University of Southern Queensland

# SIMPLE Hub
# Centre for Future Materials
# Summer Research Program

2024-2025

# Contents





UniSQ

# About the Centre for Future Materials

The Centre for Future Materials (CFM) was established in 1995 and has positioned itself as a leader in collaboration with local, national, and international SME's and large companies.

CFM's unique strength is in industrial engagement and development, to develop personnel, IP, new products, and open new sectors through collaborative research programmes which utilises industry funding leveraged against state and national funding mechanisms in order to de-risk the cost of research and deliver maximum impact for industry, the funding body, and the University of Southern Queensland.

CFM is working closely with industry and other research institutions to develop cutting edge technologies, through fundamental research and industry application in the area of advanced composites and concrete, and to provide solution-support to the community.

## About the SIMPLE Hub

The Hub will implement a comprehensive research program targeted at the development of sustainable cross-sector industry 'ecosystems' that support development of new circular economies. The SIMPLE Hub will create a step-change by focusing on capacity building initiatives to enable industry and universities to co-design and develop new products and processes to support regional manufacturing priorities such as technical, environmental, economic, educational and cultural aspects of green energy, resource recovery and waste recycling/upcycling. The SIMPLE Hub will enable an innovative ecosystem, linking industry with regional universities to create more efficient, intelligent, responsive and agile industry sectors that are profitable, scalable and transferable nationally and globally. It will also create a workforce pipeline to support the sector, with a focus on training of industry-ready researchers who will be the innovators for regional manufacturing industries into the future, while attracting and retaining manufacturing opportunities and talent in regional areas. To contact the leadership team of SIMPLE Hub please email simplehub@unisq.edu.au.

SIMPLE Hub is a major research project run out of the UniSQ CFM and is funded by the Australian Government Department of Education.

# About the SIMPLE Summer Research Program

## Summary

In 2024, SIMPLE Hub will offer up to 7 summer research scholarships for undergraduate and Masters coursework students. These scholarships will provide students the opportunity to work with experienced researchers and gain invaluable research, professional, and academic skills through engaging in a 37.5 hour/5-day week, 12-week intensive research and development project. Students will have the opportunity to establish academic and industry connections and discover research before engaging in research projects and higher degree studies.

## SIMPLE summer research program eligibility

Applicants must:

- be a current undergraduate or Masters coursework student in Australia
- have completed at least 8 units of study
- have a GPA of 5.5 or above at the time of application

### Selection Criteria

Scholarships are awarded on a competitive basis with consideration of the following:

- undertaking a related undergraduate or Masters coursework program;
- project availability;
- prior and active engagement with the Project supervisor; and
- the academic standing of the applicant.

Additional consideration would be given to applicants who:

- have an engineering, science or education background
- competent with lab work or are open to trying new work
- have an intermediate level of competency in Excel for data analysis

## SIMPLE summer research program scholarship value

A maximum value of $5000 that will be paid across the life of the research project (12 weeks).

## How to apply for the SIMPLE Hub Scholarship projects

1. Choose up to 3 projects (available projects listed below):

2. Prior to submitting an application, make contact with the leadership team of the SIMPLE Hub, by sending an email to simplehub@unisq.edu.au with a subject line of *'SIMPLE Project [insert project number] enquiry'* to obtain more information.

3. Submit the Application Form at the following link by 5:00 PM (AEST) **13th of September 2024**.

Application Form: https://forms.office.com/r/cV1XB43xcb

## Closing date

Friday 13th of September 2024 at 5:00 PM (AEST)

All applicants will be notified of the outcome of their application by the **25th of September 2024** and are expected to commence on the **4th of November 2024**.

Students must conclude their summer project by the **7th of February 2025**. Please inform us if you're following the block calendar so that we can adjust dates accordingly if possible.



UniSQ

# SIMPLE Hub Summer Research Projects on Offer: Materials and Renewable Energy

# Project 1: Evaluation of recyclability of used Nylon 6 rod guides through characterisation and material testing

Prof Allan Manalo | Chundu Gyem Tamang | Dr Wahid Ferdous | A/Prof Polly Burey | Dr Tristan Shelley
Institute of Advanced Engineering and Space Sciences/Centre for Future Materials

*Project Description*

Sucker rod guides which are globally used in oil and gas explorations are currently disposed of in landfills after six to twenty-four months of use, which is generating over 300 metric tonnes of thermoplastic wastes every year. This massive polymeric waste generation is resulting from the absence of characterisation studies on used rod guides that can support the invention of rod guide recycling technology. Moreover, there are different types of thermoplastics which are used in manufacturing sucker rod guides such as Polyphthalamide (PPA), Polyphenylene Sulphide (PPS), Polyamide (PA) and Polyether ether ketone (PEEK). Nylon 6 (PA 6) which constitutes 2/3 of the total PA production is one of the most popular and widely used rod guide materials. For example, some of the biggest downhole material suppliers in Queensland such as Oilfield Piping System use Nylon 6 with glass fiber reinforcement for sucker rod guide fabrication. However, the effect of downhole temperature, contamination and frictional forces on Nylon 6's properties are still lacking.

Hence, this study aims to test and characterise used Nylon 6 rod guides through extensive microstructural testing and determination of fiber length distribution and fiber orientation distribution. Other characterisation tests such as water absorption and fluid compatibility will also be carried out through immersion tests in acids, bases, hydrocarbons, and brine solution. Furthermore, research outcomes from this project will encompass the possibility of recycling Nylon 6 which is a hygroscopic material to be reused as a downhole sucker rod guide through evaluation of its dimensional stability during prolonged fluid submersion and role of glass fiber reinforcement in service life estimation.

Therefore, the results of this project will provide useful information on the behaviour of glass fiber reinforced Nylon 6 when used as a rod guide material and the effect of downhole environment on its properties which will determine the extent of its recyclability.

*Project Location*

The successful candidate will be required to work at the Toowoomba campus for the duration of the project with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Be trained in the use of advanced research facilities at Toowoomba campus
- Understanding of the test procedures in characterizing glass fibre reinforced Nylon 6
- Safe use of processing equipment
- Experimental design and testing
- Data collection and data analysis
- Understanding importance of waste recovery and value add.
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will provide a better understanding of different characteristics of glass fibre reinforced Nylon 6 used as a sucker rod guide material and will generate useful information on its recyclability, thereby adding value to this waste material which in current practice is being landfilled globally.
Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 2: Utilisation of waste in environmentally friendly grout mixtures

A/Prof Ali Mirzaghorbanali | Dr Hadi Nourizadeh | A/Prof Polly Burey
School of Engineering, Centre for Future Materials

Project Description

The project aims to replace parts of the clinker content in conventional grouts with composite material wastes. The environmental and ecological benefits of using alternative supplementary and waste materials include:

1. Utilising non-recycled waste materials from landfills
2. Reducing the consumption of non-renewable natural resources.
3. Decreasing energy usage for cement production.
4. Reducing greenhouse gas emissions.

This project will investigate the mechanical properties of amended grout products mixed with composite wastes using compression testing machines. Initially, grout samples will be cast by replacing cement with various percentages of waste, ranging from 1% to 20%. These samples will then be cured for different time intervals (1, 7, 14, 21, and 28 days) and tested to determine Uniaxial Compressive Strength, Elastic Modulus in Compression, and Shear Strength. The results will be compared with the compressive strength of conventional grouts available on the market. Various mix designs will be explored, considering particle size distribution, the percentage of waste materials incorporated, and the chemical reactions of the waste materials with the cementitious binder. This is to optimize the performance of the grouts while ensuring compatibility with cable bolting systems.

Project Location

The successful candidate will be required to work at the Toowoomba or Springfield campus for the duration of the project with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

Benefits for Successful Candidates

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- How to carry out a systematic literature review
- How to plan research studies
- How to cast small-scale concrete samples for testing
- How to use Engineering testing equipment
- A general understanding of safety and risk assessment in Engineering
- Data analysis using Excel,
- Report preparation and submission

Student may have the opportunity to attend in Resource Operators' Conference in Feb 2025.

*Project Outcomes*

This project will lead to a better understanding of amended green grout applications in various conditions. An empirical equation will be developed based on the collected experimental data to model the strength of amended grout in relation to various Engineering parameters. Findings will be presented at Resource Operators' Conference in FEB 2025.

# Project 3: Repurposing waste glass aggregate for reuse in concrete applications

Dr Hannah Seligmann | Dr Jessica Feldman | Dr Matt Flynn
Centre of Future Materials, School of Engineering

*Project Description*

Waste glass material in Australia currently forms a substantial lost economic opportunity. Approximately 1.54 Mt of waste glass was produced in Australia in 2020 – 21, and it is estimated that 41% of this was sent to landfill. Due to the Australian export ban for glass introduced in January 2021, it is imperative that domestic options be developed to be able to utilise this glass waste.

Most recycled glass packaging in Australia is collected through kerbside recycling and container deposit schemes. The challenge with sorting glass cullet for new glass packaging is the requirement to remove contaminants and glass fines (<8mm in size), separate colours, and ensure that glass from ceramics, fluorescent light fittings, and cathode ray tubes are not included. Due to challenges like these as well as transport costs, new glass bottles in Australia only contain around 37% post-consumer glass cullet. Consequently, the other remaining 63% of the total glass packaging consumption of ~1.3 million tonnes need to be used for other applications to prevent ending up in landfill.

An alternative pathway is the use of glass waste in construction materials, however the material produced must have less than 2% organic matter, must be cubical in shape, and free from contaminants such as sugars. This study will investigate waste glass material produced by recycling facilities to determine its suitability for use as a replacement to sand in construction materials. Treatment measures to remove sugars will be investigated and evaluated for sustainability and cost effectiveness.

*Project Location*

The successful candidate will be required to work at either the Toowoomba or Springfield campus for the duration of the project with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Be trained in the use of advanced research facilities at Toowoomba and Springfield campus
- Understanding of the test procedures in characterizing waste glass materials
- Safe use of processing equipment
- Experimental design and testing
- Data collection and data analysis
- Understanding importance of waste recovery and value add.
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will lead to a better understanding of the characteristics of glass materials produced from ‘waste’ and will generate useful information to determine the most suitable uses and value-add for this waste material. Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 4: New materials from recycled coated paper products

Dr Pratheep Kumar Annamalai | Dr Matt Flynn | Dr Hannah Seligmann
Centre of Future Materials, School of Engineering

*Project Description*

Plastic-coated paper-based products such as Tetra Pak cartons and disposable cups pose a significant problem for recyclers. The plastic coating means that if left in typical recycled paper and cardboard collections, they have the potential to contaminate pure paper and cardboard recycling streams. Without access to advanced recycling infrastructure, these products almost exclusively end up in landfill. Worldwide, the number of cartons and disposable coffee cups used each year exceeds **half a trillion**, with a recycling rate which falls behind more other categories of waste.

This project aims to develop a cost-effective solution to utilise coated paper cartons, collected through Queensland's Container Exchange scheme, to produce fibre-reinforced plastic composites. These composites could take the form of pressed or extruded shapes, similar to the products made by SaveBoard, or they could be formed into filaments of pellets to be used in 3D printing, injection moulding, etc. This study will involve sample preparation through breakdown/milling of plastic-coated paper products collected through the Container Exchange scheme, and laboratory analysis of the materials to determine both physical and chemical properties. The milled products will be compression moulded as-is or blended with waste plastics and extruded to create new product prototypes.

The results of this project are anticipated to provide useful information that is required to determine the most suitable uses of plastic-paper composites in the development of novel and sustainable materials for a range of applications.

*Project Location*

The successful candidate will be required to work at the Toowoomba and Springfield campus for the duration of the project with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Be trained in the use of advanced research facilities at Toowoomba campus
- Understanding of the test procedures in characterizing plastics
- Safe use of processing equipment
- Design of processes to produce novel materials
- Data collection and data analysis
- Understanding importance of waste recovery and value add
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will develop novel materials from currently under-utilised recyclable waste. The outcomes have potential to help combat waste generated from products such as Tetra Pak on a global scale, and may also address waste which was previously managed through the RedCycle scheme. The successful candidate will also develop a better understanding of the properties of plastic composites and how to process them. Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 5: Testing of mycelium-based composites from agri-food waste streams

Ms Zahra Parhizi | A/Prof John Dearnaley | A/Prof Polly Burey
Centre for Future Materials, School of Agriculture and Environmental Science

*Project Description*

Construction of buildings and infrastructure consumes a large amount of resources and is also responsible for generating huge amounts of construction and demolition waste and greenhouse gas emissions. At the same time, increasing pressures on the agricultural industry to meet the world's food demand has resulted in increased production of agricultural wastes such as rice husks and citrus peels. Consequently, much attention has been drawn to microbial-based materials since they are low-cost, accessible, easily prepared, biodegradable, and they can utilise these agricultural waste streams to prevent them ending up in landfill. These microbial-based materials could be used in multiple applications including high-value construction materials.

Developing these microbial-based materials in a controlled way is essential to enable their use as construction materials. To materialise this strategy, mycelium, the vegetative lower part of fungi has been chosen. Mycelium has been identified as the largest living organism on earth. Mycelium is mainly composed of natural polymers as chitin, cellulose, proteins, etc, so it is a natural polymeric composite fibrous material. Agri-food waste streams such as rice husks and citrus peels will be incorporated into these mycelium composites.

This project aims to test and improve the mechanical and physical properties of the mycelium composites, using techniques such as heat pressing, tensile tests, compression tests, and flexural tests. These improvements will help to establish mycelium-based materials as a viable replacement for traditional construction materials in the near future. As part of this project, there is an opportunity to be involved in fungi characterisation testing that will be used to identify other species of fungi that can efficiently produce the mycelium used in these composites.

*Project Location*

The successful candidate will be required to work at the Toowoomba campus for the duration of the project with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Be trained in the use of advanced research facilities at Toowoomba campus
- Understanding of the test procedures in mechanical testing of composites
- Safe use of processing equipment
- Data collection and data analysis
- Understanding importance of waste recovery and value add
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will further research to develop viable mycelium composites that can be used as construction materials. Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 6: Repurposing landfill wastes for sustainable and flood resilient roads

Dr Hannah Seligmann, Dr Jessica Feldman
Centre for Future Materials, School of Engineering

*Project Description*

The Queensland road network is the longest in Australia, comprised of 226,000 km of Council and State-owned roads. One third of Queensland is situated on expansive clay soils; in particular, black cotton soil, which is commonly found in rural areas of Queensland. Black cotton soil undergoes significant volume changes when exposed to water. This shrink and swell behaviour of the soil is problematic for road construction and can cause premature failure and increased maintenance costs, particularly in areas prone to flooding. The most common technique for stabilisation of these soils is lime stabilisation. However, lime is both cost prohibitive and has a high embodied energy.

In this project you will develop innovative subgrade improvement techniques from current waste material including waste glass, ore sands, and fly ash products. This will be achieved by adding these products to expansive subgrade material. The performance of the material will be investigated using maximum dry density, Atterberg limits, linear shrinkage and unconfined compressive strength.

*Project Location*

The successful candidate will be required to work at the Springfield campus for the duration of the project with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Be trained in the use of advanced research facilities at Toowoomba and Springfield campus
- Understanding of the test procedures in characterizing waste materials and soil stabilisation works
- Safe use of processing equipment
- Experimental design and testing
- Data collection and data analysis
- Understanding importance of waste recovery and value add.
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will lead to a better understanding of the characteristics of materials produced from ‘waste’ and will generate useful information to determine the most suitable uses and value-add for this waste material. Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 7: Production of metal composite beads with optimal heat transfer and energy storage characteristics for solar thermal applications

A/Prof Andreas Helwig | Dr Hong Duc Pham | Dr Mark Lynch | Dr Tristan Shelley
Institute of Advanced Engineering and Space Sciences/Centre for Future Materials/School of Engineering/School of Agriculture and Environmental Science

*Project Description*

There is currently a wide variety of waste resources such as agricultural waste, microalgae, macroalgae, sewage sludge, and organic waste that could be converted into renewable energy and other high-value products. Hydrothermal treatment is a promising technology to achieve this goal, but one of the continuing barriers for hydro-thermal waste treatment is the cost of thermal energy to drive this process. Solar energy is a potential option to drive the thermal energy required for this process, but thermal storage is required to extend the working hours beyond the daylight hours available.

Our industry partner, Impacts, is working closely with this research project to develop hydro-thermal energy storage to accomplish this. Heat beads containing different combinations of metal powders (e.g. tin, zinc, aluminium) will be produced and then tested for their thermal heat transfer and heat energy storage characteristics incrementally up to 650°C. The project will then explore how these beads can be used to store and release heat energy when assembled in an array.

*Project Location*

The successful candidate will be required to work at the Toowoomba campus, with some occasional travel to the Springfield campus for the duration of the project with opportunities to work with other students, researchers and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Be trained in the use of advanced research facilities at Toowoomba campus
- Energy systems and energy flow/efficiency analysis skills
- Development of 3D design and construction skills
- Safe use of equipment
- Experimental design and testing
- Data collection and data analysis
- Understanding of the importance of solar thermal storage contribution towards the development of various hydro-thermal chemical waste treatments
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project is the next R&D step for the SIMPLE Hub project in collaboration with Impacts Renewable Energies to explore hydro-thermal pyrolysis development. This provides the groundwork for interested municipal councils and to contribute towards improving the economic viability of hydro-thermal organic waste treatment. Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 8: Using machine learning models to predict biocrude yield of hydrothermal processes

Dr David (Hong-Duc) Pham | Dr Thong Nguyen-Huy | Dr Jessica Feldman | Dr Tristan Shelley | A/Prof Polly Burey | A/Prof Andreas Helwig
Institute of Advanced Engineering and Space Sciences/Centre for Future Materials/Centre for Applied Climate Sciences/School of Engineering/School of Agriculture and Environmental Science

*Project Description*

The valorisation of biomass to renewable energy and other high-added value products is a promising solution to deal with a wide variety of waste resources such as microalgae, macroalgae, sewage sludge, organic waste, lignocellulosic resources, and so on. To date, thermochemical and biological conversion methods are widely employed depending on the properties of biomass waste and target products. Since the thermochemical processes (e.g., combustion, gasification, pyrolysis, hydrothermal carbonisation, and hydrothermal liquefaction) allow upgrading a broad spectrum of biomass feedstocks and avoid the need for high energy- and chemical-demanding pretreatment processes, they have attracted considerable attention in comparison with the biological ones (e.g., microbial fuel cells, anaerobic digestion).

Hydrothermal liquefaction (HTL) is a well-established process that converts moisture-content biomass waste into biocrude using high pressure and moderate temperatures in water. Biocrude production through HTL has been intensively studied across the world. Nevertheless, there is no single model that predicts well the biocrude yield for HTL due to the variation of HTL experimental conditions (e.g., working volume, temperature, residence time, the addition of catalyst, etc.) as well as the feedstock properties (e.g., high content of either lipid or cellulose, the location of waste collection). Hence, the project aims to guide suitable models for different specific waste feedstock. Furthermore, the project will advance the knowledge base of the quantitative modelling of HTL outcomes.

*Project Location*

The successful candidate will be required to work at the Toowoomba or Springfield campus for the project's duration with opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Literature review, data collection, and data analysis
- Understanding the importance of biomass waste properties, thermochemical technology, operating conditions of hydrothermal processes, and machine learning models.
- Get involved in laboratory experience with supervisory team members.
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will potentially lead to a better understanding of the conversion of various types of waste into biocrude using hydrothermal processes. The project's data may also be used to publish high-quality journal articles. The successful candidate will be a co-author on these outputs.

# Project SCU: Fire retardant recycled polymers as building material

Yee, Lachlan H.1. | Pingan Song 2. | Steve Rosewell 3 | Ernest Du Toit 1.
1. Faculty of Science and Engineering, Southern Cross University, Lismore, NSW
2. School of Agriculture and Environmental Science, UniSQ,
3. Studio Kite, The Pocket, NSW, 2483

*Project Description*

Affordable housing in the current age is a challenge, especially housing for victims of natural disasters such as flooding in Lismore as well as entering the property market for our young adult population looking to establish young families. However, one method of creating affordable housing would be to utilise the large-scale 3D printing model that has been developed by Steve at Studio Kite. *Jindi*, a representation of affordable housing that is a combination of 3D printed recycled polymers such as High-Density Polypropylene (HDPE) and Polypropylene (PP) is the product of just such an approach and 2 prototype models have already been manufactured at Studio Kite in NSW.

However, mechanical properties testing, choice of polymer types, recycled polymer to virgin polymer ratios and as fire retardancy of the materials as well as 3D printability of the fire-retardant polyolefin materials involved in manufacturing is ongoing. This requires more effort to complete the data set that will assist in demonstrating these structure meeting building standards within NSW and Qld in Australia. Therefore, a summer student capable of learning to utilise polymer processing equipment and fire testing facilities at UniSQ as well as mechanical and chemical analysis equipment at SCU could facilitate such a research mission.

This study aims to test several formulations of HDPE, PP, fire retardant additives to determine the optimised formulation that enables Australian standard like properties whilst maintaining the ability to 3D print test pieces for testing and prototype housing models.

*Project Location*

The successful candidate will be required to work at the Springfield (Qld) campus as well as the SCU Lismore Campus with occasional visits to the Mullumbimby to work at Studio Kite. The candidate will need to arrange own transport. The candidate will have opportunities to work with other students, researchers, and industrial partners. Some aspects of the project including literature review and data analysis may be able to be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*

The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development may include:

- Review literature and industry for suitable fire retardants and interaction with plastics
- Be trained in the use of advanced research facilities at Springfield and Lismore campuses
- Understanding of the test procedures in characterizing plastic 3D printer formulations
- Safe use of polymer processing equipment
- Experimental design and mechanical and fire testing on 3D printed coupons
- Data collection and data analysis
- Understanding importance of waste recovery and value add.
- Opportunity to meet and engage with industry partners, government and interested stakeholders

*Project Outcomes*

This project will lead to a better understanding of 3D printing formulations, recycled polymer properties and the relationship between the components and chemical, physical and fire-retardant properties of the resulting product testing coupons and preliminary prototype panels. Addressing affordable housing with satisfied mechanical and fire-retardant properties is the ultimate aim in which a project of this design will contribute to bringing such a plan from the drawing board to reality.

# SIMPLE Hub Summer Research Projects on Offer: Medical Technologies

# Project 9: Developing extra cellular matrixes to support cellular growth in a novel 3D printed scaffold.

Dr Louisa Windus | Miss Alissa Reinke | A/Prof Polly Burey
School of Health and Medical Sciences, Centre for Future Materials

*Project Description*
Prostate cancer (PCa) is the most diagnosed cancer in males. Early stage PCa is treatable in most patients however when the cancer has metastasised outside of the prostate, predominantly into the bone, treatment can be a challenge. A major reason for the lack of effective drugs to treat bone metastases is that most current therapeutic approaches work on the primary cancer before it has spread. Cancer researchers have effective in vitro and in vivo primary cancer models and these have been used over the past several decades to develop suitable anti-cancer therapeutics. Cancer researchers do not currently have in vitro models to recapitulate metastatic cancer, particularly bone metastases.

This project aims to develop and optimise an inexpensive bioscaffold using agri-waste egg shells that can be used alongside prostate cancer and accessory cells to create an in vitro bone microenvironment model. This model will then be used in the laboratory to investigate the interactions between cells that leads to tumourigenic activity in the bone and evaluate whether the model could be used to test the efficacy of putative anti-prostate cancer fighting drugs, prior to progressing to pre-clinical trials.
As a summer student you will investigate the effects of the addition of extra cellular matrixes to the established eggshell/chitosan scaffolds and their role in aiding cell adherence and proliferation for a range of cells found in the bone microenvironment.

The results of this project are anticipated to provide useful information that is required to determine the most suitable extra cellular matrix composites in the development of our novel scaffolds.

*Project Location*
The successful candidate will be required to work at the Toowoomba campus for the duration of the project with opportunities to work with other students and researchers. Some aspects of the project including a literature review and data analysis can be completed off campus. This would need to be negotiated with the supervisory team.

*Benefits for Successful Candidates*
The successful candidate will gain experience working in a collaborative research environment and with researchers from different disciplinary backgrounds. Skills development will include:

- Be trained in the use of advanced research facilities at Toowoomba campus including a bioprinter
- Understanding of the test procedures in characterising eggshell/chitosan composites
- Experimental design and testing
- Data collection and data analysis
- Understanding importance of extra cellular matrix in supporting cellular growth

*Project Outcomes*
This project will lead to a better understanding of the characteristics of the different matrices used to grow cells in the 3D scaffold model and will generate useful information to determine the most suitable composites to support cellular growth. Data from the project may be also used in publishing high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 10: Development of sustainable hernia repair materials using renewable polymers and nanofillers

Pratheep Kumar Annamalai | Johnny Arakkakunel | Anna Chruscik | Eliza Whiteside
Centre for Future Materials, School of Health and Medical Sciences

*Project Description*

Hernia repair is a common surgical procedure requiring the implantation of mesh materials to support weakened or damaged tissue usually in the abdomen. Traditionally petroleum-derived or synthetic polymers (such as polypropylene, polyethylene terephthalate, and nylon) have been used however these materials have been linked with poor biocompatibility over time and this can lead to complications including chronic pain and infection. Poly(lactic acid) (PLA), poly(caprolactone) (PCL), and cellulose have been explored as promising renewable (and low cost) alternative polymers due to their established biocompatibility in other biomedical applications. However, their biocompatibility and mechanical strength as hernia mesh materials has not been established. The overall project aims to develop hernia mesh prototypes combining PLA, PCL, and nanocellulose, and evaluate the physical, mechanical, and biocompatibility properties of these nanocomposite materials. The project will also compare the performance of electrospun mats and solution-cast membrane/films in terms of their biocompatibility and mechanical properties. Methods in the study will include structural analysis (FTIR spectroscopy), morphological analysis (electron microscopy), and mechanical properties measurement. Those prototypes that demonstrate the most ideal mesh properties will be tested for their biocompatibility with human cell lines.

*Project Location*

The successful candidate will be required to work at the Toowoomba campus for the duration of the project with opportunities to work with other students, researchers, medical doctors, and other industry partners. Some aspects of the project including the online training, literature review, and data analysis may be able to be completed off campus.

*Benefits for Successful Candidates*

In addition to producing and testing one of the prototypes, the successful Summer Student will also have the opportunity to contribute to the drafting of a research manuscript. Skills development in the biomedical and engineering research laboratories will include:

- Training in the use of advanced biomedical and engineering research techniques
- Experimental design and testing
- Data collection and data analysis
- Understanding the importance of developing biomedical materials from renewable sources rather than petroleum-based products
- Opportunity to meet and engage with Hospital staff, industry partners, and other interested stakeholders (e.g. consumers/patients with a hernia mesh).

*Project Outcomes*

The expected outcomes of this project include the development of PLA/PCL/nanocellulose composite prototypes with improved mechanical strength, flexibility, and biocompatibility compared to contemporary hernia mesh products. This project will also generate useful information to determine the suitability of these materials as sustainable and low-cost alternatives to synthetic or petroleum-derived hernia meshes. Literature review content and data from the project may also be incorporated into high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 11: Circular economy demonstrator - production of a low-cost, 3D printed, reusable lumbar spine model using non-clinical hospital plastic waste

**Nikita Walz | Steph Piper | Doogie Whitcombe | Polly Burey | Eliza Whiteside**
Centre for Future Materials and MakerSpace, University of Southern Queensland
Rural Clinical School, The University of Queensland
Ability Enterprises, Toowoomba

*Project Description*

Circular economy involves the recycling, re-purposing, or re-manufacturing waste products into another product within the same industry. This approach in a hospital setting has benefits for both the environment and human health. This Summer Student project will be a collaboration across three organisations and will provide evidence of the efficacy of using 3D printer filament produced from re-processing surgical wrap (non-clinical waste) to manufacture low cost, 3D printed, reusable lumbar spine models.

Performing a spinal injection is a challenging technique to master and insufficient training can result in patient complications ranging from severe infections to post dural puncture headaches. Whilst there are commercially available training tools that are used by medical students and trainee anaesthetists, these tools are not sustainable as they need to be re-purchased following approximately 10 uses. Many commercial models are also cost-prohibitive and do not accurately simulate the specific tissue layers through which the needle penetrates. In addition to producing these models using waste plastic from the hospital setting, this study aims to evaluate the lumbar spine training tool in developing the confidence and competence of medical students and trainee anaesthetists.

*Project Location*

The successful candidate will be required to work at the Toowoomba campus for the duration of the project with opportunities to work with other students, researchers, medical doctors and medical educators, and other industry partners. Some aspects of the project including the online training, literature review, and data analysis may be able to be completed off campus. There will be a requirement to travel to the UQ Rural Clinical School (Toowoomba) and Ability Enterprises (Wilsonton, Toowoomba). This will be group travel, and transport can be arranged together.

*Benefits for Successful Candidates*

In addition to producing and evaluating the prototype models, the successful Summer Student will also have the opportunity to contribute to the drafting of a research manuscript.

Skills development in the biomedical and engineering research laboratories will include:

- Training in the use of 3D printing, CAD/CAM, materials testing
- Experimental design and testing
- Data collection and data analysis
- Understanding the importance of developing multi-use educational materials from renewable sources rather than petroleum-based materials
- Opportunity to meet and engage with Ability Enterprises, Rural Clinical School and Toowoomba Hospital staff and students, industry partners, and other interested stakeholders

*Project Outcomes*

The expected outcomes of this project include the development of reusable 3D printed lumbar spine prototypes. This project will also generate useful information to determine the suitability of 3D printed models as sustainable and low-cost alternatives to high cost, limited use, plastic models. Literature review content and data from the project may also be incorporated into high quality journal articles. The successful candidate will be a co-author on these outputs.

# Project 12: Development and evaluation of a low-cost, 3D printed, reusable tracheostomy model to improve clinical skills for medical students

**Nikita Walz | Steph Piper | Doogie Whitcombe | Polly Burey | Eliza Whiteside**
Centre for Future Materials, MakerSpace, University of Southern Queensland and
Rural Clinical School, The University of Queensland

*Project Description*

A tracheostomy is a vital medical procedure in which a stoma is cut in the neck to facilitate breathing through a tube, bypassing the mouth and nose, due to chronic patient health challenges or critical medical emergencies. It is an important skill taught during medical training and while limited and expensive models are available for procedural demonstration or practice, an anatomically correct, economical training model is not available, limiting valuable training opportunities. In this applied research project, the student will collaborate with The University of Queensland Rural Clinical School to develop and evaluate an effective and economical tracheostomy training model.

Following consultation with UQ Rural Clinical School educators, the successful Summer Student will research the design and effectiveness of existing models and develop an anatomically correct tracheostomy model in collaboration with the UniSQ MakerSpace and its 3D printing facilities. It is proposed that a 3D printed trachea would form the foundation of the model, surrounded by hydrogels for the surrounding tissue and covered with simulated skin to create an economical, sustainable (reusable), and effective model to increase student tracheostomy training opportunities and improve student confidence and competence in undertaking the technique. The effectiveness of the final model will be evaluated by medical students at the UQ Rural Clinical School.

*Project Location*

The successful candidate will be required to work at the Toowoomba campus for the duration of the project with opportunities to work with other students, researchers, medical doctors and medical educators, and other industry partners. Some aspects of the project including the online training, literature review, and data analysis may be able to be completed off campus. There will be a requirement to travel to the UQ Rural Clinical School.

*Benefits for Successful Candidates*

In addition to producing and evaluating the prototype models, the successful Summer Student will also have the opportunity to contribute to the drafting of a research manuscript.

Skills development in the biomedical and engineering research laboratories will include:

- Training in the use of 3D printing, CAD/CAM, hydrogel/other materials testing
- Experimental design and testing
- Data collection and data analysis
- Understanding the importance of developing reusable educational materials from renewable sources rather than petroleum-based materials
- Opportunity to meet and engage with Rural Clinical School and Toowoomba Hospital staff and students, industry partners, and other interested stakeholders

*Project Outcomes*

The expected outcomes of this project include the development of reusable 3D printed tracheostomy prototypes. This project will also generate useful information to determine the suitability of 3D printed models as sustainable and low-cost alternatives to high cost, limited use, plastic models. Literature review content and data from the project may also be incorporated into high quality journal articles. The successful candidate will be a co-author on these outputs.

University of Southern Queensland

**unisq.edu.au**

info@unisq.edu.au