aid diagnosis and prognosis. **Aims:** To identify or develop novel biomarkers of age-related eye disease and determine the burden of disease within the population attributable to these diseases. **Objectives:** • Use the NICOLA longitudinal dataset to design a study focused on novel risk factors or biomarkers for age-related eye disease. • Adopt innovative methodologies including machine learning to identify novel relationships within the high-dimensional data. A project can be developed to suit the interests, skills and career goals of the student with full training provided in new methods.
Project Keywords:	Age-related macular degeneration, diabetic retinopathy, glaucoma, epidemiology, computer vision, biomarkers, multi-modal imaging

3.1.10 Exploration of Therapeutic Potential of the Engineered Mesenchymal Stem Cells Exosomes in Pre-Clinical Models of Acute Respiratory Distress Syndrome (ARDS)

Supervisor	Dr Anna Krasnodembskaya
Mode of Study	Full Time at QUB
Project Overview:	In this project we wish to develop the novel unique next-generation stem cell therapy product based on MSC exosomes and iPSC technology which will have superior scaling capabilities for GMP manufacturing. Overexpression of specific factor (previously identified by our group) will enable enhanced therapeutic efficacy of MSC EVs through their capacity to more effectively restore mitochondrial function in recipient cells. Given that mitochondrial dysfunction underpins pathophysiology of multiple diseases as well as the process of aging, translational potential of such product is very high. Collectively, this work will enable further translational development of iPSC MSC cell therapy product, new foreground IP and open opportunities for new collaborations with academic, clinical and industrial partners. This project offers exciting training opportunities for early career researcher in the fast developing field of stem cell based therapies.
Project Description: Detailed description of the project.	Acute Respiratory Distress Syndrome (ARDS) is a major cause of acute respiratory failure in critically ill patients requiring mechanical ventilation and is associated with high mortality and morbidity. ARDS has no specific pharmacological therapy and advanced therapeutics based on mesenchymal stromal cells extracellular vesicles are rapidly moving towards clinical translation. Previously we demonstrated that mitochondrial dysfunction in the lung tissue significantly contributes to development of severe lung injury in ARDS while Mesenchymal Stromal Cells (MSC) exosomes are able to improve survival and reduce severity of lung injury at least partially through restoration of mitochondrial fitness in the recipient host cells. Interestingly, we have identified that MSC EVs carry mitochondrial transcriptional co-factor which is capable of enhancing mitochondrial biogenesis. In this project we aim to develop 'engineered' MSC extracellular vesicles overexpressing this co-factor with the enhanced capacity to modulate mitochondrial function in recipient cells and enhanced therapeutic efficacy in ARDS.
Project Keywords:	Mesenchymal stem/stromal cells, exosomes, ARDS, iPSCs, mitochondrial dysfunction

3.1.11 Overwriting Blood Vessel Identity to Prevent Coronary Graft Failure

Supervisor	Dr Denise McDonald
Mode of Study	Full Time at QUB
Project Overview:	**Cardiovascular disease (CVD)** is the leading cause of death worldwide. Coronary heart disease (CHD) is the most common type of CVD and is responsible for 10 million deaths globally every year. CHD is caused by thrombotic occlusion of the blood vessels that supply the heart, which leads to local tissue ischaemia and irreversible damage to the underlying cardiomyocytes. Currently, treatment relies on stenting or **coronary artery bypass graft (CABG) surgery** whereby a blood vessel is removed from the patient's leg (saphenous vein), chest (internal mammary artery) or arm (radial artery), and used to bypass the obstructed vessel, allowing re-vascularisation of the damaged heart. While very successful, this procedure is limited by the development of accelerated atherosclerosis, a condition called **vein graft disease** which leads to 75% of grafts being occluded within 10 years. The reasons for this accelerated disease progression are not well understood. Recently, we have identified several novel targets that we hypothesise could be used therapeutically to enhance blood vessel stability to prevent graft failure or significantly extend its efficiency. Ethical approval and a well-rehearsed SOP for collecting and processing human samples will facilitate the speed of this project.
Project Description: Detailed description of the project.	***OBJECTIVE:*** *Using our unique expertise in vascular and molecular/ cell biology, this study will investigate the underlying mechanisms that disturb healthy endothelial cell (EC) function in patients with cardiovascular disease.* **Overall outcomes of research project:** This study will elucidate novel ways to promote the long-term survival of EC and prevent the deleterious consequences of graft failure. **AIMS AND EXPERIMENTAL DESIGN** **Aim 1:** Investigate the function of novel proteins important for promoting arterial properties in EC. **Aim 2:** Investigate the impact of these novel targets on EC biology using genome engineering. **Aim 3:** Investigate how these targets are altered in disease using in vitro models of vascular disease. **The student will gain state-of-the-art expertise in cell and molecular biology techniques which will be transferable to a wide range of disciplines and research areas.** **<u>Training will be provided:</u>** 1. Primary cell culture of EC. 2. Molecular biology techniques such as RNA isolation, PCR, protein extraction and western blot, immunocytochemistry and sub-cellular tracking using GFP/ RFP constructs. 3. Gene transfer techniques and reporter assays to investigate the role of key signalling pathways implicated in disease models.

	4. Key skills: Data mining and Gene expression profiling and analysis; Data analysis; Critical analysis of the literature; Presentation skills; scientific writing. Overall, the proposed project will provide training in a wide range of laboratory skills essential for a future career in science.
Project Keywords:	Cardiovascular disease, Vascular function, vascular endothelial cells (EC), nitric oxide, oxidative stress, vein graft disease, coronary artery bypass surgery (CABG)

3.1.12 The Development of Liquid Biopsy Tests for the Early Detection and Improved Diagnosis of Poor Outcome Cancers

Supervisor	Professor Paul Mullan
Mode of Study	Full Time at QUB
Project Overview:	Blood tests, instead of invasive tissues biopsies, are becoming increasingly important for improved diagnosis and treatment approaches for cancer patients. Such blood tests are often called "Liquid Biopsies" and offer many advantages over tissue biopsies including being faster, cheaper, and more routinely available. Even if Liquid Biopsies do not fully replace all tissue biopsies, they could add benefit by enabling real time monitoring for tumour recurrence and treatment responses, contributing to improved patient outcomes and quality-of-life. This project will involve the development of blood tests aimed at improving our ability to diagnose cancers, specifically cancers of poor outcome such as Ovarian. Triple Negative Breast, Pancreatic and Lung Cancers. These cancers currently are diagnosed in their later stages.
Project Description: Detailed description of the project.	**Background:** Substantial information originating from tumours enter body fluids, such as the bloodstream, and so have potential as Liquid Biopsies, serving as non-invasive alternatives to surgical biopsies. Tumour derived materials, include circulating tumour cells, circulating tumour DNA (ctDNA) and RNA; and extracellular vesicles containing cancer cell contents. The student will build upon work developed at QUB, where researchers have identified multiple DNA methylation (DNAme) events in tumours, including early-stage tumours. These DNAme markers could serve as the basis of PCR-based Liquid Biopsy tests for the improved diagnosis of Ovarian Cancers and other 'difficult to diagnose' cancers, such as Triple Negative Breast Cancers, Lung Cancers and Pancreatic Cancers. This PhD studentship will build upon work developed in the Mullan group, where researchers have identified multiple DNA methylation (DNAme) events in Cancers, including early-stage tumours. We aim to identify DNAme markers in these cancer types, and develop PCR-based blood tests for the detection of DNAme markers found in ctDNA, to evaluate their diagnostic and disease monitoring potential. We will generate our own methylation datasets, as well as using publicly available datasets, to prioritise the very best DNAme markers. A well-established bioinformatics analysis pipeline will maximise our chances of successfully identifying such markers and developing improved diagnostic tests. **Aims:** 1. To identify candidate DNAme regions differentially methylated between control and cancer tissue 2. To validate DNAme markers using cell line, FFPE tissue; and plasma samples 3. To design MSRE-ddPCR tests to diagnose cancer versus non-cancer and validate in independent blood samples
Project Keywords:	Liquid Biopsy, diagnosis, early detection, DNA methylation

3.1.13 Mechanisms of Pathogenesis and Immunity During *Shigella* Infections

Supervisor	Dr Andrea Puhar
Mode of Study	Full Time at QUB
Project Overview:	Bacterial gut pathogens area a leading cause of disease and death worldwide. Pathogens have evolved complex ways to establish infection, manipulate host cells, and survive within the host. On the other hand, to combat infection, our immune system mounts a protective inflammatory response. However, immune responses cause damage when they are uncontrolled, for example during inflammatory diseases. Therefore, an in-depth understanding of pathogenic and inflammatory mechanisms is required to harness the beneficial power of immunity during infection while contrasting pathogenic activities with specific therapy.
Project Description: Detailed description of the project.	Extracellular ATP is a proinflammatory mediator that is secreted by infected host cells as early alert response. We are running an ambitious research programme studying how intestinal cells and microbes control the abundance of the inflammatory mediator extracellular ATP and how they respond to it. We have open projects focusing on the host or the bacteria. Our special interest is on Enterobacteriaceae, such as *Shigella flexneri* and *Escherichia coli*. Using systems biology approaches, we are studying *Shigella* mechanisms of pathogenesis at genome-wide level.
Project Keywords:	Infection, inflammation, host bacteria interaction, extracellular ATP, immune sensing, virulence factors, *Shigella*

3.1.14 Investigations Into the Pro-Inflammatory and Pro-Fibrotic Microenvironment in Pulmonary Fibrosis

Supervisor	Dr Bettina C Shock and Professor Andriana Margariti
Mode of Study	Full Time at QUB
Project Overview:	Interstitial lung disease (ILD) is the leading cause of death in patients with systemic sclerosis (SSc) and idiopathic pulmonary fibrosis (IPF). In ILD, highly activated fibroblasts called myofibroblasts produce excessive amounts of extracellular matrix, which leads to lung fibrosis. Repeated injury to endothelial and pulmonary epithelial cells are the initiating factors, but the mechanism leading to myofibroblast activation remains unclear. This project we will generate human induced pluripotent stem cell-derived fibroblasts, endothelial and epithelial cells and use a co-culture model to determine endothelial and epithelial factors (the disease specific microenvironment) leading to inflammation and fibrosis in the lungs. Bioinformatical approached will be used to identify new therapeutic approached to halt fibrosis.
Project Description: Detailed description of the project.	***Pulmonary fibrosis*** is a serious, life-limiting lung disease. It causes scarring and thickening of lung tissue over time, making it harder to breathe. There is currently no cure for pulmonary fibrosis. The most common type of pulmonary fibrosis is idiopathic pulmonary fibrosis (IPF), a progressive fibrotic lung disease with unknown cause, affecting approximately 3 million people worldwide. Lung fibrosis is also one of the most common complications in patients with Systemic Sclerosis (SSc). Worldwide 30-50% of SSc patients develop lung fibrosis. The prevalence of SSc-ILD in East Asia is 56% (95% CI 49%-63%) with the highest prevalence occurring in China (72%). Repetitive endothelial and epithelial cell injury is believed to be the first step in the pathological process, which leads to recruitment and activation of fibroblasts and differentiation of fibroblasts to myofibroblasts. While pulmonary fibrosis causes hypoxia, hypoxia also drives progressive fibrosis. Of particular importance is the diseases-specific microenvironment in which fibroblasts are activated. Our work in SSc-ILD (Fields A *et al*. 2022) and published data in IPF (Schruf E, *et al.* 2020*)* show that the microenvironment is highly pro-inflammatory and fibrogenic. Therefore, the source of these microenvironment constituents is a pharmaceutical target to limit pulmonary fibrosis. Due to the very high mortality rate and the currently limited therapeutic options, there is an unmet need for further research to develop new anti-fibrotic drugs. However, access to patient-derived lung fibroblasts for research is ethically difficult and cells from end stage disease may not accurately reflect disease progression. Therefore, there is also a need for a patient relevant disease model. The project will use a patient-derived induced pluripotent stem cell (iPSC) in-vitro cell model of fibroblasts and other lung relevant cells. The proposed project will use patient derived iPSC cells derived from peripheral blood derived mononuclear cells as described by Vilà-González M *et al*., (2019). This well-established technique offers the unique opportunity to facilitate patient related investigations into the mechanisms of pulmonary fibrosis and patient-focused drug responses.

	This study ***aims*** to characterize the underlying mechanism(s) of persistent myofibroblasts activation in pulmonary fibrosis using a patient-derived iPSC in-vitro cell model and will evaluate the role of the fibrogenic and pro-inflammatory disease specific microenvironment. iPSC derived cells (fibroblasts, endothelial, epithelial cells) will be used to investigate the flowing ***objectives***: **1.** ***Characterize the differences between control fibroblasts and SSc/SSc-ILD fibroblasts.*** Peripheral blood derived iPSC fibroblasts will be stimulated the identified microenvironment in the presence and absence of TGFβ1. Gene and protein expression (mRNA, qRT-PCR; Western blotting, proteomics) will be used to determine the pro-fibrotic and inflammatory responses. ***2.*** ***Identify the effect of hypoxia injury of the alveolar epithelium and endothelium to the activation of iPSC derived fibroblasts from patients and controls.*** iPSC derived endothelial and epithelial cells from patients and controls will be exposed to hypoxia and the supernatant will be characterised (cytokine array, proteomics). Co-cultures of iPSC derived fibroblasts with alveolar epithelial and endothelial cells or their conditioned medium) will be used to determine the pro-inflammatory and pro-fibrotic response of iPSC fibroblasts at gene and protein level using next generation sequencing and proteomics. Candidate genes/proteins will be confirmed by qRT-PCR Western blotting (WB). ***3.*** ***Identify mechanisms of disease focusing on the effect of identified constituents of the microenvironment.*** For instance, the effect of hu rHE4 on iPSC-derived fibroblast will be evaluated by NGS and proteomics. Candidate genes/proteins will be confirmed by qRT-PCR / WB / immunohistochemistry. The effect of HE4 inhibiting drugs such as Dapagliflozin to inhibit/normalize the effect of HE4 on iPSC-derived fibroblasts will be tested. Further HE4 reducing drugs that can be repurposed will be identified using bioinformatical approaches such as SscMap. This proposed iPSCs- and diseases microenvironment-centered research will bring new insights to understanding the link between inflammation and fibrosis and will open novel treatment option for patients with pulmonary fibrosis. Results may also be transferable to other pulmonary fibrosis diseases such as Covid-19 associated ILD or chronic obstructive pulmonary diseases (COPD).
Project Keywords:	Induced pluripotent stem cells (iPSCs), pulmonary fibrosis, fibroblasts, diseases-specific microenvironment, pharmacological treatment

3.1.15 Dissecting the Regulation of Antibacterial Responses of Immune Cells by Protein Glycosylation

Supervisor	Dr Gunnar N Shroeder
Mode of Study	Full time at QUB
Project Overview:	Bacterial infections are among the top 10 causes of suffering and mortality worldwide, in parts driven by a rising the human population with underlying health conditions. How conditions such as for example diabetes influence the immune response and outcome of bacterial infections on a molecular level is still poorly understood. This project aims to determine how protein glycosylation, a post-translational modification closely linked to the metabolic state of cells, regulates the antibacterial response of macrophages and neutrophils. We will use an interdisciplinary approach including cell and immunobiology, microbiology and biochemistry techniques and proteomics and imaging to dissect the signalling pathways and antibacterial capacity of cells under different infection conditions and determine if bacterial pathogens manipulate protein glycosylation to overcome the host response. This will provide important knowledge to design treatments that could boost the antimicrobial capacity of immune cells for the fight against infection.
Project Description: Detailed description of the project.	Bacterial infections are among the top 10 causes of suffering and mortality worldwide. Increasing antibiotic resistance and growing populations with health conditions that predispose to infection are expected to exacerbate this in the future. Macrophages and neutrophils are the first line of defence against bacterial pathogens. Over the last 5-10 years, it has emerged that mounting the antibacterial response is intimately linked to adaptations of immune cell metabolism, bearing huge potential as target for host-directed antimicrobial therapy, (Galli & Saleh, 2021) and "immunometabolism" research has become one of the fasted evolving and most exciting fields. Despite substantial progress, our understanding of how changes in small molecule metabolites are translated into changes in protein activity and antimicrobial programs is still superficial. An effective mechanism for this is the direct use of metabolites to modify proteins. These post-translational modifications (PTMs) change the enzymatic activities and/or protein-protein interactions of the modified proteins allowing fast, dynamic transmission of signals. Protein O-GlcNAcylation, the reversible modification with a sugar moiety, has emerged as key PTM (Schjoldager, 2020), which connects nutrient sensing, metabolism (in particular availability of glucose), signal

	transduction and transcription, and plays important roles in development and cell physiology. O-GlcNAcylation has been implicated in controlling macrophage activation and immune cell migration and hundreds to thousands of proteins can be dynamically regulated by the sugar transferase OGT and the glycosidase OGA (Schjoldager, 2020; Chang, 2020). However, it is poorly understood which of them are key for regulation of immune cell adaptation, how the modification changes their functions and how glucose levels in hypo- or hyperglycaemia, for example in diabetes, change the O-GlcNAcylation network and thus the antibacterial capacity of the cells. Moreover, currently we also lack an understanding if the O-GlcNAcylation signalling network is general or specific in response to different bacterial pathogens and if pathogens manipulate O-GlcNAcylation to subvert the immune response. This knowledge is however needed to design therapies to modulate this system to optimise the antibacterial capacity of macrophage and neutrophils. **Aims/Objectives** This project builds on a current BBSRC UKRI research project which analyses the role of bacterial glucosyltransferase toxins in the interaction of *Legionella pneumophila* with host cells. To assess the function of the O-GlcNAcylation network in the bacteria-host interaction more general we will: 1. Use pharmacological inhibitors and gene-editing to make mammalian cells in which we can control expression of OGT and OGA by targeted protein degradation and/ or CRISPR interference/ activation. 2. Challenge the cells with different pathogen-derived molecules and pathogens with and without modulation of glucose levels and determine the antibacterial capacity of the cells (cell migration, phagocytosis, expression of antimicrobial molecules and cytokines (proteome/ transcriptome), phagocytosis, bacterial killing etc.) 3. Determine the proteins which are differentially glycosylated using glycoproteomics and assess if pathogens use virulence factors to modulate the response. 4. Analyse the effect of glycosylation on the function of selected proteins in cell signalling and immune cell activation. This project offers the exciting opportunity to engage in highly interdisciplinary research and get hands-on experience in a wide variety of techniques in cell and immunobiology, microbiology and biochemistry including e.g. molecular biology, gene-editing, cell-based assays, bacterial infection assay and proteomics/ transcriptomics and imaging. In addition, you will receive training in experimental design, data analysis and scientific writing and communication skills by the Schroeder team.
Project Keywords:	Microbiology, Immunobiology, Bacterial infection, Host-pathogen interaction, Cell biology, Glycobiology, Innate Immune Signalling

3.1.16 The Role of Cysteinyl Proteases in Lung Injury and Inflammation

Supervisor	Professor Cliff Taggart
Mode of Study	Full time at QUB
Project Overview:	In chronic lung diseases such as Chronic Obstructive Pulmonary Disease, the lung is susceptible to destruction of lung tissue by human cells that normally participate in removing bacteria from the lung. These human cells (neutrophils) release enzymes that can degrade lung tissue and cause inflammation in the lung. In this study, we will evaluate how these enzymes are synthesised prior to their release from neutrophils which will include development of new inhibitors to regulate their activity.
Project Description: Detailed description of the project.	Neutrophil Serine Proteases (NSPs) such as Neutrophil Elastase (NE) are known to be present in the lungs of individuals with various chronic lung diseases including Cystic Fibrosis (CF) lung disease and Chronic Obstructive Pulmonary Disease (COPD). It is known that NE correlates significantly to the development of bronchiectasis in early CF and other studies have demonstrated that inhibition of another protease, cathepsin C (CatC), which is known to regulate NSP activation, results in reduced frequency of exacerbation in individuals with bronchiectasis. However, recent data from the Taggart laboratory shows that there is another level of regulation of NSP activity. The proposed project will delineate further this novel NSP processing activity and evaluate how this activity impacts neutrophil function including oxidant generation and bacterial killing. In addition, there will be a focus on measurement of protease activity assays and analysis of neutrophil gene expression. The study will be a collaboration between the Taggart laboratory in the Wellcome Wolfson Institute for Experimental Medicine, the Williams laboratory in the Patrick G Johnston Centre for Cancer Research, the Tirouvanziam laboratory in the Emory University, Atlanta, USA and the company partner ProAxsis, where the student will spend time conducting protease activity assays.
Project Keywords:	Respiratory Disease, neutrophil, protease

3.2 SCHOOL OF BIOLOGICAL SCIENCES

3.2.1 Machine Learning Approaches to Investigate Niche Specialisation and Optimal Communities in the Rumen Microbiome

Supervisor	Professor Chris Creevey
Mode of Study	Full Time at QUB
Project Overview	This computational project will use Machine Learning approaches as applied to large-scale metagenomic sequencing data from the rumen microbiome to investigate how these microbes form stable ecological communities which impact environmental emissions, efficiency, and health of the host.
Project Description: Detailed description of the project	How microbes assemble to form coherent, robust communities is an outstanding question in microbiology. Each stable microbial assemblage represents one of possibly many different optimal communities that could exist given the same stable environmental conditions. One of the key drivers of stability in these optimal communities is niche specialisation, where each organism plays a unique and often critical role defined by the sets of genes it possesses. Recently, our group in Queen's University Belfast has led the application of evolutionary approaches to assess the hidden variation in microbiomes demonstrating how they could reveal previously unknown niche specialisation in microbial communities [1]. We have also pioneered the development of the theoretical underpinnings of 'metagenome individual haplotyping' [2] from metagenomic data and open access tools to reconstruct cryptic haplotypes from microbial communities that underpin niche stability within species. This project will build upon these advancements by applying machine learning approaches to elucidate the patterns of adaptive variation between species underpinning stable microbial communities. From this we will identify the fundamental rules governing niche specialisation in complex microbiomes. These approaches will be applied to the rumen microbiome, to understand how the different stable-state communities identified impact important phenotypes in these animals, such as emissions, efficiency and health status. [1] https://doi.org/10.1038/ismej.2017.34 [2] https://doi.org/10.1093/bioinformatics/btaa977
Project Keywords	Microbiome, Metagenomics, Machine Learning, Ruminants, climate change, computational biology, bioinformatics

3.2.2 Biocultural Baselines, Using Dental Calculus to Assess Socioecological Systems in Medieval Ireland

Supervisor	Dr Bobby Graham (BIO) and Professor Eileen Muphy (NBE)
Mode of Study	Full Time at QUB
Project Overview	Historical ecological baselines are key to recreating reference points from which to measure ecological changes and model sustainable natural resource use and sustainably in human societies in relation to the ecosystems they live in. Therefore, sustainability is dependent on multifactorial historical, climatological, environmental, and cultural circumstances shaping socioecological systems and responses to change. Environmental archaeology represents an archaeological-palaeoecological approach to studying the palaeoenvironment. Reconstructing past environments and past peoples' relationships and interactions with the landscapes they inhabited provides archaeologists with insights into the origin and evolution of anthropogenic environments. Human dental calculus is an excellent target for examining the plant component of ancient diets. Microfossils become imbedded within dental calculus throughout life, providing an overall picture of plant foods available (e.g. in Rapa Nui showing population diet prior to European contact [Tromp and Dudgeon 2015]). Analysis of calculus has also been shown to reveal information about the oral biome and health status of an individual (see e.g. Hendy et al. 2018; Velsko et al. 2022). The integration of proteomic analysis of calculus with data derived from chronology, human osteoarchaeology and palaeopathology and other aspects of environmental archaeology, including plant microfossils, plant macrofossils and zooarchaeology, will enable an understanding to be gained about the relationship between humans and their environment across the medieval period in selected sites from Ireland.
Project Description: Detailed description of the project	The environment in general, and climate in particular, are at times a catalyst for human resilience and adaptation. Notwithstanding, environmental and climatic variability can also have catastrophic effects on human health. In this project, we test the hypothesis that human diet and oral health tracks environmental and climatic variability. While supported by state-of-the-art archaeological method and theory, this project focuses on proteomics and osteological data analysis of human skeletal assemblages curated at Queen's University Belfast. The project explores the role of the environment with respect to human health through consideration of how past societies responded to the impact of differential environmental conditions. Environmental (including climate) volatility is of major interest today and we will explore its influence on population health, disease loads and the diet of medieval populations in Ireland. The environment clearly has a huge impact on human health both now and in the past. A knowledge of the effects of environmental conditions, and change, on the health of early historic communities in Ireland has the potential to inform critical components of modern human health in the region, including oral health. The project will be the first to undertake a largescale proteomics analysis of samples of dental calculus from Irish

	medieval skeletal populations. The process whereby dental plaque builds up on the surface of a tooth and becomes calcified (calculus) results in the entombment and preservation of biomolecules connected to both the oral microbiota and the individual. Additionally, inhaled and/or ingested microparticles may be related to the environment, human behaviour and foodstuffs. The presence of dietary particles on the teeth can provide direct evidence of the nature of foods consumed, which can complement more generalised measures of past diet, including dental palaeopathology, stable isotope analyses, zooarchaeology and analysis of plant remains. The preserved proteins are robust and highly diagnostic and different parts of plants (e.g. seeds versus leaves) and animals (e.g. muscle versus milk) can be identified (Tromp and Dudgeon 2015; Hendy et al. 2018; Velsko et al. 2022). The aim of the project is to integrate the proteomic analysis of calculus with data derived from chronology, human osteoarchaeology and palaeopathology and other aspects of environmental archaeology, including plant microfossils and zooarchaeology, to enable an in depth exploration of the relationship between humans and their environment across the medieval period in Ireland. The objectives of the calculus analysis are to provide: 1) A new dimension for the understanding of past diet at both individual and population level. 2) Insights into oral health and infectious disease through the integration of proteomic and osteological data. 3) Comparison of the oral biomes of children and adults. The project will be supervised by a biological scientist (Dr Bobby Graham), with expertise in proteomics and the oral microbiome, and an osteoarchaeologist (Professor Eileen Murphy), with a detailed knowledge of the human skeletal populations to be included in the project. It will be supported by the acquisition of a state of the art mass spectrometry system that will run alongside the Chemoproteomics Centre of Excellence in the School of Biological Sciences, co-directed by Dr Bobby Graham. Training in proteomics analysis, Irish medieval archaeology and bioarchaeology will be provided.
Project Keywords	Dental calculus, proteomics, medieval, osteoarchaeology, environment

3.2.3 Green Technologies to Produce Sustainable Novel Food Ingredients from Biopolymers of Agricultural By-Products

Supervisor	Dr Tassos Koidis
Mode of Study	Full Time Distance Learning
Project Overview:	The environmental impact agri-food is high, generating huge amounts of waste streams rich in different forms of cellulose (e.g., vegetable leftovers) that are undervalued and often discarded. Here, we propose adding value to these waste streams by using green technologies to extract and process fibrous hemicellulosic fractions so that they gain interesting technological and functional properties. These novel ingredients will be used to clean label the next generation of plant-based foods.
Project Description: Detailed description of the project.	Production of biopolymers from waste streams' by-products such as fruit, vegetable peels and spent grains (defatted seeds or meals mostly) received a lot of scientific attention. Among them, modified micro-fibrillated cellulosic type material (MFC) from sugar beet pulp and carrot peels have shown promising results as a rheology modifier, emulsifier and binder for proteins. Although chemical modification result in such positive changes, the process itself is energy inefficient and contributing to carbon emissions. Green technologies such as cold plasma, ultra-sonification, dielectric heating and others have the potential to produce molecules with similar functionality, but sustainable and positively perceived by consumers, regulators and the food industry at large. This project will deliver new knowledge by investigating sustainable sources to enrich, process, modify and subsequently test micro-cellulosic fibres and their use as novel emulsifying and binding agents in food products.
Project Keywords:	biopolymers, agri-food, waste streams, green technologies, sustainable, food structure, functional properties

3.2.4 Valuing the Monetary Benefits of Combating Climate Change in Qatar

Supervisor	Professor Alberto Longo
Mode of Study	Full Time Distance Learning
Project Overview:	Qatar is one of the largest world producers of natural gas. Its economy has boomed since gas reserves were found in the country. Yet, this rapid economic growth has led to an increase in the consumption of fossil fuels which are contributing to (i) local air pollution and (ii) climate change. This project aims to explore society's attitudes, preferences and willingness to pay to support a transition to a low carbon economy in Qatar.
Project Description: Detailed description of the project.	This project will use stated preference methods, such as contingent valuation and discrete choice experiments to study society's willingness to pay for embracing a low carbon economy in Qatar. The successful applicant will be required to develop and administer a survey of the local population in Qatar, with a sample size of approximately 1,000 respondents. The survey will first gather evidence on the relative importance of sustainable development in Qatar, and explore respondents' attitudes for a shift towards a more sustainable society. The survey will then provide respondents with a hypothetical scenario of reduction in air pollution and greenhouse gas emissions arising from a set of policy measures, such as improved transport, improved energy efficiency, increase in the use of renewable energy. Respondents will then queried for their willingness to pay to implement the hypothetical scenarios of improved environmental quality. The data will be analysed with econometric models using the software R, STATA, SAS, NLogit, and/or Biogeme. The results of the study will be of invaluable use to local government agencies to determine the amount of public funds to invest for supporting a transition of Qatar towards a low carbon society.
Project Keywords:	Applied econometrics, environmental economics, non-market valuation, contingent valuation

3.2.5 Predicting Schistosomiasis Risk Using Eco-Environmental Models

Supervisor	Professor Eric Morgan
Mode of Study	Full Time Distance Learning
Project Overview	Schistosomiasis is a serious disease whose global distribution is changing. In some areas, e.g. the Middle East, some species of the parasite are already present and periodic introduction is a risk for establishment of more pathogenic species. Elsewhere, e.g. parts of Africa, mass drug administration is suppressing parasite populations, but focal transmission hotspots remain. This project will exploit the increasing availability of remotely sensed environmental data and new parasite surveillance methods to develop models that identify areas at higher risk of emergence and persistence, in order to focus resources to maximal effect. The work will be mostly desk-based, developing skills in spatial epidemiology and modelling of climate change impacts.
Project Description: Detailed description of the project	Control and eradication of schistosomiasis must take account of the complex life cycle of the parasite and the multiple environmental and ecological influences on transmission potential. Models that apply knowledge of these factors to predict areas more suited to supporting transmission can be used to focus surveillance and control efforts. At the same time, advances in detection methods, including of environmental DNA (eDNA) in water bodies, are now able to supply occurrence data at a scale suitable for calibration and validation of such models. By combining snail distribution and abundance data with human density, movement and infection data, and environmental layers, a highly integrated predictive epidemiological approach is now within reach. The project will apply these methods to map invasion hazard for *Schistosoma haematobium* in the Middle East, and explore optimal approaches to its prevention and early detection. Outcomes will include a novel framework for micro-scale management of schistosomiasis risk that can be applied to other marginal regions in danger of range expansion under climate change. The approach will further be adapted to predict areas in Africa in which eradication by mass drug administration is becoming limited by persistent hotspots of transmission. Existing published data on parasite occurrence could be supplemented by targeted surveys using novel eDNA methods developed by the supervisory team. Students will gain training and education in cutting-edge epidemiological methods that combine predictive computer modelling and advanced molecular diagnostics to address changing infection patterns under climate change.
Project Keywords	Schistosoma, bilharzia, snail, trematode, eDNA, epidemiology, climate change, prediction, disease eradication, neglected tropical diseases

3.2.6 Evaluation of Natural Plant-Based Botanicals as Alternative to Therapeutic Antibiotics

Supervisor	Dr Chen Situ
Mode of Study	Full Time Distance Learning
Project Overview	It has become widely recognised that antimicrobial resistance (AMR) is one of the biggest health threats that mankind faces, encompassing huge health and economic burdens on governments and societies in every region of the globe. Widespread and extensive use of antibiotics in human and veterinary medicine as well as agricultural livestock has been linked to the emergence and spread of AMR. Such practice encourages potential pathogenic microorganisms to evolve and become resistant to many of the currently therapeutic antibiotics. In addition, AMR can be transmitted horizontally and vertically between animal species, and from animals to humans and the environment. Reducing the unnecessary use of antibiotics and promoting the development of alternatives are among the key recommendations for immediate action by governments worldwide.
Project Description: Detailed description of the project	The purpose of the PhD project is to evaluate the antimicrobial property of various indigenous medicinal plants and traditional herbal medicines for their potential application in treatment and/or prevention of infectious diseases in humans and/or animals, as well as providing a safe alternative to antibiotics in agricultural food animals. Evidence-based scientific knowledge will be obtained through in vitro and in vivo experimentations with analytical evaluation of efficacy on several health and growth parameters. Research analysis techniques to be trained in include conventional and advanced laboratory and analytical techniques across different disciplines of life sciences from microbiology to biochemistry, immunology, molecular biology, phytochemistry, analytical chemistry and biotechnology.
Project Keywords	AMR, antibiotic, infectious disease, phytochemistry, botanicals, phytobiotic, herbal medicine, biotechnology

3.3 SCHOOL OF PHARMACY

3.3.1 Investigating Relationships Between the Gut Microbiome and the Metabolism of Commonly Prescribed Drug Compounds

Supervisor	Dr Stephen Kelly
Mode of Study	Full Time at QUB
Project Overview	This project will investigate the effect of commonly prescribed prescription medicines on the gut microbiome. It will also examine the effect of different microbiome profiles on drug metabolism, such as those seen in different disease states, informing future personalised medicine prescribing.
Project Description: Detailed description of the project	The human gut is home to trillions of microorganisms and their genes, known as the gut microbiome. This microbiome has a profound effect on human health, as well as on the metabolism of pharmaceuticals. Prescription medicines, in particular antibiotics, have been shown to disrupt the gut microbiome, creating a state of dysbiosis. However, a considerable amount remains unknown about the effect of non-antibiotic medicines on the gut microbiome, and why people respond differently to certain medicines. This project aims to investigate the effect of non-antibiotic prescription medicines on the gut microbiome. It also aims to investigate the effect of different microbiome profiles on the metabolism of various drugs compounds. Project aims will be achieved through the use of an established *in vitro* gut screening model, and downstream microbiome and metabolite analysis. The successful candidate will join a dynamic research group focused on the analysis and functional characterisation of microbiomes from various niches, to help investigate the link between the microbiome and metabolism of drugs. This project will involve wet lab experiments, as well as considerable bioinformatics analysis. Full technical training will be provided, providing skills which will help prepare the student for a career in a variety of sectors.
Project Keywords	Microbiome, drug metabolism, personalised medicine, human health

3.3.2 Microbiome Analysis to Improve Infection and Health Outcomes in Post-Kidney Transplant Patients

Supervisor	Dr Stephen Kelly and Professor Brendan Gilmore
Full Time at QUB	3 Years
Project Overview	The project will involve a large patient study, analysing the impact of both the gut and urinary tract microbiomes on health outcomes following renal transplantation. This will primarily focus on the development on infection and molecular diagnostic tools to help predict infection onset and optimise treatment choices for urinary tract infections.
Project Description: Detailed description of the project	Infection following kidney transplant surgery represents an important healthcare problem, with colonisation of medical devices such as ureteric stents of particular concern. Recent research has suggested the microbiome may even play a critical role in determining the successful outcome of renal transplantation. Despite these advances, much is still unknown about the relationships between the renal-associated microbiome and health outcomes, such as infection development, in kidney transplant patients. The successful candidate will join a dynamic research group focused on the analysis and functional characterisation of microbiomes from clinical settings, to help investigate the link between the microbiome and infectious disease following kidney transplantation. This project builds on an exciting collaboration between the School of Pharmacy and renal transplant clinicians in Belfast City Hospital. Project aims will be achieved using a combination of DNA extraction and sequence analysis using bioinformatic methods, alongside basic microbiology and culture-based techniques for the cultivation and characterisation of clinically-relevant microorganisms. Applicants should have a keen interest in learning basic bioinformatics techniques to analyse large genomic datasets to improve healthcare outcomes. Full technical training will be provided, with opportunities to attend international conferences in the research area, ensuring the successful candidate is well prepared for a career in a variety of sectors.
Project Keywords	Antimicrobial Resistance (AMR), Bioinformatics, Infection, Microbiome, Renal

3.3.3 Design and Simulation Studies of 3D Printed Systems

Supervisor	Professor Dimitrios Lamprou
Mode of Study	Full Time at QUB
Project Overview	3D printing permits the fabrication of high degrees of complexity with great reproducibility, in a fast and cost-effective fashion. 3DP has been used as a rapid and cost-effective technique in wide range of fields, and the term involves many 3D printing processes, which use different types of printing technologies, hundreds of materials, various resolutions and speeds. Computational studies using FEM and CAD are needed to carry out and simplified models to be generated in order to have better printed systems.
Project Description: Detailed description of the project	3D Printing (3DP) or Additive Manufacturing (AM) is a family of technologies that implement layer-by-layer processes to fabricate physical prototypes, based on a Computer Aided Design (CAD) model of the design. 3DP permits the fabrication of high degrees of complexity with great reproducibility, in a fast and cost-effective fashion. 3DP technology offers a new paradigm for the direct manufacture of individual dosage forms, and has the potential to allow variations in their size and geometry varied to control dose and release behaviour. 3DP thus offers the perfect innovative manufacturing route to address this critical capability gap hindering the widespread exploitation of personalised medical devices (e.g. catheters) and drug delivery systems (e.g. microneedles). It is important to utilise parametric CAD modelling, finite element methods (FEM) and computational fluid dynamics (CFD) to investigate the full design space and to ensure the optimum design is printed. During the 3 years, different systems for drug delivery and medical devices applications will be designed using leading existing engineering CAD software (e.g. SolidWorks) by creating a parametric design for a range of different designs and varying the associated shape, thickness, and size parameters. Moreover, FEM (e.g. Abacus) and CFD simulations will be used to investigate the behaviour of the designed systems under different physiological parameters and the haemodynamic performance of the newly designs. While CAD systems such as SolidWorks lead the field in terms of CAD technology of today. It is recognised that the techniques they use to represent geometry are not well suited to 3D printing, therefore news designs will need to be investigated. During the visits in QUB, the student will have the opportunity to test these designs using the state-of-the-art 3D printers in the school (over 10).
Key Words	Simulation Studies, 3D printing, Drug Delivery, Quality Control

3.3.4 3D Printed Based Drug Delivery Systems for Local Treatment of the Oral Cavity

Supervisor	Professor Dimitrios Lamprou
Mode of Study	Full Time at QUB
Project Overview	The project involves the development of an advanced drug delivery system by 3D printing for the delivery of drug(s) through the surface of the patients' oral mucosa. In this project, different 3D printed systems, such as microneedles & patches will be investigated.
Project Description: Detailed description of the project	The conventional methods of drug delivery require repeated dosing in the oral cavity due to the presence of saliva. Therefore, "implantable" devices that could provide sustained release of the drug in the oral cavity is needed. Microneedle (MN)-mediated drug delivery systems (DDS) and patch systems have been developed to enable patients to painlessly administer therapeutic micro- and macromolecule drugs. A wide range of designs including solid metal or polymeric or hallow microneedles, and reservoir or matrix patches. 3D printing process was patented in 1986; however, only in the last decade has been used for medical application, and has been utilized in the fields of prosthetics, bio-fabrication, and pharmaceutical printing. The aim of this project is to develop 3D printed systems of various designs using advanced additive manufacturing technologies. The printing capabilities of suitable polymer grades will assess in terms of flexibility, mechanical strength and drug efficiency. Furthermore, printed patches will be evaluated both *in vitro* and *in vivo* to investigate release patterns, drug loading, stability and clinical effectiveness.
Project Keywords	Microfabrication, microneedles, patches, oral applications, drug delivery

3.3.5 Design and Evaluation of an Eye-on-a-Chip Microfluidic Device

Supervisor	Professor Dimitrios Lamprou
Mode of Study	Full Time at QUB
Project Overview	This project will focus on preparing an eye-on-a-chip, to better mimic ocular micro-environment-related events and demonstrated a promising approach to emulate both physiology and anatomy of the eye in in-vitro settings.
Project Description: Detailed description of the project	With the increasing prevalence of debilitating eye diseases such as age-related macular degeneration, glaucoma, and dry-eye syndromes, there is a pressing need for the development of novel therapeutic strategies. The development and testing of an ophthalmic drug currently rely mainly on animal models, which may require many years before results can be translated into clinical practice. The development of new medicines is resource-intensive, and the high costs of development and attrition rates in drug development represent significant challenges for the pharmaceutical industry, healthcare providers and patients. Enhanced screening tools could help address the problem of late-stage failures and reduce the attrition rate of drugs in the clinical development pipeline by providing more informative, critical information at an earlier stage. Most in-vitro studies are conducted using common 2D cell culture methods that fail to recapitulate the biological cues inherent in native tissue. This project will manufacture a microfluidic (lab-on-a-chip) device to mimic the 3D microenvironment in vitro more closely giving rise to the more physiologically relevant eye-on-a-chip.
Project Keywords	Bioprinting, lab-on-a-chip, microfluidics, Ocular

3.3.6 Stakeholder Opinions on Peptide Hydrogels as Long Acting Injectables to Improve Patient Adherence to Medicines

Supervisor	Dr Garry Laverty
Mode of Study	Full Time Distance Learning
Project Overview	The objective of this project is to engage with relevant groups of stakeholders (patients, their carers, charities, medicine regulators and healthcare professionals) to assess the acceptability of a novel long-acting injectable drug delivery platform.
Project Description: Detailed description of the project	Our research group (Biofunctional Nanomaterials Group, Queen's University Belfast) has developed a drug delivery platform composed of tissue-like peptides that has high potential to be adopted as a novel implant for the sustained delivery of drugs for conditions where patients have difficulty adhering to their medicines (e.g. HIV/AIDs, Alzheimer's, tuberculosis, depression, schizophrenia, malaria). This project aims to assess the acceptability of our peptide hydrogel approach to long-acting injectable administration of drugs in key stakeholders, for example patients, their carers, charities, medicine regulators and healthcare professionals. This will improve our ability to translate this technology for the benefit of patients and society worldwide.
Project Keywords	Patient engagement, peptide, drug delivery, hydrogel, HIV/AIDs

3.3.7 Peptide-Based Nanoparticles for Brain-Targeted Gene Delivery

Supervisor	Dr Emma McErlean
Mode of Study	Full Time at QUB
Project Overview	Development of novel peptide-based gene delivery systems designed to overcome the blood-brain barrier and target brain tissue for gene therapy; for the treatment of neurodegenerative disease and cancer.
Project Description: Detailed description of the project	Gene therapy has the potential to provide therapeutic benefit in treatment of neurodegenerative diseases, such as Parkinson's Disease, and cancer. Delivery into the brain is hampered by the blood-brain barrier (BBB), which limits the efficacy of both conventional and novel therapies at the target site. Therefore, innovative delivery strategies are required, and nanoparticles (NPs) are at the forefront of future solutions. The aim of this project is to develop novel peptide-based NPs to efficiently deliver therapeutic agents to the brain, overcoming the restrictive properties of the BBB. The objectives are: to formulate and systematically characterise the physicochemical characteristics of novel peptide-based NPs; analyse the *in vitro* and *in vivo* functionality of peptide-based NPs for gene delivery to the brain and; assess the therapeutic outcomes following delivery of gene therapy to the brain via peptide-based nanoparticles.
Project Keywords	Cell Penetrating Peptides, Gene Delivery, Gene Therapy, Nanomedicine, Targeted Treatments, Blood Brain Barrier

3.3.8 Nanocrystals-in-Nanofibres as a Promising Strategy for the Delivery of Poorly Soluble Actives

Supervisor	Dr Alejandro Paredes
Mode of Study	Full Time at QUB
Project Overview	The use of the nanocrystal technology has emerged as a promising strategy for the delivery of poorly soluble drugs, with oral and intramuscular formulations on the market. This project deals with the development of novel nanocrystal-loaded dissolving nanofibers for drug delivery to the eye. The novel fast-dissolving film will act as "dry eye drop", allowing for improved treatments of a wide variety of local ophthalmic diseases using an optimised system with improved physical, chemical and microbiological stability.
Project Description: Detailed description of the project	One of the most challenging issues that the pharmaceutical industry face is poor aqueous solubility of drugs. 90% of candidate molecules within the discovery pipelines face solubility issues, posing significant hurdles to their clinical translation. Moreover, 40% of drugs in the market are also poorly soluble and need to be administered in high doses to reach therapeutic plasma levels. The formulation of drug nanocrystals (NCs) has become one of the most preferred strategies to enhance the absorption of hydrophobic drugs. NCs are nanoparticles made of the pure drug with crystalline properties. Produced using various industrially-available methodologies, NCs have made a significant clinical impact, with >20 products on the market. Since NCs do not contain any carrier material, and are stabilised by a thin stabiliser layer, their drug loading approaches 100%. Given their large specific surface, NCs have an enhanced dissolution rate, saturation solubility and bioahdesion. Initially applied to the delivery of oral medicines (i.e., Rapamune® and Emend®), NCs have been administered via multiple administration routes, including pulmonary, transdermal, ophthalmic, and intramuscular, (i.e., the long-acting products Invega Sustenna® and Cabenuva®). Dr Paredes has worked within the field for >12 years, applying the NCs technology for increasing the oral, intradermal, ocular, and mucosal absorption of poorly soluble drugs. In a major departure from current NCs applications, this project aims to develop a platform consisting of NCs embedded in dissolving nanofibres (NFs) for mucosal administration. The experimental activities will be oriented to the preparation of drug nanocrystals, which will be loaded in nanofibres using electrospinning. The systems will be fully characterised using various techniques, such as dynamic lights scattering, FTIR, XRD, DSC/TGA, and HPLC among others. Dr Paredes's group attend every year to major pharma conferences and publish papers in internationally recognised journals. The student will be part of an exciting international research group, where they will acquire technical and soft and technical skills key to their professional and personal development.
Project Keywords	Nanocrystals, nanofibers, drug delivery, ophthalmic conditions, eye delivery

3.4 SCHOOL OF NURSING AND MIDWIFERY

3.4.1 What are the Benefits of Artificial Intelligence (AI) Technologies for Nursing Care from the Perspective of Key Stakeholders?

Supervisor	Professor Christine Brown Wilson
Mode of Study	Full Time at QUB
Project Overview	This project is part of a programme of research focusing on digital innovation in nursing education and practice
Project Description: Detailed description of the project	**Background:** Digital technology is used across health services to improve patient care. However, nurses are not adequately prepared to embrace the benefits digital solutions might bring for both patients and themselves. Artificial Intelligence (AI) is rapidly evolving within health care but there is limited work undertaken to identify how it might be best used in nursing care. **Aims**: To explore the role of AI in nursing care **Objectives:** to identify the technology readiness of nurses and explore the perceived barriers and facilitators to engaging with AI in nursing **Methods:** a mixed methods study using quantitative survey and individual/ group interviews.
Project Keywords	Artificial Intelligence; technology readiness; digital health; nursing; nursing care

4. THE THOMAS J MORAN GRADUATE SCHOOL

PROVIDING SUPPORT FROM APPLICATION TO GRADUATION

In addition to a Postgraduate research degree, students are able to access an extensive range of additional courses, workshops and training programmes through the Thomas J Moran Graduate School at Queen's University Belfast. The Graduate school is a world class intellectual and social hub connecting students from all disciplines to each other and with mentors to develop their academic, employability and research skills.

The Graduate School supports students through a tailored developmental journey, to develop **innovators**, **leaders**, **communicators** and **thinkers** who are **'future ready'** for the as yet unknown. Our goal is to enable QUB graduates to stand out in a competitive, professional environment.

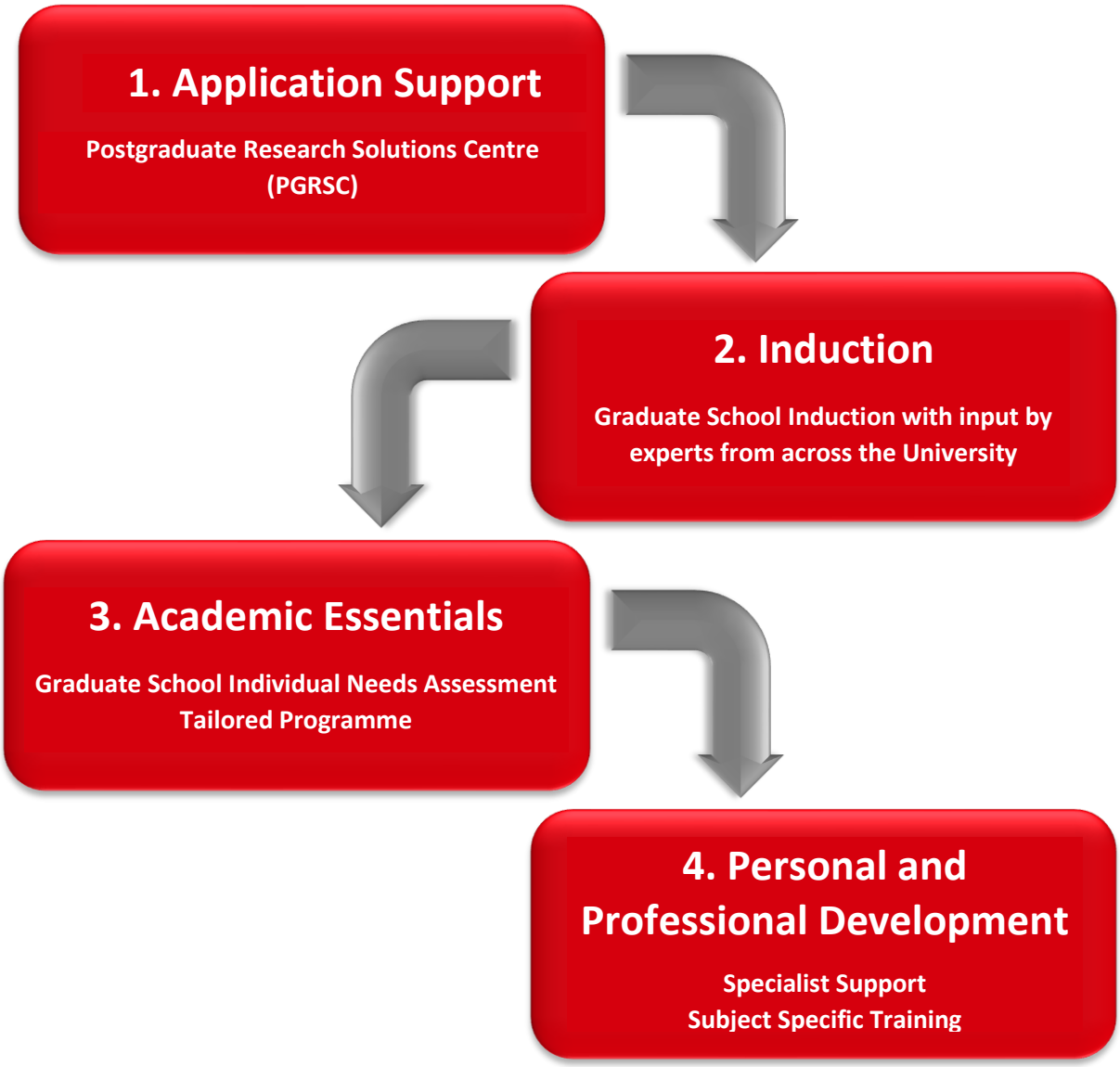


Figure 2: *The Journey for Postgraduate Students (https://www.qub.ac.uk/graduate-school/development/).*

4.1 Application Support

Once a project has been selected, dedicated support will be provided by the Postgraduate Research Solutions Centre (PGRSC – **pgrsc@qub.ac.uk**) to help set up a Teams call with the potential Supervisor, allowing a more detailed discussion on the research area and to provide detailed guidance on how to submit an application form.

Once an application form has been submitted, further support is available through the Admissions Office. (**https://www.qub.ac.uk/directorates/MRCI/admissions/PostgraduateAdmissions/**).

For student that requires additional support to meet the ***entry criteria or*** English Language requirements, Pre-Sessional English Programmes ***(and Pre-PhD courses)*** are available through INTO at Queen's. (**https://www.intostudy.com/en/universities/queens-university-belfast**)

4.2 Induction

Postgraduate Research Induction is must for any new student and covers everything they need to know. Topics covered include:

- What to expect during the PhD (PhD Student and Postgraduate Student Officer)
- How the Students' Union can provide support (PhD Student and Postgraduate Student Officer)
- Rules of the Game (Academic Affairs)
- Research Governance, Ethics and Integrity (Research & Enterprise)
- QSIS student life cycle (Student Services & Systems)
- Looking after yourself (Student Wellbeing)
- Careers and future planning (Graduate School)

Subject-specific inductions also occur within Schools to ensure students are ready to begin their research.

4.3 Academic Essentials

It is vital that QUB PGR students communicate effectively and share their research. The Graduate School runs several academic essential programmes which are a must for any researcher. These include:

- Online SPSS, NVivo, Excel and AntConc Training
- 1-2-1 Support with Academic Writing
- Peer Proofreading
- Writing Retreats
- PhD MOT series (creating healthy study habits, expanding your research, at the finish line)
- How to Peer Review
- Writing Effecting Funding Proposals

- Introduction to Teaching
- Communicating with Impact Series
- Preparing for Differentiation and Annual Progress Review
- Preparing for the Viva

For further information please see the Graduate School webpages: **http://www.qub.ac.uk/graduate-school/development/postgraduate-research-development-programme/**.

4.4 Personal and Professional Development

Only by truly understanding how they work will students be able to identify gaps that they should work on. The Graduate School has an online booking system and staff to help students evaluate what areas they need.

4.4.1 Postgraduate Research Development Programme

The postgraduate development programme is based on the requirements of both the Postgraduate Researcher Development Statement and Researcher Development Framework. These have been created by **Vitae**, an organisation that exists to support the professional and personal development of doctoral researchers and research staff in higher education institutions and research institutes. They have been endorsed by the QAA and Research Councils UK.

The programme offers students a comprehensive range of training courses, 1-2-1 support and skills development opportunities and is coordinated by the Training and Development and Employment and Enterprise Teams based in The Graduate School. The Postgraduate Development Programme exists to support research students in the development of research skills and to enhance their employability through career and personal development.

The Postgraduate Development Programme aims to support Postgraduate Research Students in developing a range of professional skills to successfully complete their research and increase their employability. For further information please see the Graduate School webpages: **http://www.qub.ac.uk/graduate-school/development/postgraduate-research-development-programme/**.

4.4.2 Chartered Management Institute (CMI)

The CMI is a professional qualification designed for postgraduate students who want to develop their leadership and management skills. The level 7 Certificate offers students a unique opportunity to achieve a professional qualification whilst studying at Queen's. The programme is designed to enhance their theoretical understanding and competencies in leadership, project management and entrepreneurial practice. For further information see the Graduate School webpages: **https://www.qub.ac.uk/graduate-school/development/chartered-management/.**

4.4.3 Postgraduate Employability, Careers Guidance and Support

The Graduate School offers a range of opportunities for students to develop their future-readiness and manage their own careers whether that is for further academia, non academic employment or self-employment. For further information please see the Graduate School webpages: **Employability, Careers & Support | The Graduate School | Queen's University Belfast (qub.ac.uk)**.

4.4.4 Enterprise and Innovation

The Graduate School is committed to encouraging our postgraduates to develop their entrepreneurial skill set and an entrepreneurial mindset. We believe that this will enable them to be better researchers and future ready leaders who seek opportunities, work flexibly and continuously improve. We do this through our various workshops and entrepreneurial speakers at our **Innovation After Hours** series. For further information please see the Graduate School webpages: **https://www.qub.ac.uk/graduate-school/development/enterprise-innovation/.**

4.4.5 Your PhD… What's Next?

Careers and employability programme tailored for postgraduate research students in their 2nd or 3rd year of study. It is designed to support students in their next career steps. The programme covers key skills as well as the recruitment process for both academic and non-academic routes. For further information please see the Graduate School webpages: **Activities | Your PhD, What's Next? | Future-Ready Award | Queen's University Belfast (qub.ac.uk)**.

4.4.6 Future-Ready Award

Current Postgraduate students have the opportunity to gain official recognition by the University as a result of developing their own skills and research in addition to their studies. For further information please see the Graduate School webpages: **Future-Ready Award | The Graduate School | Queen's University Belfast (qub.ac.uk)**

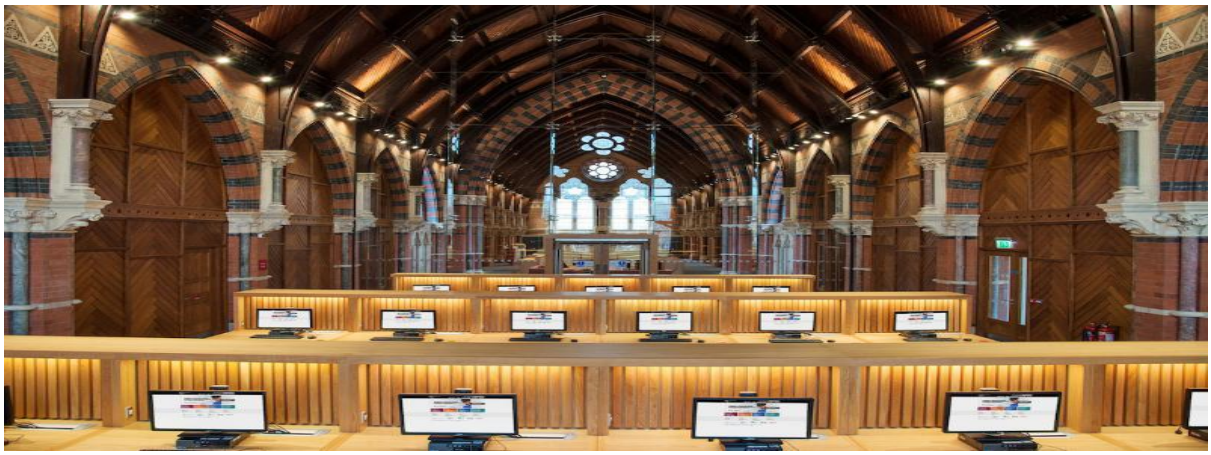
4.4.7 Myers Briggs

Myers Briggs Type Indicator (MBTI) is used to determine differing strengths and types of personalities. The interactive workshop allows students to find out how it works and discover the benefits of knowing their type.

4.4.8 Social Impact

The Graduate School can help students find a number of rewarding ways to make an impact on society and engaging with the student and wider community. Options include engaging in external volunteering opportunities, getting involved in postgraduate-led initiatives, applying to become a Postgraduate Community Assistant and many more.

5. CONTACT INFORMATION



5.1 Postgraduate Research Solutions Centre (PGRSC)

The Postgraduate Research Solutions Centre is responsible for the administration of the Qatari initiative and any questions you have may be directed to Mrs Lynne Spence at the Centre.

5.1.1 Location

The Thomas J Moran Graduate School
Lynn Building
Main Site

5.1.2 PGRSC Contact Details

Mrs Lynne Spence (Project Manager)

Email: l.spence@qub.ac.uk
Email: pgrsc@qub.ac.uk