32nd NSW STEM CELL NETWORK WORKSHOP

ENGINEERING SURFACES FOR REGENERATIVE MEDICINE:- FROM BIOMATERIALS TO MEDICAL DEVICES

RYDGES CAMPERDOWN

Monday, 20th NOVEMBER 2023
9.00am to 5.00pm

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The NSW Stem Cell Network gratefully acknowledges the support of Diabetes NSW & ACT and Cicada Innovations.

WELCOME

The goal of regenerative medicine is the ability to repair, rebuild, and regenerate tissue. Recent advances in tissue engineering have enabled scientists to more accurately model the complex biochemical and biophysical properties of the tissue microenvironment, advancing the development of engineered materials for regenerative medicine.

This workshop has been put together to explore recent advances in **biomaterials, biofabrication, bioprinting, and stem cell technologies** that have enabled researchers to move one step closer to being able to repair and regenerate damaged and diseased tissue.

The workshop will begin with discussions around current research in "**Biomaterials and Fabrication Technologies in Regenerative Medicine**". A/Prof Megan Lord will present her research on bio-nano interactions in blood vessel walls, followed by Dr Behnam Akhavan who's research on plasma-engineered biomimetic interfaces will be discussed in the context of next-generation medical devices. Dr Giselle Yeo will report findings on the role of tropoelastin in improving the regenerative function of mesenchymal stem cells, while Prof Marcela Bilek will provide insight into constructing bioinstructive platforms for cell culture.

Following morning tea, session two will cover "**Biomaterials and Devices in Regenerative Medicine**"; Prof Bernie Tuch will open the session with a discussion on bioengineered devices to deliver cell therapies. Prof Alan Rowan will discuss his research on controlling cellular activity using biomimetic materials, and Dr Vipul Agarwal will present his group's findings on neuronal regeneration using nanocomposite bioimplants.

After lunch, we move into session three, "**Bioprinting Technologies in Regenerative Medicine**". Prof Laurence Meagher will present his research on synthetic surfaces for cell culture and manufacturing, followed by Prof Jeremy Crook whose team uses bioprinting for regenerative medicine applications in cancer therapy. Dr Iman Roohani will then discuss his research on 3D printing of bioceramics from the macro- to nano-scale, and Dr Carmine Gentile will discuss how his research navigates heart repair using stem cells and biomaterials.

In our final session of the day, "**Biomaterials in the Marketplace**", A/Prof Zhilian Yue will discuss stem cells for skin regeneration. We are joined then by Dr Katja Beitat from Cicada Innovations who will discuss the processes of translating and commercialising biomaterials to the market.

To close the day, we will be launching the 9th edition of The Snapshot of Stem Cell and Regenerative Medicine Companies in Australia, presented by Mr Silviu Tiziani from The Centre of Commercialisation of Regenerative Medicine (CCRM Australia).

This workshop would not have been made possible without the support of our commercial sponsors Evident Australia, Culturon and Pacific Laboratory Products, and our supporters Rydges Camperdown, Diabetes NSW and ACT, Australasian Society for Stem Cell Research, and CCRM Australia. We encourage all delegates to visit the sponsor booths during the breaks.

We hope you enjoy the workshop and continue to support the NSW Stem Cell Network at future events.

Deb Rooz
Manager,
NSW Stem Cell Network

Dr Rachel Shparberg
Chair,
NSW Stem Cell Network

PROGRAM

9:00am	Registration Opens
9.30am	**Dr. Rachel Shparberg - NSW Stem Cell Network** Welcome
Session 1	**Biomaterials and Fabrication Technologies in Regenerative Medicine** **Chair: Prof Kristopher Kilian (University of NSW)**
9.40am	**A/Prof Megan Lord (University of NSW)** *Understanding bio-nano interactions at the blood vessel wall*
10.00am	**Dr Behnam Akhavan (University of Newcastle)** *Plasma-engineered biomimetic interfaces for next-generation implantable medical devices*
10.20am	**Dr Giselle Yeo (University of Sydney)** *Improving mesenchymal stem cell regenerative function with tropoelastin*
10.40am	**Prof Marcela Bilek (University of Sydney)** *Constructing bioinstructive platforms for cell culture and tissue-integration*
11.00am	Morning Tea
Session 2	**Biomaterials and Devices in Regenerative Medicine** **Chair: Dr Jingjing Li (University of NSW)**
11.30am	**Prof Bernie Tuch (Australian Foundation for Diabetes Research)** *Bioengineered device to deliver cell therapies*
11.50pm	**Prof Alan Rowan (Australian Institute for Bioengineering and Nanotechnology)** *Biomimetic materials: controlling cellular activity*
12.10pm	**Dr Vipul Agarwal (University of NSW)** *Electrically conducting nanocomposite bioimplants for neuronal regeneration*
12.30pm	Lunch
Session 3	**Bioprinting Technologies in Regenerative Medicine** **Chair: Dr Peter Newman (University of Sydney)**
1.40pm	**Prof Laurence Meagher (Monash University)** *Synthetic surfaces for cell culture and manufacturing applications*
2.00pm	**Prof Jeremy Crook (Universities of Wollongong and Sydney, Chris O'Brien Lifehouse)** *Bioprinting for regenerative medicine in cancer therapy*
2.20pm	**Dr Iman Roohani (University of Sydney)** *Entering a new dimension: macro to nanoscale 3D printing of bioceramics*
2.40pm	**Dr Carmine Gentile (University of Technology Sydney)** *Heart repair using stem cells and biomaterials*
3.00pm	Afternoon Tea
Session 4	**Biomaterials in the Marketplace** **Chair: A/Prof Stuart Fraser (Culturon)**
3.20pm	**A/Prof Zhilian Yue (University of Wollongong)** *Engineering functional skin-like structures through 3D bioprinting of biomaterials and cells*
3.50pm	**Dr Katja Beitat (Cicada Innovations)** *Translation and commercialisation of biomaterials for the market*
Session 5	**Snapshot of Stem Cell and Regenerative Medicine Companies in Australia**
4.10pm	**Silvio Tiziani (CCRM Australia)** *Launch of the Snapshot 9th edition*
4.30pm	Workshop Close

SPEAKER PROFILE

A PROF MEGAN LORD
ARC Future Fellow
Graduate School of Biomedical Engineering
University of NSW

ABSTRACT
Understanding bio-nano interactions at the blood vessel wall

Nanomaterial-cell interactions have been extensively explored. Crucially, all cell membranes are decorated in sugar macromolecules (glycans) which form an anionic matrix bound via proteins and lipids, referred to as the glycocalyx. Therefore, nanomaterials must pass through the glycocalyx prior to interactions at the cell membrane. However, we do not fully understand the impact of the glycocalyx on nanomaterial interactions at the cell surface. This is in large part due to most studies using isolated cells devoid of a glycocalyx. This study analysed interactions between the endothelial glycocalyx, and a polymer library functionalised with cationic groups (eg. guanidino) which possess high affinity for carboxylates and sulphates within glycans.
The glycocalyx produced by primary human endothelial cells contained the glycans hyaluronan and heparan sulphate, which bound the guanidino containing polymers as observed by confocal microscopy. In addition, the polymers were internalised by the cells as observed by light sheet and fluorescence lifetime imaging microscopy. These data indicate the ability of some polymers to pass through the glycocalyx and be internalised. The binding between the polymers and glycans was confirmed by quartz crystal microbalance and the formation of biomolecular condensates via phase separation in solution.
Together this study adds to our understanding of biomaterial properties that facilitate binding to and transport through the glycocalyx for intracellular uptake. This knowledge is an important step toward the design of more efficient and effective drug delivery systems which can interact with target cells in a controlled and predictable manner.

BIOGRAPHY
Megan Lord is an Associate Professor and ARC Future Fellow in the Graduate School of Biomedical Engineering, UNSW Sydney. Megan's research is engineering cell-biomaterial interactions for applications in drug delivery and tissue repair. Her research leadership has been recognised by numerous awards including the Barry Preston Award from the Matrix Biology Society of Australia and New Zealand in 2022. She is the Past-President of the Matrix Biology Society of Australia and New Zealand and a Council Member for the International Society for Matrix Biology. Megan also serves on the Standards Australia Committee HE-030 Biological and Clinical Evaluation of Medical Devices, which reviews and ratifies ISO 10993 and TC194, the international standard that evaluates the biocompatibility of medical devices and manages biological risk. Megan is also the founding Academic Director of the Australian Graduate School of Engineering Industry PhD Program within the Faculty of Engineering, UNSW Sydney where she has established a program with a focus on both academic and industry expertise supported by a mentoring and networking program to equip graduates with job-ready skills for their next career stage.

SPEAKER PROFILE

DR BEHNAM AKHAVAR

Senior Lecturer, ARC DECRA Fellow
Plasma Bio-Engineering, School of Engineering
Hunter Medical Research Institute
University of Newcastle

ABSTRACT

Plasma-engineered biomimetic interfaces for next-generation implantable medical devices

The prevalence of implantable medical devices has witnessed a significant rise on a global scale, with an annual occurrence of hundreds of thousands of procedures. However, a substantial portion of these procedures experience complications, frequently associated with infections or insufficient integration with the host tissues. Implementing strategic surface functionalization with bio-instructive properties offers a viable approach to regulate biological reactions and direct the differentiation of stem cells through surface-attached biomolecules and hydrogels. Here, we showcase the remarkable capabilities of plasma bio-engineering techniques in crafting such instructive interfaces on a diverse array of materials. These materials span a spectrum of chemistries and geometries, including titanium, stainless steel, bioceramics, and polymers such as ePTFE and silk. Our findings provide evidence on the covalent immobilization of multifunctional protein layers, peptide molecules with preferred orientation, hydrogel coatings, and even silver nanoparticles on the plasma-engineered surfaces. These modifications lead to improved cellular responses and bolstered antimicrobial properties, validated for a broad range of biomedical engineering applications, from surface engineering of bone implantable devices to creating constructs for cartilage tissue regeneration. The plasma bio-engineering approach holds significant promise for developing the next generation of bioactive materials and interfaces, not only for biomedical implant applications but also for broader medical advancements.

BIOGRAPHY

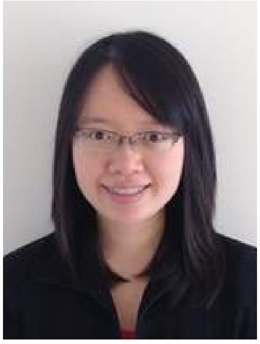
Dr. Behnam Akhavan is a Senior Lecturer and an ARC DECRA Fellow at the University of Newcastle, where he leads the Plasma Bio-engineering Research Group across the School of Engineering and the Hunter Medical Research Institute.

He earned his PhD in Advanced Manufacturing from the School of Engineering at the University of South Australia in 2015. Dr. Akhavan's pioneering research in plasma processes to tailor surface properties earned him recognition as one of UniSA's Enterprising Faces. His academic journey following his PhD graduation includes postdoctoral roles at the Max Planck Institute for Polymer Research and Fraunhofer Institute of Microtechnology in Germany and Schools of Physics and Biomedical Engineering at the University of Sydney.

Dr. Akhavan's Plasma Bio-engineering Lab is leading the way in advancing plasma science and surface engineering solutions, with a focus on developing innovative applications. These applications cover a wide range of areas, including anti-infection bone implants, tissue-integrating cardiovascular devices and artificial nerves, nanoparticles for precision cancer therapy, electrochromic coatings for wearable electronics, and micro/nanoparticles for toxin removal and water purification.

In surface and interface science, his research spans diverse areas, including thin film deposition, plasma polymerization, ion implantation, surface biofunctionalization, and interface engineering. Dr. Akhavan's contributions to biomedical engineering were honoured with the Most Innovative Engineers Award from Engineers Australia.

SPEAKER PROFILE



DR GISELLE YEO

NHMRC Emerging Leadership Fellow
School of Life and Environmental Sciences

Group Leader
Charles Perkins Centre
The University of Sydney

ABSTRACT

Improving mesenchymal stem cell regenerative function with tropoelastin

Stem cells such as mesenchymal stem cells (MSCs) are increasingly being used as therapeutic agents for a range of disorders, due to their properties of self-renewal, cell signalling, and differentiation. However, their limited natural availability typically necessitates *ex vivo* expansion prior to administration into patients. Conventional MSC culture processes are inefficient, costly, and can lead to functional heterogeneity in harvested cells. We have discovered that the soluble extracellular matrix protein, tropoelastin, which is classically designated as a structural matrix protein, strongly drives multiple aspects of MSC regenerative behaviour, including migration, proliferation, phenotypic maintenance, and differentiation. Tropoelastin induces MSC responses via activation of cell-surface integrin receptors, when immobilised on a substrate or added in solution. This duality of action converges the mechanistic features of cell-anchoring matrix proteins and soluble growth factors, and uncovers the potential of this protein for MSC expansion, targeted MSC delivery and retention, and endogenous MSC recruitment for tissue repair.

BIOGRAPHY

Dr Giselle Yeo is an NHMRC Emerging Leadership Fellow in the School of Life and Environmental Sciences and a Group Leader at the Charles Perkins Centre at The University of Sydney. Dr Yeo completed her PhD in matrix protein biochemistry at the University of Sydney, then continued on with postdoctoral studies in the biofunctionalisation of materials for tissue engineering applications. In 2018, with a USyd Early Career Development Fellowship, she established a research program focused on stem cell biology and stem cell-based regenerative applications. Her group works on understanding and controlling stem cell behaviour with extracellular matrix molecules and surface-engineered materials. Her work has been recognised by multiple early-career awards including a NSW Young Tall Poppy Award, USyd Vice-Chancellor's Award for Outstanding Early-Career Research, Selby Research Award, and Bob Fraser Young Investigator Award. Dr Yeo also directs the Australian site of the Amgen Biotech Experience, a school science outreach program dedicated to delivering a biotechnology practical curriculum to 50+ schools across Sydney.

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SPEAKER PROFILE

PROF MARCELA BILEK
ARC Laureate Fellow, Lab Head
Applied Physics and Surface Engineering,
University of Sydney

ABSTRACT

Constructing bioinstructive platforms for cell culture and tissue-integration

Materials used in biomedicine are selected according to bulk properties, such as mechanical, electrical and optical, required for particular *in-vivo* and *in-vitro* applications. However, their surfaces almost always provide suboptimum biological microenvironments and do not promote the desired biological responses.

This presentation will describe sustainable and readily scalable surface modification processes that use plasma, the forth state of matter, to enable resilient and easily tailorable biofunctionalization of all surfaces. Typical time scales of cell culture and tissue integration necessitate covalent immobilisation to prevent interface instability due to desorption and exchange with molecules in the aqueous local environment. We will examine how plasma activates a range of materials and structures for spontaneous, reagent-free, covalent functionalisation with bioactive molecules and hydrogels. Functional molecules that can be immobilised to create tailored cell microenvironments include, but are not limited to, oligonucleotides, enzymes, peptides, aptamers, cytokines, antibodies, cell-adhesion extra-cellular matrix molecules, and histological dyes. The covalent immobilisation occurs on contact via radicals embedded in the surface by energetic plasma species.

After a review of the fundamental science, processes to modify the internal surfaces of multi-well plates, porous scaffolds and micro/nanostructures will be presented. Strategies to immobilise biological microenvironment patterns and hydrogels onto the plasma activated surfaces will also be discussed.

BIOGRAPHY

Marcela Bilek is Professor of Applied Physics and Surface Engineering at the University of Sydney. Her research comprises fundamental science and practical applications in materials physics and engineering, plasma processing, and cross-disciplinary research in biointerfaces. She holds a B.Sc. (Hons I) from the University of Sydney, a PhD from the University of Cambridge, UK and an MBA from the Rochester Institute of Technology. She has published over 350 peer-reviewed journal articles, 1 book, 6 book chapters and 15 patents. She has trained 35 PhD students, and mentored 25 post-doctoral fellows and early career researchers. Honours and prizes include the Malcolm McIntosh Prize for Physical Scientist of the Year (2002); ARC Federation Fellowship (2003); Australian Academy of Science Pawsey Medal (2004); Australian Innovation Challenge Award (2011); ARC Future Fellowship (2012); Plasma Surface Engineering Leading Scientist Award (2018) and ARC Laureate Fellowship (2019-2024). She was elected to the Fellowships of the American Physical Society (APS), the American Vacuum Society (AVS) the Institute of Electrical and Electronics Engineers (IEEE) and the Australian Academy of Science (AAS) in recognition of her work on plasma processes for materials modification and synthesis.

SPEAKER PROFILE

PROF BERNIE TUCH

Chief Scientific Officer
Australian Foundation for Diabetes Research

ABSTRACT

A bioengineered device to deliver cell therapies

Type 1 diabetes is a disorder in which the insulin-producing cells (ß) of the pancreas are destroyed by an autoimmune process, resulting in the need for exogenous insulin administration to control blood glucose levels (BGL) and stay alive. Donor ß-cells, whether from donor pancreases or more likely differentiated from pluripotent stem cells, are needed to replace those destroyed, and must be delivered to recipients in a bioengineered device that protects the implant from immune rejection if recipients are to avoid having to take toxic immunosuppressive drugs. Placing human pancreatic ß-cells in alginate microcapsules prior to implantation in diabetic humans provides some immunoisolation *in vivo* but a pericapsular fibrotic reaction limits their survival. Placing encapsulated mouse pancreatic ß-cells in a scaffold of polycaprolactone made by melt electrospin writing and then implanting the device in diabetic mice results in normalisation of BGL. However, the same does not occur when human stem cell-derived ß-cells are used. The cells stay alive for the 3-month duration of the experiments, and secrete human insulin, but insufficient to normalise BGL of recipients. This is in contrast to what occurs when the same number of encapsulated human stem cell-derived ß cells are implanted without scaffolds in the immunodeficient mice, and sufficient human insulin is produced to normalise BGL.

Regulatory bodies require encapsulated stem cell derived ß-cells to be placed in a device such as a scaffold that can be retrieved, if necessary, from the recipient. To use our scaffold in diabetic humans will require an improvement in the functioning of the encapsulated stem cell-derived ß-cells seeded into it.

BIOGRAPHY

Bernard Tuch is the Chief Scientific Officer and a Director of the Australian Foundation for Diabetes Research, a not-for-profit entity that is championing the use of human stem cell-derived ß-cells as a therapy of type 1 diabetes. He is a translational consultant endocrinologist in private practice with appointments at St Vincents Private, Prince of Wales Private and the Wolper Jewish Hospitals. Dr Tuch is an adjunct Professor in the Department of Diabetes, Central Clinical School of Monash University. He has published 161 peer reviewed original manuscripts, 18 reviews, 19 book chapters, one book, and 25 state of the art publications.

He was the founding chairman of the NSW Stem Cell Network in 2002, and over the next two decades largely responsible for ensuring 30 Workshops were carried out. He passed on the reins to Dr Rachel Shparberg late last year. He also was the Executive Chairman of the cell therapy company Living Cell Technologies Ltd 2021-2, which was using encapsulated pig brains cells as a possible therapy for Parkinson's disease.

Prof Tuch is working with colleagues at The University of Technology Sydney, Queensland University of Technology and the Israeli company Kadimastem Limited, which provides the stem cell-derived ß-cells, to develop the bioengineered device that can be used to deliver a cell therapy for type 1 diabetes.

NSW StemCell NETWORK

SPEAKER PROFILE

PROF ALAN ROWAN
Director
Australian Institute for Bioengineering and Nanotechnology
The University of Queensland

ABSTRACT

Biomimetic materials: controlling cellular activity

Fibrous networks of biopolymers are found in both the intracellular and extracellular matrix. From the microscopic scale of a single cell to the macroscopic scale of fibrous tissues, biopolymers with different stiffness control cellular processes such as cell differentiation, proliferation, transportation, and communication.
In recent years many different hydrogels have been developed, often with the goal to create an artificial extracellular matrix for biomedical applications. However, the mechanical environment inside and outside the cell is not determined by a single component. Multiple biopolymers with different structural and mechanical properties which physically interact with each other, make the mechanical environment of a cell *in vivo* much more complicated than the environment of a cell in a single-component artificial matrix.

The mechanics of natural biopolymer gels however are very different from most synthetic hydrogels because they show strain stiffening behaviour. Reconstituted networks of cytoskeletal polymers such as actin or intermediate filaments or extracellular biopolymers such as collagen or fibrin show a large increase in stiffness upon an applied stress or deformation induced by the cell. The stiffening response prevents these networks from breaking under external stresses and enables communication between cells growing in these materials which is passed through to the nucleus.

Our efforts to synthesis genuine biomimetic polymer hydrogel with materials properties almost identical to these of intermediate filaments and extracellular matrices and approaches to controlling natural fibre networks will be discussed. The critical role of nonlinear mechanical properties in controlling cellular behaviour will be highlighted.

BIOGRAPHY

Prof Rowan performed his research at the interface of chemistry and biology with seminal and pioneering work on processive catalysis and functional self-assembly. Prof Rowan is widely recognised as a truly innovative scientist, working toward understanding at the molecular level the functional of hierarchical materials and catalysis.

Prof Rowan has worked across many areas, ranging from magnetic materials, single enzyme catalysis, supramolecular catalysis through to nanometer-sized solar cells and photonic materials. He developed the concept of biomimetic processive catalysis, mimicking the natural exo- and endonucleases and demonstrated that a macrocyclic catalyst can thread onto and move along a polymer substrate in a highly efficient process. More recently he has been intrigued by the complex relationship between the architecture and mechanical properties of the extracellular matrix and its interaction with cells and proteins. He has been awarded 11 patents in the areas of nanomedicine and nanomaterials and has been involved in the startup of 5 companies. In 2013 he was shortlisted as one of the Netherlands leading science entrepreneurs. Professor Rowan was awarded the RSC Soft Matter and Biophysics Prize in 2014, an Australian Research Council Laureate Fellowship in 2017 and became a Fellow of the Australian Academic of Sciences in 2020.

SPEAKER PROFILE

DR VIPUL AGARWAL

Lecturer
Research Fellow
School of Chemical Engineering,
University of New South Wales

ABSTRACT

Electrically conducting nanocomposite bioimplants for neuronal regeneration

Neurotrauma, defined as an injury to the central or peripheral nervous system, is a debilitating medical emergency affecting over 3 million people annually worldwide. It has a very high mortality rate and can render the survivors permanently disabled, requiring prolonged medical intervention and lifelong support, representing a significant social and economic burden. With limited treatment options available there is a great need to develop innovative treatment modalities. Chronic loss of function following neurotrauma is attributed to the inability of mature neurons to regenerate axons, largely due to formation of the glial scar which acts as a physical and biochemical obstruction to axon regeneration. External electrical stimulus has the potential to stimulate severed axons and promote axonal outgrowth. However current approaches have had limited success and cannot guide the direction of growth to ensure gaps are bridged and communication restored.

Several strategies and implant prototypes have been developed over the years; however, the use of metallic implants suffer from major drawbacks including inflammation, fouling requiring surgical replacement, and gliosis and scar formation. To circumvent these limitations, we developed multidimensional polymer-based implants with properties similar to metallic implants in terms of electrical conductivity and flexibility (when using thin metallic electrodes). These multi-dimensional electrically conducting implants exhibit high biocompatibility. In this talk, efficacy of these bioimplants towards electrically stimulating neuronal progenitor and stem cells to preferentially differentiate into a neuron-specific lineage with significant axonal outgrowth compared to non-stimulated control and other conducting polymer platforms.

BIOGRAPHY

Dr Vipul Agarwal is a lecturer and University of New South Wales (UNSW) Research Fellow. He received his PhD from The University of Western Australia in 2015. Following his PhD, he was awarded a Department of Science and Technology (India) National Postdoctoral Fellowship to undertake his postdoctoral training at the Indian Institute of Science, India. In 2018, he joined UNSW, on an Australian National Health and Medical Research Council (NHMRC) ECR Fellowship. He is also currently serving as the Royal Australian Chemical Institute (RACI) Nyholm Youth Lecturer (2022-23). His current research interests include development of synthetic and fabrication strategies towards two- and three-dimensional nanocomposite scaffolds for biomedical engineering application with particular focus on neuronal regeneration in the spinal cord. His research has led to significant breakthroughs towards the development of tuneable coatings and a novel foam fabrication technology.

SPEAKER PROFILE

PROF LAURENCE MEAGHER

Director of the ARC Training Centre for Cell and Tissue Engineering Technologies and SPARK Monash Program

Professor of Materials Science and Engineering
Monash University

ABSTRACT

Synthetic surfaces for cell culture and manufacturing applications

Materials used in medical applications are often chosen not for their surface properties but because they have suitable mechanical properties or that they are degradable. In this case, the surface properties often need modification to provide additional function or to reduce inflammatory or thrombogenic responses. Surface initiated polymerization (SIP) combined with bioconjugation is a versatile approach to tailor the bioactivity of cell culture substrates.

I will provide two examples, one using non-controlled radical SIP and one using a controlled radical SIP approach to generate soft, hydrogel coatings suitable for expansion of mesenchymal stromal cells (MSCs) and pluripotent stem cells (PSCs). For the scalable coating of planar substrates which are transparent to UV, self-initiating approaches using UV irradiation are very effective. Here, no initiators need to be immobilised on the substrate, making for a much simpler process (2 step). This approach was used to culture pluripotent stem cells using a fully synthetic culture system which maintained the pluripotent state of the cells over 10 passages in E8 media.

For coating of substrates with more complex geometries, polymerisation methods that do not require line of site methods for initiation are required. Here, the use of macro-chain transfer agents and reversible addition-fragmentation chain-transfer (RAFT) polymerisation is particularly suited. Coatings were grown from polystyrene substrates for the expansion of MSCs via macro-chain transfer agents chemically attached to the substrate. Expansion of MSCs and subsequent characterisation of the cells demonstrated maintenance of the MSC phenotype (cell surface marker expression and multipotency).

BIOGRAPHY

Laurence Meagher is Professor of Materials Science and Engineering at Monash University and Director of the ARC Training Centre for Cell and Tissue Engineering Technologies and the SPARK Monash Program. He is Co-Director of the SPARK Oceania program and works with Australian Universities and other organisations to facilitate the translation of technologies towards clinical application and marketed products. In his research, he works broadly across the development of bioactive coatings and materials for therapeutic cell manufacturing, tissue engineering and regeneration (particularly of skeletal muscle), bioactive molecule delivery (drug, protein and antimicrobial compound delivery) and medical device applications. A key focus of his research activity is translation towards clinical application of the technologies he and his group develop. He is very active in the area of bioprinting for application in a range of clinical unmet needs (cardiac, neural, vascular, muscle) and novel bioink carrier development. He develops synthetic, chemically defined coatings for expansion and directed differentiation of cells for therapeutic applications as well as antimicrobial polymers and coatings and delivery technologies for a range of bioactive molecules, particularly novel antimicrobial compounds.

SPEAKER PROFILE

PROF JEREMY CROOK

Professorial Fellow
Biomedical Engineering
Australian Institute of Innovative Materials & Intelligent Polymer Research Institute
University of Wollongong

Arto Hardy Family Chair of Biomedical Innovation
School of Medical Sciences
University of Sydney

Director Biomedical Innovation
Chris O'Brien Lifehouse

ABSTRACT

Bioprinting for regenerative medicine in cancer therapy

Regenerative medicine strategies for cancer treatment are commonly associated with addressing the need to predict, diagnose and eradicate tumour cell growth through in vitro tissue (including cancer microenvironment) modelling, stem cell transplantation for immune system recovery, production of cancer-specific T cells from induced pluripotent stem cells (iPSCs), and use of stem cells as vectors to deliver anti-cancer agents for targeted therapy. However, reconstruction of tissue following disease and/or tumour resection may be included in a patient's treatment plan during or after the disease period to improve their quality of life. The repair of a critical-size bone defect following surgical removal of a mandibular tumour is one example, being a major challenge where the current gold standard of treatment involves the use of autologous grafts, associated with donor site morbidity and insufficient bone for repair. Printable biocompatible natural and synthetic materials offer new opportunities for regenerative medicine in cancer therapy by providing smart surfaces for controlling the interface between cells and their substratum. The Arto Hardy Family Biomedical Innovation Hub (BMIH) at Chris O'Brien Lifehouse is investigating advanced printable polymeric materials (including composites) for tissue reconstruction, able to deliver chemical and non-chemical cues to direct cell fate ectopically and be safely integrated into the body whilst maintaining sufficient mechanical stability without additional stabilisation. My presentation will provide an overview of the research being undertaken at the BMIH, including the combination of clinically amenable 3D printed smart permanent polymers, resorbable polymeric gels, and tissue derived stem cells as a promising strategy for bone reconstruction following oral cancer.

BIOGRAPHY

Jeremy Crook is Director and conjoint Arto Hardy Family Chair and Professor of Biomedical Innovation at the Chris O`Brien Lifehouse and School of Medical Sciences, University of Sydney, respectively, and Professorial Fellow of Biomedical Engineering, University of Wollongong. Jeremy completed his PhD at the University of Melbourne (UoM; 1998) followed by a US National Institutes of Health (NIH) Fogarty International Centre Medical Research Fellowship (NIH Fellows Award for Research Excellence). Since 2002, Jeremy has held the positions of Program Manager in the stem cell biotech ES Cell International (2002-2007), Group Leader in Singapore's A*STAR Institute of Medical Biology (2007-2009), Head of the Stem Cells and Disease Modelling Laboratory in the UoM Centre for Neural Engineering (2011-2014), and Chief Investigator and Deputy Theme Leader (Synthetic Biosystems) in the ARC Centre of Excellence for Electromaterials Science (2014-2021). Jeremy is a member of international Task Forces and Steering Committees including the International Society of Stem Cell Research Standards Task Force (Standards for Human Stem Cell Use in Research, published June 2023), an inventor of several patents on methods for translational stem cell research, and advanced materials for tissue engineering and regenerative medicine, and has published more than 100 publications with over 7240 citations. Jeremy's award-winning research (Research Australia 2019 Health and Medical Research Frontiers Research Award) focuses on next-generation tissue building for drug discovery, medical device development, and regenerative and cancer medicine.

SPEAKER PROFILE

DR IMAN ROOHANI

Senior Research Fellow
Musculoskeletal Health
School of Biomedical Engineering
The University of Sydney

ABSTRACT

Entering a new dimension: macro to nanoscale 3D printing of bioceramics

Over the past decade, advancements in 3D printing technologies for bioceramics, particularly calcium phosphates (CaP), have significantly increased the flexibility of producing implants and structures with complex geometries, overcoming the limitations of traditional methods. This advancement has facilitated their extensive use in tissue engineering; the creation of patient-specific implants for the repair and reconstruction of bone defects; and the development of advanced biomimetic material. However, the resolution of such prints has been limited to the micrometer scale, with the smallest achievable features being approximately 100 microns. In this report, we present a technology that allows for the 3D printing of CaP constructs with nanoscale precision, achieving an unprecedented resolution of sub-150 nm. This development opens up a range of new applications and functional gains for bioceramics, such as attaining superior mechanical properties through nano-latticing—including increased deformability and reaching theoretical strength limits—; the fabrication of bio-inspired and hierarchically structured designs; producing surfaces with precise nanoscale topography; and enhancing *in vitro* models. This represents a significant advancement in the application of ceramics as biomedical materials.

BIOGRAPHY

Dr. Roohani is a Sydney Musculoskeletal Health Fellow at the School of Biomedical Engineering and Senior Research Fellow in Prof. Zreqiat's Lab at the University of Sydney. He is a visiting Research Fellow at the School of Chemistry at the University of New South Wales. He obtained his PhD in Biomedical Engineering from the University of Sydney followed by receiving the National Health and Medical Research early career fellowship in 2016. Dr Roohani`s research interest is to understand how environmental factors regulate the function of musculoskeletal cells. This research underpins a more translational program aimed at developing novel biomaterials, 3D bioprinting technologies and tissue engineering strategies to regenerate damaged and diseased musculoskeletal tissues. He is the author of 71 publications (h index of 32, >3100 citations), and inventor of a single-stage biofabrication technique (COBICS) to create a 3D heterogeneous bone-analogous microenvironment. His research in the development of biomaterials for bone tissue regeneration has attracted attracted funding of over $2M and led to translational output, inventions and numerous awards such as finalist of Eureka innovative use of technology 2023, and Young Investigator Award of Year 2021 (TERMIS). He has been a peer review committee member of several national and international grants bodies such as member of the Australian National Health and Medical Research Council and Australian Research Council and several governmental funding bodies in Europe.

SPEAKER PROFILE

DR CARMINE GENTILE

Group Leader
Cardiovascular Regeneration Group
University of Technology Sydney

ABSTRACT

Heart repair using stem cells and biomaterials

Cardiovascular disease, including myocardial infarction (MI) and heart failure (HF), is a leading cause of death globally. Our laboratory has developed a novel approach to 3D bioprint cardiac tissues containing human cardiac spheroids (hCSs) together with alginate/gelatin (Alg/Gel) hydrogels. We have previously demonstrated that bioprinted Alg/Gel patches containing hCSs are characterised by morphological, biochemical, and pathophysiological features similar to the ones of the *in vivo* human cardiac tissue. For this reason, they have been extensively used to test toxicity of drugs, as well as to model the damage that follows myocardial infarction ("heart-attack-in-a-Petri-dish"). Given their unique ability to mimic the human heart microenvironment, we hypothesised that bioprinted patches containing hCSs in Alg/Gel could protect against impaired cardiac function in an *in vivo* mouse MI model. To test this hypothesis, we compared the effects of few groups of patches in animals. Infarcted MI mice received either (i) AlgGel acellular patches, or (ii) AlgGel patches with freely suspended cardiac cells, or (iii) AlgGel patches with hCSs. Control groups included (iv) mice that underwent a sham (SHAM) procedure and (v) infarcted mice that did not receive any patch (MI). We performed cardiac function measurements via ultrasound imaging up to 28 days. Epicardial transplantation of patches containing hCSs was the best treatment to significantly ($p=0.010$) improve left ventricular ejection fraction (LVEF%) from 41% (MI mice) to 64%. Similarly, the infarct area was significantly reduced in mice receiving hCS patches compared to MI animals not receiving any patch. Bulk RNAseq analyses of heart tissues demonstrated similar gene expression profiles between SHAM and MI mice receiving AlgGel patches with hCSs. Altogether, our findings support the novel use of cardiac Alg/Gel patches containing hCSs to protect against MI-induced HF. Together with our clinical partners, current studies are focussing on the personalisation of bioprinted patches from both the cellular and morphological aspect, as well as to the minimally-invasive delivery of the patch to quickly translate our findings from the bench to the bedside.

BIOGRAPHY

Dr Carmine Gentile, PharmD/PhD, FAHA, leads the Cardiovascular Regeneration Group working on 3D bioprinting and stem cell technologies at the University of Technology Sydney (UTS). He is also a Senior Lecturer (Faculty) within the School of Biomedical Engineering (Faculty of Engineering and IT) at the UTS. He received his BSc/MSc (Pharmaceutical Chemistry and Technologies) and PharmD at the University of Pisa, Italy and his PhD in Biomedical Sciences (Cardiovascular) at the Medical University of South Carolina, Charleston, SC, USA, funded by a prestigious American Heart Association Fellowship. Since 2013 Dr Gentile has worked in Australia at the Heart Research Institute, the University of Sydney and now at UTS, supported by several awards and grants, working within a multidisciplinary team with scientists, industry partners and clinicians to quickly translate his findings from bench to bedside. Dr Gentile is internationally recognized for his studies in 3D bioprinting and stem cell technologies and his more recent studies focus on novel molecular and cellular approaches to treat cardiovascular disease, including myocardial infarction and heart failure. These studies are based on the use of "mini-hearts" he developed as "bioinks" for human heart tissues. In 2016, he was invited as Visiting Research Fellow at Harvard Medical School, where he worked towards novel *in vitro* models using mini-hearts to study human heart physiology.

SPEAKER PROFILE

A/PROF ZHILIAN YUE
Principal Fellow
Australian Institute for Innovative Materials
Intelligent Polymer Research Institute
University of Wollongong

ABSTRACT

Engineering functional skin-like structures through 3D bioprinting of biomaterials and cells

Bioprinting has shown promise in improving the functions and quality of tissue-engineered products. Key to realizing this potential is the development of appropriate biomaterials, cells, and their combinations. We present here some recent examples of our studies undertaken towards the applications in skin repair and regeneration. Catechol-functionalized inks have been developed to provide cytocompatible structural support. The formulations produce double network hydrogels with high fracture toughness and elasticity, where the protein of interest is readily immobilized *in situ*. Mechanically reinforced cell-laden structures were 3D printed with built-in micro-channels that simulate vasculature. The structures support the formation of skin-like structures expressing key proteins found in the native dermis and epidermis.

Innervation of tissue-engineered skin remains a challenge due, in part, to a lack of access to native human cells and the fragility of mature neurons. Our collaborative group developed a novel approach to the fabrication of 3D sensory neuron constructs. A transgenic human pluripotent stem cell line was first differentiated into neural crest cell progenitors, which were then bioprinted, and further differentiated. The 3D printed structures demonstrated extensive neurite outgrowth and expression of markers consistent with various somatosensory neuron subtypes, and functionality. We currently combine this approach with skin printing to develop a 3D innervated human skin model. Our approach opens avenues of research into advanced nervous system and disease modelling, as well as co-culture applications with other bioprinted tissues.

BIOGRAPHY

A/Prof Yue received her PhD in Polymer Chemistry in 2002 from Heriot-Watt University, UK. She is a principal research fellow at the Intelligent Polymer Research Institute, University of Wollongong.

A/Prof Yue brings over 20 years of experience in biomaterials, with a multidisciplinary focus on converging advanced polymer science, biological science, and engineering to tackle critical biomedical challenges. Her areas of research include Bioprinting, Tissue Engineering and Regenerative Medicine, Medical Bionics, and Drug Delivery. She has published 106 peer-reviewed journal papers, and 6 book chapters (h-index of 34, Google Scholar). A/Prof Yue is also a strong advocate for transdisciplinary research training and education, providing multidisciplinary research supervision to 40 HDR students.

SPEAKER PROFILE

DR KATJA BEITAT

Head of HealthTech
Cicada Innovations

ABSTRACT

Translation and commercialisation of biomaterials for the market

The potential impact of recent advances in biomaterials and biofabrication, bioprinting and stem cell technologies on patients and clinicians is significant. However, for those to eventuate, early stage research and development projects require to be commercialised. In this session, Dr Katja Beitat, Head of HealthTech at Cicada innovations, one of Australia's oldest deep tech incubators, will take us through what is involved to get an idea to market; where can researchers and clinicians get the right support, and what to expect along the way.

BIOGRAPHY

Dr Katja Beitat is the Head of HealthTech at Cicada Innovation, founder and CEO of Clinivid, a digital health venture facilitating virtual multidisciplinary clinical teams (acquired in 2020), and Director of Radiology Across Borders, a global non-for-profit providing radiology education, training, and support to clinicians in over 130 countries. She is an experienced entrepreneur, researcher, and executive working within the healthcare industry, both in Australia and internationally. Katja is passionate about helping researchers, clinicians, and innovators accelerate technological transformation in healthcare at scale, and solve the many complex challenges that need to be addressed to maintain and improve our healthcare system; as well as helping to bring the world class innovations conceptualised in Australia to a wider market.

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