AIBN REPORT 2020

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

CREATE CHANGE

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Cover image: TEM image of fractal silica nanoparticles. These are new type of rough nanomaterials known as fractals-in-a-sphere. Captured by Sukitha Kothalawala

Message from the Vice-Chancellor and President

This year was certainly one of the most challenging and disruptive years in living memory.

Alongside the substantial risks that the pandemic posed to human health and economic stability, it has also presented – and continues to present – immense challenges to carrying out scientific research.

The Australian Institute for Bioengineering and Nanotechnology (AIBN) is a wonderful example of a scientific research body, where the researchers pulled together to overcome these difficult circumstances and produced some outstanding results.

"The potential global impact of this research highlights how some of the world's biggest problems actually need to be tackled at the nanoscale"

AIBN researchers are tackling the global challenge of COVID-19 through multiple avenues, including developing rapid diagnostics and surface coatings to prevent the spread of the virus. The Institute's specialist biomanufacturing capabilities also played a central role in the development of UQ's COVID-19 vaccine candidate, allowing the UQ vaccine team to produce a lead candidate within weeks and then work with partners to produce clinical grade vaccines for pre-clinical and early clinical trials.

While the vaccine candidate ultimately did not proceed to further trials, the underlying technology platform proved it was up to the task of rapid production, and the team will continue to develop this technology for future vaccines.

The potential global impact of this research highlights how some of the world's biggest problems actually need to be tackled at the nanoscale. It is only by investigating at the nanoscale that we have an opportunity to address all sorts of challenges – including the detection of viruses, the triggering of immune responses, cleaning up pollutants or overcoming barriers to sustainable energy.

Despite the many challenges and disruptions of 2020, AIBN researchers continued to make advances towards solving these problems, and many more.

AIBN researchers are contributing to improvements in human health by improving the design of medical diagnostics and treatments, and the development of high-quality vaccines at advanced speed.

AIBN knowledge leaders are also seeking to develop sustainable solutions for our society by progressing cutting-edge innovations in advanced materials, and energy production and storage.

Examples include projects that involve turning sugarcane waste into packaging; breakthroughs in solar cell efficiency; and the design of hydrogen-powered fuel cells.

I'd like to extend my thanks to everyone who contributed to AIBN's success in 2020, including our staff, students, alumni, industry partners, the Board, the Scientific Advisory Committee and philanthropists. It is my pleasure to introduce this 2020 annual report.

Professor Deborah Terry

Vice-Chancellor and President
The University of Queensland

Message from the Director

When 2020 began, little did we know just how much the world was about to change. But while the year was indeed one of grief and worry, it was also one of extraordinary effort.

There were already so many reasons I am proud to be at the helm of AIBN, but the ingenuity, perseverance and camaraderie I have witnessed at our institute this year has surpassed my greatest expectations.

Facing enormous time pressure, researchers worked at AIBN around the clock developing a rapid production pipeline for an entirely new type of vaccine to target an entirely novel virus spreading rapidly in real time. This was bioengineering design and roll-out at an unprecedented speed, and — let me be very clear — it was successful. Production of clinical grade vaccine was optimised and scaled-up so that pre-clinical and clinical trials were able to quickly get underway.

Although the current version of the vaccine will not proceed to further trials – a gut-wrenching outcome for all those from the School of Chemistry and Molecular Biosciences and AIBN who poured their hearts and souls into this endeavour – we know that this is precisely how science works. And, thanks to this year's remarkable endeavours, we now have compelling evidence of the safety and efficacy of the UQ vaccine platform. We know that it can be rapidly mass-produced to exacting standards. The importance of this critical groundwork to our ability to combat future epidemics and pandemics cannot be overstated.

Throughout the year, despite the substantial logistical challenges imposed by lockdown, our scientists pressed on and continued to make discoveries and developments in many different areas.

Our researchers are continuing to learn how nanomaterials interact with our biology, and are using that knowledge to design nanoparticles that can carry medicines and imaging agents to diseased cells and tissues – such as tumours – while leaving healthy tissues alone. Our scientists are also designing nanostructures that can give vaccines better stability, a bigger boost and fewer side-effects.

Meanwhile, continued advances in stem cell research at AIBN are setting us on the path to a better understanding of how healthy tissues grow and function, and how diseases disrupt these processes. Such work will be critical for the identification of new therapeutic targets, the development of new medicines, as well as the optimisation and repurposing of existing medicines. This work is also informing new ways to promote tissue growth to aid in organ repair.

In order to treat a disease, clinicians must first be able to diagnose it. AIBN is already home to some of the most compelling new diagnostic nanotechnology in the world, and this year, our researchers quickly pivoted their research programs to design new diagnostic technologies for virus detection. The result is a suite of technologies that are incredibly swift, sensitive and accurate, as well as inexpensive and easy to use. Technologies progressed this year could help detect infectious viruses as well as a raft of other diseases including cancer, with more than one technology also potentially able to monitor the safety and efficacy of cancer treatments in addition to detection.

AIBN research is also playing an important role in setting us on the path toward a more sustainable future, one with cleaner energy sources, better power storage systems, smarter materials, and fewer pollutants. Indeed, our scientists have continued to make substantial in-roads in turning green waste into sustainable packaging, improving the efficiency of solar cells via the use of tiny nanoparticles called 'quantum dots' and designing of high-performance large energy storage devices, called supercapacitors. Such advances are not only crucial in their own right, but will also facilitate a sustainable long-term economic recovery.

Our researchers won accolades at a national and international level for their leadership, and excellence in research and teaching. We were awarded competitive fellowships and grants, and continue to be published in some of the world's top-ranking journals. This is a remarkable effort in the current funding environment. In fact, a new analysis of research income across The University of Queensland shows that AIBN has the highest average research income per academic staff member, a testament to our lean, efficient operations.

In addition to our research efforts, we continued to engage with the broader community through both in-person and virtual events. We also hosted a number of VIP guests during the year, including the Prime Minister of Australia, Premier of Queensland and the Chief Scientist of Australia.

We focused on our people through initiatives in career development, LGBTQIA+ and mental health support, which were particularly important in a challenging year. There are no doubt new challenges and opportunities in store for us in the year ahead, but 2020 has shown us that we can rise to the occasion and help create a better world. I thank all at AIBN and beyond who have helped us achieve in 2020.

We look forward to continuing to share our journey with you.

Professor Alan Rowan

Director, AIBN
The University of Queensland

AIBN Board

Chair

Dr Cathy Foley AO

Dr Cathy Foley is CSIRO Chief Scientist and from 2021 will be Chief Scientist of Australia. She has made distinguished contributions to the understanding of superconducting materials and to the development of devices using superconductors for a number of applications including to detect magnetic fields and locate valuable deposits of minerals. She is also the Chair of the Australian National Fabrication Facility Victorian Node Collaboration Committee and the ARC Steel Hub Advisory Committee as well as sitting on several other committees and boards. She has made significant contributions to the scientific community as president of several scientific societies and as a member of committees such as PMSEIC giving advice to Government on scientific and technological matters. She was awarded the `Woman of the Year' by the NSW Government in 2013 and the International IEEE Award for Continuing and Significant Contributions to Applied Superconductivity 2014. In 2015 she was awarded the Clunies Ross Medal of the Australian Academy of Technological Science and Engineering and Australian Institute of Physics' Outstanding Service to Physics Award. As a leader in CSIRO, she is working to help Australia to transform to be globally competitive and sustainable by engaging with Australian researchers, government and industry to assist with the translation of research for a healthy and sustainable Australia that is also economically successful.

Professor Aidan Byrne

Professor Byrne completed a BSc and MSc degrees at the University of Auckland before commencing a PhD degree at the ANU in 1981. Following the completion of his degree at the Department of Nuclear Physics he held positions with the University of Melbourne and spent over two years in Bonn, Germany as a von Humboldt fellow. He returned to the ANU in 1989 as a Research Fellow and in 1991 commenced a joint appointment between the Department of Physics, in the Faculty of Science and the Department of Nuclear Physics, Research School of Physical Sciences and Engineering. He was Head of the Department of Physics from 2003 to 2007. His research interests involve the use of gamma-rays as probes to determine the structure of heavy nuclei and the examination of the atomic level structure of materials (especially semiconductors). He has published over 200 papers.

Professor Alan Rowan

Professor Alan Rowan was appointed director of AIBN in 2015. He has performed his research at the interface of chemistry and biology with seminal and pioneering work on processive catalysis and functional self-assembly. Professor Rowan's group developed the first truly biomimetic hydrogel, which mimics precisely the mechanical behaviour of the natural fibrous materials. This work has received considerable attention since it is the first step to truly controlling cell behaviour. This scientific breakthrough is already now being developed commercially for wound dressing, drug therapeutic and cell growth. Professor Rowan has published more than 400 peer-reviewed articles and books which were cited 12,000 times.

Ms Stephanie Jillett

Stephanie Jillett joined AIBN in 2020, having worked at the University of Queensland since 2014 as Legal Counsel and Research Partnership Manager. Prior to joining UQ, Stephanie practised as an intellectual property lawyer in Brisbane.

Ms Kathy Hirschfeld

Kathy Hirschfeld is Chair of Powerlink Queensland, and a non-executive director of Central Petroleum Ltd, Queensland Urban Utilities and Tellus Holdings Ltd. She is a former non-executive director of InterOil Corp, Transfield Services Limited, and Toxfree Solutions; and former Senator of The University of Queensland. She also sat on the board of UN Women in Australia. A chemical engineer, Ms Hirschfeld's 20-year career with BP included oil refining, logistics and exploration, located in Australia, the UK and Turkey. Her last executive role was as Managing Director of BP Bulwer Island Refinery in Brisbane, with responsibility for all aspects of the business.

Kathy was recognised by Engineers Australia in 2014 as an Honorary Fellow – the 9th woman to be so honoured. She is a Fellow of the Australian Academy of Technological Sciences and Engineering and the Institution of Chemical Engineers (UK) and a member of Chief Executive Women.

Professor Wilhelm Huck

Prof. Wilhelm T. S. Huck is a Professor of Physical Organic Chemistry. He received his PhD (promoter Prof. David Reinhoudt) in 1997 from the University of Twente. After postdoctoral research with Prof. Whitesides at Harvard University, he took up a position in the Department of Chemistry at the University of Cambridge, where he was promoted to Reader (2003) and Full Professor of Macromolecular Chemistry (2007). He became Director of the Melville Laboratory for Polymer Synthesis in 2004. In 2010 he moved to the Radboud University Nijmegen and completely changed research direction. His main interest is in understanding how life works at the molecular level and the ultimate goal of his group is to build a synthetic cell. His group focuses on the physical organic chemistry of the cell and aims to elucidate, using model systems, the influence of the special nature of the cellular environment on complex reaction networks in cells. Another important area of research is the synthesis and analysis of complex reaction networks and the incorporation of 'molecular programmes' into synthetic materials. He was elected to the Royal Netherlands Academy of Arts and Sciences (KNAW) in 2012 and elected to the Royal Society of Chemistry. He has published around 250 papers and supervised ~20 PhD students. For his work in Nijmegen he received an ERC advanced grant (2010), a VICI award (2011), and the Spinoza prize (2016).

Dr Kym Baker

Dr Kym Baker is General Manager, Pharma Services for Patheon, part of Thermo Fisher Scientific, which provides industry-leading pharma services solutions for drug development, clinical trial logistics and commercial manufacturing to customers of all sizes through the Patheon brand. Dr Baker has a strong academic and commercial background, holding a variety of positions in the biotechnology and biopharmaceutical industry for >20 years in the UK. Following Industrial sponsored post-doctoral studies at the University College of London and University of Kent working with Celltech (now UCB), GSK, British Biotech and Lonza, Kym joined the management team in Lonza,

UK holding a variety of senior positions across both development, manufacturing and quality. Returning to Australia, Dr Baker took up the GM role in Patheon. Dr Baker graduated with 1st class Honours from the first-ever intake of University of QLDs Bachelor of Applied Science Biotechnology programme then obtained her PhD from the Australian National University in Canberra based in CSIRO. Dr Baker is passionate about science education and the development of future scientific and engineering talent to help grow the Biotechnology industry in Australia through improved collaboration between industry and academia.

Mr Luke McGrath

Luke McGrath has a unique background and deep experience in investment management and strategy as well as with philanthropic management with particular expertise in medical research funding and development. He also has significant experience identifying and developing new technology businesses, fostering medical advances, delivering strategic and focused financial advice to ultra-high net worth individuals and family groups and private and public foundations on their risk framework along with their grant giving.

For investors, Luke has produced significant increases in value within their investment framework. He has been integral in the fostering and development of high-technology companies from initial funding through further development periods to listing on stock exchanges globally. He has also negotiated the sale of some of these companies to significant listed purchasers across the globe.

In medical research, Luke has helped to provide seed and development funding to some of Australia's most important medical research. Some of the areas he has been involved with include drug development, skin cancer, cerebral palsy, artificial intelligence, and big data. In the past, Luke has had trusted roles in investment management with Macquarie Bank, the Commonwealth Bank of Australia and a number of other financial services organisations. Luke also manages his own financial advisory and consultancy business.

Research highlights

Pots of gold engineered to help with early disease detection

AIBN researchers have used nanoengineered porous gold to develop biosensors that more effectively detect early signs of disease, improving patient outcomes. PhD candidate Mostafa Masud and research supervisors Professor Yusuke Yamauchi and Dr MD Shahriar Hossain have developed a cheaper, faster and ultrasensitive biosensor for point-of-care testing.

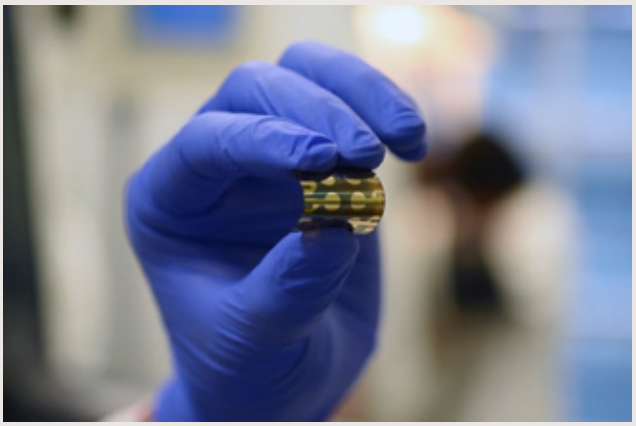
The new diagnostic technique allows for direct detection of disease-specific miRNA, which, unlike other biomarkers, is detectable at early stages of diseases such as cancer. The platform was nanoengineered by the team to read samples of blood, urine, saliva or plasma through a surface covered in a gold film, which has millions of tiny pores. The team is continuing to develop this platform, and plans for it to be available to medical practitioners in the next five years. The platform would use a small fluid sample from patients to test for diseases instantly, for around one quarter of the cost of other diagnostic techniques. It would be easy to use and particularly useful in remote locations and developing countries where rapid and early diagnostics are critical, especially in the case of viral infections.

Hendra virus battle helps researchers fight global killers

A process developed by AIBN researchers to produce larger quantities of the Hendra virus therapeutic antibody was used to produce material for a world-first human Hendra virus clinical trial. Professor Trent Munro, Director of the National Biologics Facility (NBF) based at AIBN, said his team had worked with Queensland Health, Uniformed Services University of the Health Sciences (USU) and the Henry M. Jackson Foundation for the Advancement of Military Medicine (HJF) to obtain an antibody-producing cell line and then develop an optimised process to produce the larger amounts required for human clinical use.

The therapeutic antibody, m102.4, developed by Professor Chris Broder and his team at the USU and the National Institutes of Health in the US, blocks the virus' entry to healthy human cells, enabling the immune system to fight it off. The National Biologics Facility offers a unique capability to manufacture these novel products, which would normally only be possible at great expense and long timelines within a commercial facility.

Professor Munro said that there was potential to use the antibody against another henipavirus such as the lethal Nipah virus – listed by the World Health Organisation as a priority pathogen with epidemic potential.

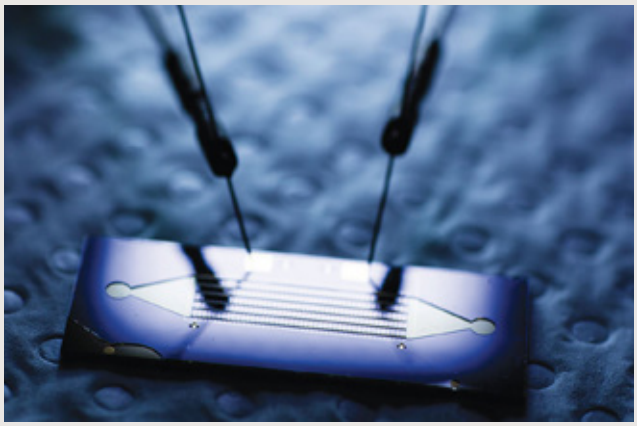


Solar technology breakthrough

UQ researchers set a world record for the conversion of solar energy to electricity via the use of tiny nanoparticles called 'quantum dots', which pass electrons between one another and generate electrical current when exposed to solar energy in a solar cell device. The development represents a significant step towards making the technology commercially-viable and supporting global renewable energy targets.

Professor Lianzhou Wang, who led the breakthrough, said conventional solar technologies use rigid, expensive materials while the new class of quantum dots are flexible and printable. This opens up a huge range of potential applications, including the possibility to use it as a transparent skin to power cars, planes, homes and wearable technology, which could eventually see the technology play a major part in meeting the United Nations' goal to increase the share of renewable energy in the global energy mix.

Professor Wang's team set the world record for quantum dot solar cell efficiency by developing a unique surface engineering strategy to deliver a near-25 per cent improvement in efficiency over the previous world record.



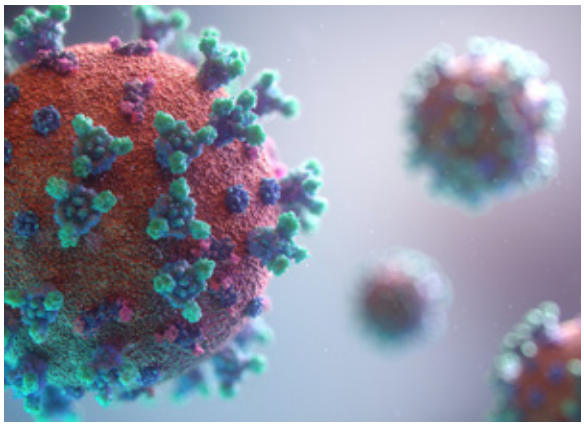
Gold nanoparticles detect signals from cancer cells

A novel blood test that uses gold nanoparticles to detect cancer has also been shown to identify signals released by cancer cells which could result in earlier diagnosis and better treatment. The nanotechnology developed by AIBN scientists can detect and monitor extracellular vesicles (EVs) in the bloodstream. Researcher Jing Wang said the discovery could lead to more effective, personalised cancer therapy by allowing oncologists to rapidly determine how treatment is progressing.

EVs are nanoparticles that are constantly emitted by healthy cells and cancer cells to enable cell-to-cell communication. AIBN researcher Dr Alain Wuethrich said cancer EVs have been difficult to distinguish from EVs emitted from healthy cells, which are more abundant in the bloodstream. The researchers used an electrically activated nano-fluidic chip that helps capture only cancer-emitted EVs, coupled with a special type of gold nanoparticle attached to antibodies that stick to molecules found only on the surface of cancer EVs. When tested on blood samples from 23 melanoma patients, the new device accurately detected cancer EVs in the blood samples, and successfully tracked how the cancer EV fingerprint changed in response to therapy for each patient.

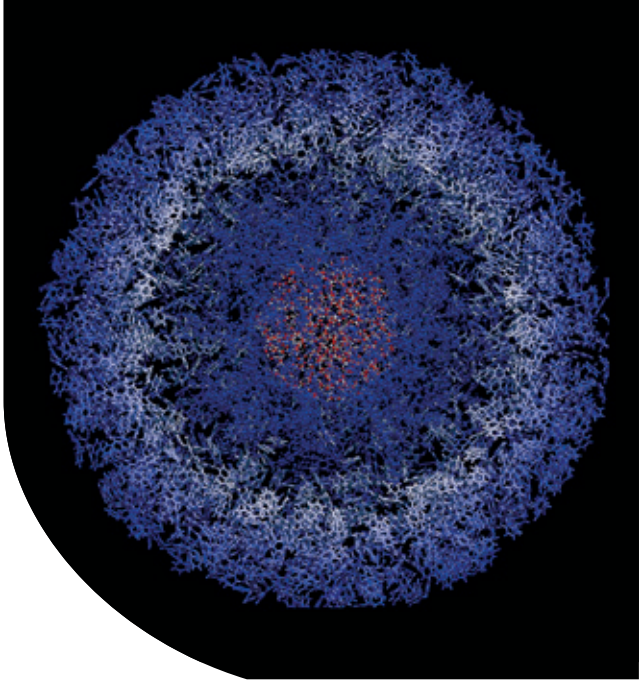
Molecular 'clamp' to halt virus

In January 2020, UQ researchers led by Professor Paul Young, Head of UQ's School of Chemistry and Molecular Biosciences (SCMB), Dr Keith Chappell from SCMB and AIBN, and Professor Trent Munro from AIBN were asked to develop a vaccine for the coronavirus outbreak at unprecedented speed, using new technology. The key to the potential vaccine's speedy development, which is occurring in AIBN laboratories, is the 'molecular clamp' technology, which provides stability to the viral protein that is the primary target for immune defence. The technology was designed as a platform approach to generate vaccines against a range of human and animal viruses and has shown promising results in the laboratory targeting viruses such as influenza, Ebola, Nipah and MERS coronavirus.



Bernhardt Group

Theoretical and Computational Chemistry



The Bernhardt Group, led by Senior Group Leader Professor Debra Bernhardt, focuses on the development of theory and computational methods to study molecular systems and their application to nanotechnology, environmental science and nonequilibrium systems. Using quantum electronic structure methods, classical and quantum molecular dynamics, statistical mechanics and dynamics systems theory they characterise the photophysical, kinetic, transport, material and catalytic properties of complex systems in targeted application areas.

The Bernhardt Group operates in a state-of-the-art computational laboratory at the AIBN.

Highlights

In 2020, Professor Bernhardt commenced her ARC Laureate Fellowship, "New frontiers for nonequilibrium systems". This project aims to develop new principles and methodologies for predicting the properties of systems that are far from equilibrium, using statistical physics and molecular simulations. Our goal is to understand, control and use the distinctive behaviour of these systems to provide capabilities for high-end technologies, such as nanofluidics and energy storage systems.

In 2020, our group and collaborators from the National Institute for Materials Science and The University of Tokyo, were awarded a Foundation of Australia-Japan Studies project grant entitled "Improving Future Energy Storage Systems at the Molecular Level". This will fund the study of the charge/discharge process in supercapacitors. We aim to use electrodes of nanoarchitectured porous carbon to design more efficient electrode materials, and produce advanced energy storage technologies for use in electric vehicles and household energy storage.

This year we have made discoveries related to materials for clean energy and advanced electronics applications. For example, solid-state electrolytes used in solid-state batteries are attractive for safety and structural reasons but have low ionic conductivity. Small changes in their structure can affect conductivity, so we continue to focus on reliably calculating their conductivity to identify ideal structural properties for optimal conductivity.

Key Publications

Demir B, Chan K-Y, Searles DJ. (2020) Structural electrolytes based on epoxy resins and ionic liquids: A molecular-level investigation. *Macromolecules* 53, 7635–7649.

Bu S, Yao N, Hunter MA, Searles DJ, Yuan Q. (2020) Design of two-dimensional carbon-nitride structures by tuning the nitrogen concentration. *npj Computational Materials* 6, 128.

Debnath S, Phan C, Searles DJ, Hankel M. (2020) Graphdiyne and hydrogen-substituted graphdiyne as potential cathode materials for high-capacity aluminum-ion batteries. *ACS Applied Energy Materials* 3, 7404–7415.

Baktash A, Reid JC, Roman T, Searles DJ. (2020) Diffusion of lithium ions in lithium-argyrodite solid-state electrolytes. *npj Computational Materials* 6, 162.

Radchenko AV, Chabane H, Demir B, Searles DJ, Duchet-Rumeau J, Gérard J-F, Baudoux J, Livi S. (2020) New epoxy thermosets derived from a bisimidazolium ionic liquid monomer: An experimental and modeling investigation. *ACS Sustainable Chemistry & Engineering* 8, 12208–12221.

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Blakey Group

Polymer Chemistry

The Blakey Group, led by Group Leader Associate Professor Idriss Blakey, focuses on understanding the relationships between the structure of materials and their performance in applications such as nanomedicine and nanofabrication.

Highlights

This year we were awarded ARC Discovery Project funding (2020–2023) for a project entitled "Programming anisotropy into responsive soft materials". The chief investigators on this project are Professor Jason Stokes, Associate Professor Idriss Blakey, Associate Professor Kevin Jack and Professor Elliot Gilbert. The project will focus on modifying the surface properties of nanocellulose, a naturally derived material, with the specific aim of tailoring its phase behaviour and physical properties. Applications of the resulting materials will range from regenerative medicine and sensing technology to functional foods.

Recent advances in the group's research include introducing a novel method for the assembly of plasmonic particles that can control optical properties, and help develop optically-based sensors. We have also had exciting results using polymer-coated nanoparticles that exhibit ultra-low friction and show great promise as lubrication additives, which could improve the energy efficiency of vehicles.

Key Publications

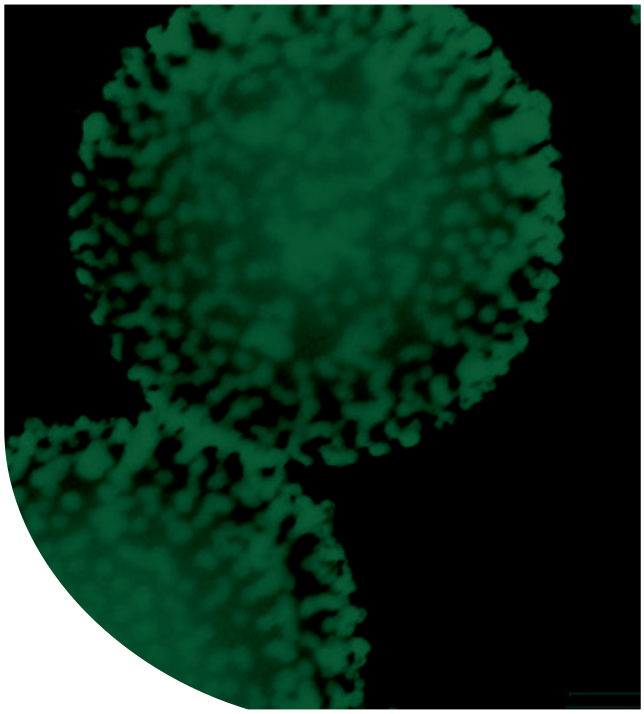
Dey P, Blakey I, Stone N. (2020) Diagnostic prospects and preclinical development of optical technologies using gold nanostructure contrast agents to boost endogenous tissue contrast. *Chemical Science* 11, 8671–8685. (Front Cover)

Dey P, Thurecht KJ, Fredericks PM, Blakey I. (2020) Stepwise like supramolecular polymerization of plasmonic nanoparticle building blocks through complementary interactions. *Macromolecules* 53, 7469–7478.

Beheshti A Y, Huang Y, Ohno K, Blakey I, Stokes JR. (2019) Improving tribological properties of oil-based lubricants using hybrid colloidal additives. *Tribology International* 144, 106130–106141.

Chambers LC, Huang Y, Jack KS, Blakey I. (2019) Spatial control of the topography of photo-sensitive block copolymer thin films. *Polymer Chemistry* 10, 3135–3145.

Dey P, Thurecht KJ, Fredericks PM, Blakey I. (2019) Tagged Core-Satellite Nanoassemblies: Role of assembling sequence on surface-enhanced Raman scattering (SERS) Performance. *Applied Spectroscopy* 73, 1428–1435.



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Davis Group

Precision Medicine

The Davis Group, led by Senior Group Leader Professor Thomas Davis, is focused on polymerisation kinetics, nanostructured films, nanoparticles, protein conjugates, nanoparticle enhanced bio-imaging, gene delivery and targeted therapeutics.

Highlights

A new approach to nanomedicine targeting endosomal signalling, PCT WO/084471, licensed to Takeda Pharmaceuticals – Nanoparticle Encapsulation To Target G Protein-coupled Receptors In Endosomes.

In 2020, we secured two NHMRC Investigator awards (to both TPD and Ruirui Qiao). ARC Linkage grant (to TPD). Funding to establish a biomaterials international joint laboratory of Jilin province (TPD and Ruirui Qiao).

Key Publications

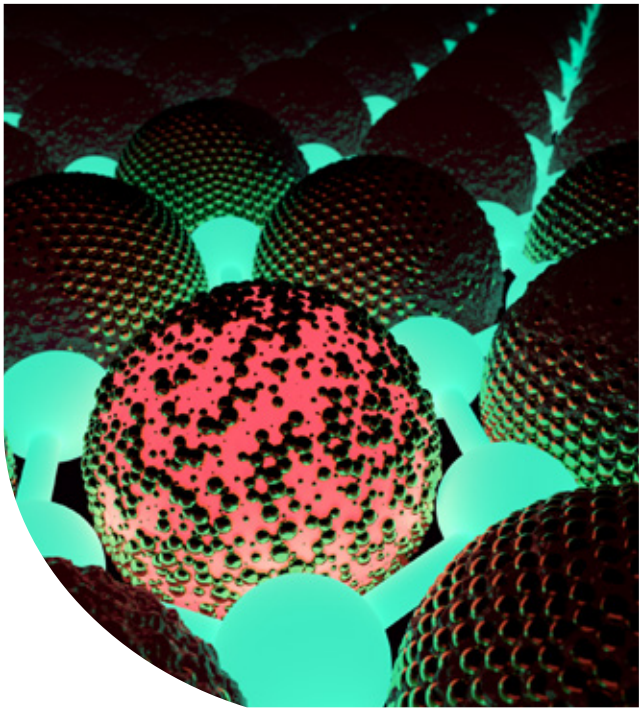
Ke PC, Zhou R, Serpell LC, Riek R, Knowles TPJ, Lashuel HA, Gazit E, Hamley IW, Davis TP, Otzen DE, Chapman MR, Dobson CM, Eisenberg DS, Mezzenga R. (2020) Half a century of amyloids: Past, present and future. Chemical Society Reviews 49, 5473–5509.

Javed I, Zhang Z, Adamcik J, Fulcher AJ, Otzen DE, Davis TP, Lin S, Mezzenga R, Ding F, Ke PC. (2020) Accelerated amyloid beta pathogenesis by gut bacterial amyloid protein FapC. Advanced Science 7, 2001299.

Ke PC, Pilkington EH, Sun Y, Javed I, Käkinen A, Peng G, Ding F, Davis TP. (2020) Mitigation of amyloidosis with nanomaterials. Advanced Materials 32, 1901690.

Goos JACM, Dilling TR, Davydova M, Cho A, Puttick S, Gupta A, Price WS, Quinn JF, Whittaker MR, Lewis JS, Davis TP. (2020) Delivery of polymeric nanostars for molecular imaging and endoradiotherapy through the enhanced permeability and retention effect. Theranostics 10, 567–584.

Qiao R, Fu C, Li Y, Ni D, Wu T, Zhong J, Tang S-Y, Xin F, Pan S, Zhang C, Whittaker MR, Whittaker AK, Davis TP. (2020) Sulfoxide-containing polymer-coated nanoparticles demonstrate minimal protein fouling and improved blood circulation. Advanced Science 7, 2000406.



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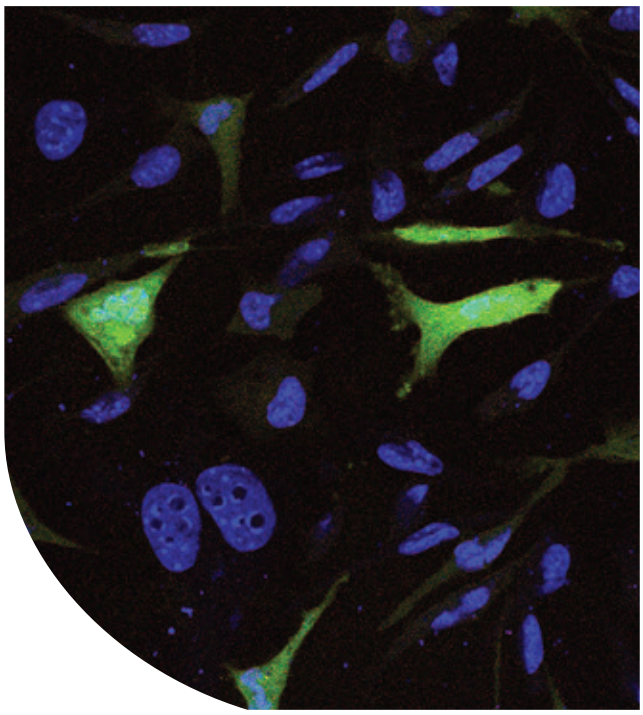
Mahler Group

Research and development of biologic medicines

The Mahler Group, led by Senior Group Leader Professor Stephen Mahler, works in biopharmaceutical discovery and development, principally researching biologic medicines and antibody-targeted nanomedicines for the treatment of human disease.

The Group's research focuses on the discovery of new therapeutic proteins, as well as the development of drug delivery platforms to precisely target cancer cells.

Professor Mahler is the Director of the ARC Industrial Transformation Training Centre for Biopharmaceutical Innovation (CBI).



Key Publications

Playford EG, Munro T, Mahler SM, Elliott S, Gerometta M, Hoger KL, Jone, ML, Griffin P, Lynch KD, Carroll H, El Saadi D, Gilmour ME, Hughes B, Hughes K, Huang E, de Bakker C, Klein R, Scher MG, Smith IL, Wang L-F, Lambert SB, Dimitrov DM, Gray PP, Broder CC. (2020) Safety, tolerability, pharmacokinetics, and immunogenicity of a human monoclonal antibody targeting the G glycoprotein of henipaviruses in healthy adults: A first-in-human, randomised, controlled, phase 1 study. *The Lancet Infectious Diseases* 20, 445–454.

Henry MN, MacDonald MA, Orellana CA, Gray PP, Gillard M, Baker K, Nielsen LK, Marcellin E, Mahler S, Martinez VS. (2020) Attenuating apoptosis in Chinese hamster ovary cells for improved biopharmaceutical production. *Biotechnology and Bioengineering* 117, 1187–1203.

Houston ZH, Bunt J, Chen K-S, Puttick S, Howard CB, Fletcher NL, Fuchs AV, Cui J, Ju Y, Cowin G, Song X, Boyd AW, Mahler SM, Richards LJ, Caruso F, Thurecht KJ. (2020) Understanding the uptake of nanomedicines at different stages of brain cancer using a modular nanocarrier platform and precision bispecific antibodies. *ACS Central Science* 6, 727–738.

Sivaram AJ, Wardiana A, Alcantara S, Sonderegger SE, Fletcher NL, Houston ZH, Howard CB, Mahler SM, Alexander C, Kent SJ, Bell CA, Thurecht KJ. (2020) Controlling the biological fate of micellar nanoparticles: Balancing stealth and targeting. *ACS Nano* 14, 13739–13753.

Niamsuphap S, Fercher C, Kumble S, Huda P, Mahler SM, Howard CB. (2020) Targeting the undruggable: Emerging technologies in antibody delivery against intracellular targets. *Expert Opinion on Drug Delivery* 17, 1189–1211.

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Highlights

CBI has 16 PhD students and five postdoctoral scientists, and engages in research under three thematic areas, including the discovery of new biologics, cells as factories for biologics production and advanced biomanufacturing.

In 2020, there have been several exciting research outcomes emanating from CBI researchers, including:

- discovery of new monoclonal antibodies against diagnostic and therapeutic targets
- development of novel drug delivery systems
- computational modelling of targets
- cell engineering for enhanced protein production
- optimisation of bioreactor operation for biologics production
- development of downstream processes based on continuous chromatography
- evaluation of process simulation as a decisional tool for biopharmaceutical contract manufacturing development.

This research, in collaboration with Australian industry leaders, continues to contribute to the transformation of the industry, and is making a significant contribution to the growth of the Australian Medical Technologies and Pharmaceutical (MTP) sector.

CBI, together with funding from the federal government growth centre MTP Connect, has also developed a Continuing Professional Development program called the National Biologics Training Program (NBTP). The NBTP covers many aspects of Biologics R&D, advanced biomanufacturing and regulatory issues.

Mar Group

Bioinformatics methods to understand how regulatory processes go awry in human diseases

The Mar Group, led by Group Leader Associate Professor Jessica Mar, focuses on the development of bioinformatics methods to understand how regulatory processes go awry in human diseases. The Mar Group are interested in modelling how variability of gene expression contributes to regulation of the transcriptome. This interest has led them to single-cell biology, where there is a great need to develop accurate statistical approaches for data arising from single-cell sequencing. Elucidating heterogeneity and variability in gene expression in this context is important, as it can uncover new cellular subtypes or identify stochasticity in the usage of key pathways or master regulators.

The explosive availability of big data sets, coupled with the speed of advancement in sequencing technologies, have created an exciting environment for computational biology research. The Mar Group looks to modern tools in statistics, such as Bayesian methodologies and machine learning algorithms, to make sense of biology from big data.

Highlights

The Mar Group has had a tremendously productive 2020. With our team of seven people, it seems that we are starting to make real waves at AIBN! PhD student, Malindrie Dharmaratne was awarded runner-up in the AIBN's Three Minute Thesis competition in July. Malindrie also received the inaugural Australasian Genomic Technologies Association PhD top-up scholarship in October.

PhD student, Ebony Watson won second place in the poster competition at the 7th Annual Conference of the Society of Biomolecular Imaging and Informatics, with her poster describing her research on image analysis of cellular senescence in ageing.

Associate Professor Mar won the Georgina Sweet Award for Women in Quantitative Biomedical Science. She also received the Mid-Career Researcher Award from the Australian Bioinformatics and Computational Biology Society.

Research projects in the Mar Group are beginning to take off. We collaborated with researchers at the Albert Einstein College of Medicine in New York, on a study that used single-cell RNA-sequencing data to understand tumour heterogeneity in the PyMT mammary tumour model. This work was published as an abstract in Cancer Research at the 2020 American Association for Cancer Research Annual Meeting.

Key Publications

Lu T, Mar JC. (2020) Investigating transcriptome-wide sex dimorphism by multi-level analysis of single cell RNA-sequencing data in ten mouse cell types. *Biology of Sex Differences* 11, 61.

Kulkarni A, Peck BD, Walton RG, Kern PA, Mar JC, Windham ST, Bamman MM, Barzilai N, Peterson CA. (2020) Metformin alters skeletal muscle transcriptome adaptations to resistance training in older adults. *Aging* 12, 19852–19866.

Piqué DG, Greally JM, Mar JC. (2020) Identification of a novel subgroup of endometrial cancer patients with loss of thyroid hormone receptor beta expression and improved survival. *BMC Cancer* 20, 857.

Piqué DG, Montagna C, Greally JM, Mar JC. (2019) A novel approach to modelling transcriptional heterogeneity identifies the oncogene candidate CBX2 in invasive breast carcinoma. *British Journal of Cancer* 120, 746.

Mar JC. (2019) The rise of the distributions: Why non-normality is important for understanding the transcriptome and beyond. *Biophysical Reviews* 11, 89–94.

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Marcellin Group

Systems metabolic engineering for industrial biotechnology

The Marcellin Group, led by Group Leader Dr Esteban Marcellin, is dedicated to developing systems metabolic engineering toolboxes, with the goal of better understanding biological cells to enhance the production of fuels, chemicals and biopharmaceuticals. Systems metabolic engineering incorporates the concepts and techniques of systems biology, synthetic biology and bioprocess optimisation, offering a framework to modify pathways and bioprocesses for the optimal bioproduction of desired products.

It is possible to characterise cells at the molecular level to efficiently manufacture natural and non-natural bioproducts through multi-omics data integration using computational models. The Group's research aims to integrate multi-omics data to accelerate the design of cells into efficient biological factories.

The Group has recently established a state-of-the-art gas fermentation facility, unique in Australia, which enables fermenting methane and syngas in instrumented fermenters.

The explosive availability of big data sets, coupled with the speed of advancement in sequencing technologies, have created an exciting environment for computational biology research.

Highlights

This year, the Marcellin group continued using biological systems as 'supercatalysts' to recycle carbon. Using microbial systems, it is possible to convert greenhouse gases, such as CO2, into liquid fuels and chemicals. While many technologies exist for carbon capturing, biological solutions have a big advantage, as waste gases do not require extensive cleaning before being fed into bacterial systems. Also this year, part of our work on gas-consuming microrganisms, was published in the prestigious journal Proceedings of the National Academy of Sciences.

Also in 2020, our Group was successful in securing a Linkage Grant with BondiBio to convert CO2 into flavours and fragrances using cyanobacteria.

We have continued working within the ARC Training Centre for Biopharmaceutical Innovation (CBI) on developing bioprocesses for culturing Chinese Hamster Ovary cells at high cell densities for producing biologics.

In other exciting developments, we are now part of the new ARC Centre of Excellence in Synthetic Biology based at Macquarie University in New South Wales. At the Centre, new systems metabolic engineering approaches will be used to engineer biological systems to produce useful chemicals and fuels from waste resources.

Key Publications

Mahamkali V, Valgepea K, de Souza Pinto Lemgruber R, Plan M, Tappel R, Köpke M, Simpson SD, Nielsen LK, Marcellin E. (2020) Redox controls metabolic robustness in the gas-fermenting acetogen Clostridium autoethanogenum. Proceedings of the National *Academy of Sciences* 117, 13168–13175.

Heffernan JK, Valgepea K, de Souza Pinto Lemgruber R, Casini I, Plan M, Tappel R, Simpson SD, Köpke M, Nielsen LK, Marcellin E. (2020) Enhancing CO2-Valorization Using Clostridium autoethanogenum for Sustainable Fuel and Chemicals Production. *Frontiers in Bioengineering and Biotechnology* 8.

Orellana CA, Martínez VS, MacDonald MA, Henry MN, Gillard M, Gray PP, Nielsen LK, Mahler S, Marcellin E. (2020) 'Omics driven discoveries of gene targets for apoptosis attenuation in CHO cells. *Biotechnology and Bioengineering* DOI:10.1002/bit.27548.

Reis ALM, Deveson IW, Wong T, Madala BS, Barker C, Blackburn J, Marcellin E, Mercer TR. (2020) A universal and independent synthetic DNA ladder for the quantitative measurement of genomic features. *Nature Communications* 11, 3609.

de Souza Pinto Lemgruber R, Valgepea K, Tappel R, Behrendorff JB, Palfreyman RW, Plan M, Hodson MP, Simpson SD, Nielsen LK, Köpke M, Marcellin E. (2019) Systems-level engineering and characterisation of Clostridium autoethanogenum through heterologous production of poly-3-hydroxybutyrate (PHB). *Metabolic Engineering* 53, 14–23.

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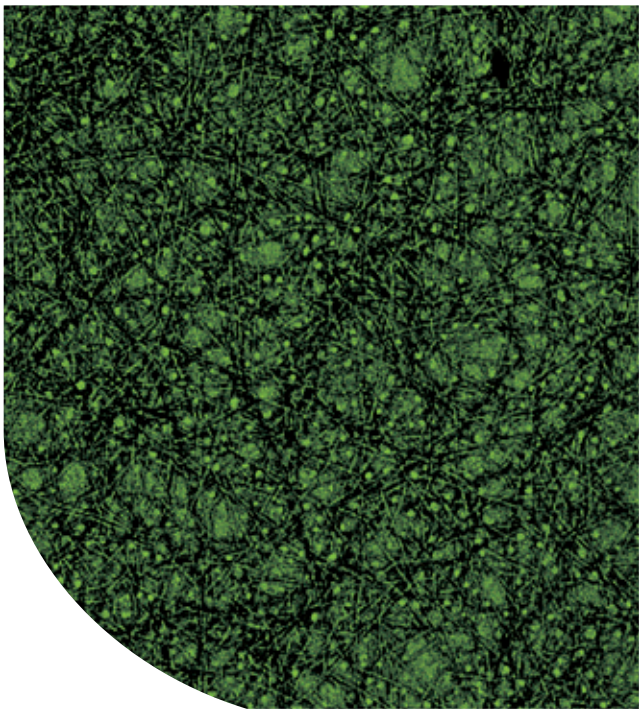
Martin Group

Polymer nanocomposites and nanotoxicology

The Martin Group, led by Senior Group Leader Professor Darren Martin, is investigating ways to replace or improve everyday materials such as plastics, rubbers, packaging, insulation foams and carbon – many of which are unsustainably sourced from petrochemical-derived materials with sustainable alternatives or additives. The Group is also seeking to enhance the mechanical properties and performance of these new materials technologies compared to existing products.



Key Publications

Nanjundan, A., Gaddam, R., Farokh Niaei, A., Annamalai, P., Dubal, D., & Martin, D. et al. (2020). Cover Feature: Potassium-Ion Storage in Cellulose-Derived Hard Carbon: The Role of Functional Groups (Batteries & Supercaps 9/2020). *Batteries & Supercaps*, 3(9), 791-791.

Pennells, J., Godwin, I., Amiralian, N., & Martin, D. (2019). Trends in the production of cellulose nanofibers from non-wood sources. *Cellulose*, 27(2), 575-593.

Kępa, K., Chaléat, C., Amiralian, N., Batchelor, W., Grøndahl, L., & Martin, D. (2019). Evaluation of properties and specific energy consumption of spinifex-derived lignocellulose fibers produced using different mechanical processes. *Cellulose, 26*(11), 6555-6569.

Humphry, J., Yang, N., Vandi, L., Hernandez, B., Martin, D., & Heitzmann, M. (2020). Isothermal differential scanning calorimetry analysis of the anionic polymerisation of polyamide-6: Separation by dual asymmetric gaussians. M*aterials Today Communications*, 25, 101473.

Highlights

The Spinifex cellulose nanofiber (CNF) project has been our major initiative over the last 12 months. With support from the Dugalunji Aboriginal Corporation and UQ Vice-Chancellor's Strategic Funding, the objectives have been to progress the underpinning science, while converting opportunities into the next phases of translation and commercial outcomes. Excellent progress with essential standard operating procedures and quality systems at the Long Pocket Nanocellulose Pilot Plant has enabled the consistent kilogram-scale production of several grades of nanocellulose, which have been supplied for various commercial customer trials. Our unique ability to control CNF cellulose I, hemicellulose and lignin composition gives us a differentiated and more "tuneable" product compared to our competitors, who use majority wood-based CNF.

2020 has also been a successful year for awards in our group. We were presented with the following awards:

- Darren Martin 2020 UTS Chancellor's Award
- Darren Martin 2020 UTS Alumni Award for Excellence – Faculty of Science
- Darren Martin 2020 election to the Fellowship of the Australian Academy of Technology & Engineering (ATSE)
- UQ PIREA 2019 (2nd PIREA, adding to 2016, for the UQ/UniQuest/DAC partnership).

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Monteiro Group

Polymer synthesis, characterisation and applications

The Monteiro Group, led by Senior Group Leader Professor Michael Monteiro, takes a holistic approach towards polymer chemistry, to understand the fundamentals of kinetics and thermodynamics of polymers for creating complex polymer architectures that can be custom designed to suit specific applications.

Taking their work on complex structures further, the Group studies emulsion polymerisation to make nanoparticles outside of the traditional spherical shape. Recent advances have enabled the creation of a range of shapes from loops, rods, worms, vesicles, and now, a bicompartmentalised tadpole nanostructure.

Professor Monteiro has a joint appointment with SCMB.

Highlights

This year we have been focusing on the synthesis of polymer constructs demonstrated to enhance the expansion stem cells and other cells. We have been looking at the use of these polymer constructs to develop organoids. We have also been investigating the application of polymer nanostructures and architectures to bioapplications.

The group's research contributions have been making an impact on the synthesis of complex polymer architectures (e.g. dendrimers), synthesis and mechanisms in polymerisations, synthesis of polymer nanostructures in water, and the use of such polymers in bioapplications (e.g. stem cells, drug and vaccine delivery, and antiviral surfaces).

We have pioneered new polymerisation processes, including (i) the temperature-directed morphology transformation method to prepare a wide range of nanostructures including rods, worms, nanorattles, tadpoles and, vesicles; and (ii) new methods and insights into 'living' radical polymerisation (SET-LRP, RAFT and new nitroxide 'click' coupling reactions). In recent years, we have successfully used designer nanostructures for the expansion of pluripotent and neural stem cells.

Key Publications

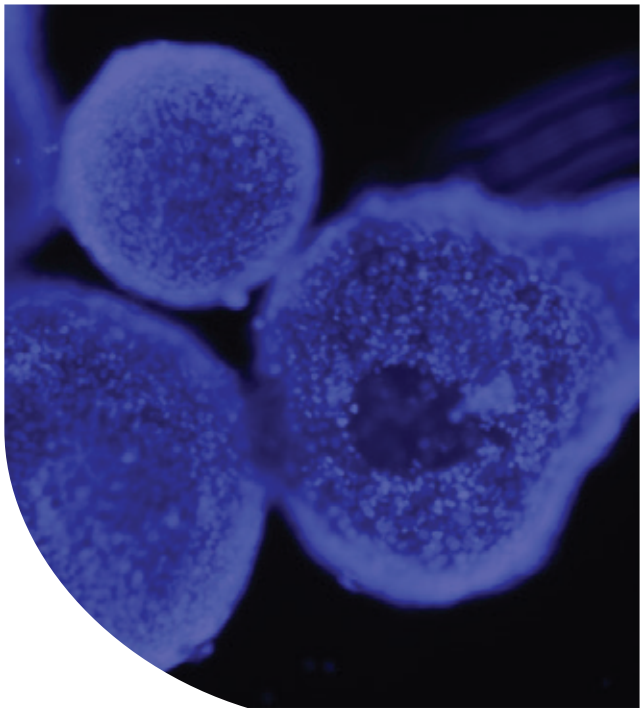
Holerca MN, Peterca M, Partridge BE, Xiao Q, Lligadas G, Monteiro MJ, Percec V. (2020) Monodisperse macromolecules by self-interrupted living polymerization. Journal of the *American Chemical Society* 142, 15265–15270.

Bobrin VA, Lin Y, He J, Qi Y, Gu W, Monteiro MJ. (2020) Therapeutic delivery of polymeric tadpole nanostructures with high selectivity to triple negative breast cancer cells. *Biomacromolecules* 21, 4457–4468.

Grandes Reyes CF, Chen S-PR, Bobrin VA, Jia Z, Monteiro MJ. (2020) Temperature-induced formation of uniform polymer nanocubes directly in water. *Biomacromolecules* 21, 1700–1708.

Chen S-PR, Jia Z, Bobrin VA, Monteiro MJ. (2020) UV-Cross-Linked Polymer Nanostructures with preserved asymmetry and surface functionality. *Biomacromolecules* 21, 133–142.

Monteiro MJ, Sherman SE, Percec V. (2020) Precise and accelerated polymer synthesis via mixed-ligand and mixed-RAFT agents. *Chem 6*, 1203–1204.



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Munro Group

Biologics, vaccines, COVID19

The Munro Group, led by Senior Group Leader Professor Trent Munro, is focused on the development, engineering and production of complex therapeutics using biological systems. This includes engineering mammalian cells to improve their efficiency and utility in the production of complex proteins, with a focus on biopharmaceuticals. Professor Munro leads the National Biologics Facility (NBF), and has established a research program in the development of therapeutics and vaccines.

Key Publications

Pregelj L, Hine DC, Oyola-Lozada MG, Munro TP. (2020) Working hard or hardly working? Regulatory bottlenecks in developing a COVID-19 vaccine. *Trends in Biotechnology* 38, 943–947.

Playford EG, Munro T, Mahler SM, Elliott S, Gerometta M, Hoger KL, Jones ML, Griffin P, Lynch KD, Carroll H, El Saadi D, Gilmour ME, Hughes B, Hughes K, Huang E, de Bakker C, Klein R, Scher MG, Smith IL, Wang LF, Lambert SB, Dimitrov DS, Gray PP, Broder CC. (2020) Safety, tolerability, pharmacokinetics, and immunogenicity of a human monoclonal antibody targeting the G glycoprotein of henipaviruses in healthy adults: A first-in-human, randomised, controlled, phase 1 study. *The Lancet Infectious Diseases* 4, 445–454.

Watterson D, Wijesundara D, Modhiran N, Mordant F, Li Z, Avumegah M, McMillan C, Lackenby J, Guilfoyle K, van Amerongen G, Stittelaar K, Cheung S, Bibby S, Daleris M, Hoger K, Gillard M, Radunz E, Jones M, Hughes K,... Chappel, K. (2020) Molecular clamp stabilised Spike protein for protection against SARS-CoV-2. Advance Online Publication.

Alfaleh MA, Alsaab HO, Mahmoud AB, Alkayyal AA, Jones ML, Mahler SM, Hashem AM. (2020) Phage display derived monoclonal antibodies: From bench to bedside. *Frontiers in Immunology* 11, 1986.

Highlights

In 2020, NBF expanded and established new collaborations to take an investigational theranostic antibody into clinical evaluation for Ovarian Cancer. This included a $2 million program funded by the Medical Research Future Fund together with CSIRO, Mater Research and the Royal Brisbane Hospital. In mid-2020, we also received over $1 million for capacity expansion for COVID-19 related programs.

In another exciting development, antibody KB312 (discovered by Dr Martina Jones, Professor Stephen Mahler and Professor Munro) progressed to commercialisation, and intellectual property was passed to Kira Biotech. KB312, which targets difficult-to-treat immune disorders like rheumatoid arthritis, without the negative impacts of immunosuppression, will progress to clinical trials in 2021 after securing $20 million in Series A funding.

Our group played a central role in UQ's COVID-19 vaccine program, developing strategies for manufacturing and commercial partnerships, which were key to clinical progression and vaccine development. We secured over $25 million to enable the first human dosing only five months after selecting the lead vaccine candidate. Although the Phase 1 trial showed that the vaccine elicited a robust response to the virus and had a strong safety profile, it also generated antibodies that would have interfered with certain HIV tests. Given the time imperative of rolling out a COVID-19 vaccine, development did not proceed further. However, the underlying technology has been proven sound and will continue to be a platform for the development of future vaccines.

Our group continues to play important roles in Australian Biosecurity, manufacturing an anti-Hendra antibody for high-risk virus exposure, as emergency use prophylaxis. We published the first human trials of this antibody in early 2020.

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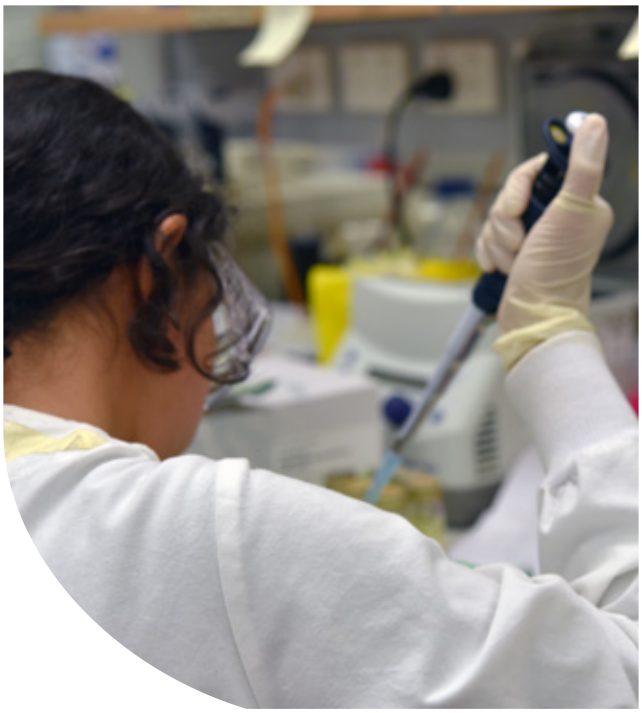
Nielsen Group

Systems and synthetic biology

The Nielsen Group, led by Senior Group Leader Professor Lars Nielsen, uses systems biology—systems science, modelling and simulation—to integrate data streams and generate knowledge. As applied systems biologists or biotechnologists, they do more than develop tools for better understanding (analysis); they use these tools to design products and processes for human benefit (synthesis). The science is moving from crude retrofitting of living systems with a single or a few genes, to using genetic engineering for purposeful reengineering of living systems—via systems and synthetic biology.

Drawing on a common core of expertise in genome-scale metabolic modelling and the full range of 'omics' technologies, the Group studies a diverse range of biological systems, including model and industrial microbes, animals cells, plants and increasingly complex ecosystems.



Highlights

2020 has been an important transition year for our group, laying the foundation for the next five years, both at UQ and at the Technical University of Denmark (DTU). At UQ, we secured an ARC Centre of Excellence in Synthetic Biology, in which Professor Nielsen heads the Systems Bioengineering program. Our support for metabolomics and proteomics, through Bioplatforms Australia, was also extended for another four years.

Professor Nielsen has been associated with the Novo Nordisk Foundation Center for Biosustainability (CFB) at DTU since 2016 through a seven-year Laureate Research Grant. As Chief Scientific Officer, he played a critical role in this years' five-year renewal of CFB with its increased focus on big data generation and analysis. He also led the successful three-year transition grant for the CFB Chinese Hamster Ovary program to establish a Danish Biologics Facility. Both entities will work closely with AIBN, the former on Data Driven Biofoundry operations and the latter on rational cell line engineering.

Key Publications

Sergeeva D, Lee GM, Nielsen LK, Grav LM. (2020) Multicopy targeted integration for accelerated development of high-producing Chinese Hamster Ovary cells. *ACS Synthetic Biology* 9, 2546–2561.

Széliová D, Ruckerbauer DE, Galleguillos SN, Petersen LB, Natter K, Hanscho M, Troyer C, Causon T, Schoeny H, Christensen HB, Lee DY, Lewis NE, Koellensperger G, Hann S, Nielsen LK, Borth N, Zanghellini J. (2020) What CHO is made of: Variations in the biomass composition of Chinese hamster ovary cell lines. *Metabolic Engineering* 61, 288–300.

Mahamkalia V, Valgepeaa K, Lemgrubera RDsP, Plan M, Tappel R, Köpke M, Simpson SD, Nielsen LK, Marcellin E. (2020) Redox controls metabolic robustness in the gas-fermenting acetogen Clostridium autoethanogenum. *Proceedings of the National Academy of Sciences USA*. 117, 13168–13175.

Lieven C, Beber ME, Olivier BG, Bergmann FT, Ataman M, Babaei P, Bartell JA, Blank LM, Chauhan S, Correia K, Diener, Dräger A, Ebert BE, Edirisinghe JN, Faria JP, Feist AM, Fengos G, Fleming RMT, García-Jiménez B, Hatzimanikatis V, van Helvoirt W, Henry CS, Hermjakob H, Herrgård MJ, Kaafarani A, Kim HU, King Z, Klamt S, Klipp E, Koehorst JJ, König M, Lakshmanan M, Lee DY, Lee SY, Lee S, Lewis NE, Liu F, Ma H, Machado D, Mahadevan R, Maia P, Mardinoglu A, Medlock GL, Monk JM, Nielsen J, Nielsen LK, Nogales J, Nookaew I, Palsson BO, Papin JA, Patil KR, Poolman M, Price ND, Resendis-Antonio O, Richelle A, Rocha I, Sánchez BJ, Schaap PJ, Malik Sheriff RS, Shoaie S, Sonnenschein N, Teusink B, Vilaça P, Vik JO, Wodke JAH, Xavier JC, Yuan Q, Zakhartsev M, Zhang C. (2020) MEMOTE for standardized genome-scale metabolic model testing. *Nature Biotechnology* 38, 272–276.

Bongers M, Perez-Gil J, Hodson MP, Schrübbers L, Wulff T, Sommer MOA, Nielsen LK, Vickers CE. (2020) Adaptation of hydroxymethylbutenyl diphosphate reductase enables volatile isoprenoid production. *eLife* 9, e48685.

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Ngo Group

Neurometabolism

The Ngo Group, led by Group Leader Dr Shyuan Ngo, is interested in understanding how metabolic homeostasis, at the systemic and cellular level, can affect neurodegenerative processes. The group works on a research program named Metabolic Exploration in Neurodegenerative Disease (MEND). MEND centres on Motor Neurone Disease (MND), which is a fatal neurological condition with an average life expectancy of 27 months. In MND, the irreversible degeneration of neurones in the central nervous system leads to progressive paralysis and eventually death. There is no effective treatment for MND, and no cure.

Key Publications

Lacoangeli A, Lin T, Al Khleifat A, Jones AR, Opie-Martin S, Shatunov A, Coleman JRI, Sproviero W, Williams KL, Garton F, Restuadi R, Henders AK, Mather KA, Needham M, Mathers M, Nicholson GA, Rowe DB, Henderson R, McCombe PA, Pamphlett R, Blair IP, Schultz D, Sachdev PS, Newhouse SJ, Fogh I, Ngo ST, Dobson RJB, Wray NR, Steyn FJ, Al-Chalabi A. (2020) Genome-wide meta-analysis finds the ACSL5-ZDHHC6 locus is associated with ALS and links weight loss with the disease genetics. *Cell Reports* 33, n 108323.

Steyn FJ, Li R, Kirk SE, Tefera TW, Xie TY, Tracey TJ, Kelk D, Wimberger E, Garton FC, Roberts L, Chapman SE, Coombes JS, Leevy WM, Ferri A, Valle C, Rene F, Loeffler J-P, McCombe PA, Henderson RD, Ngo ST. (2020) Altered skeletal muscle glucose-fatty acid flux in amyotrophic lateral sclerosis. *Brain Communications* 2, fcaa154.

Tracey TJ, Kirk SE, Steyn FJ, Ngo ST. (2020) The role of lipids in the central nervous system and their pathological implications in amyotrophic lateral sclerosis. *Seminars in Cell and Developmental Biology* S1084–9521, 30202.

Ngo ST, Restuadi R, McRae A, van Eijk RPA, Garton FC, Henderson RD, Wray NR, McCombe PA, Steyn FJ. (2020) Progression and survival of patients with motor neuron disease relative to their faecal microbiota. *Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration* doi:10.1080/21678421.2020.1772825.

Scaricamazza S, Salvatori I, Giacovazzo G, Loeffler J-P, Renè F, Rosina M, Quessada C, Proietti D, Heil C, Rossi S, Battistini S, Giannini F, Volpi N, Steyn FJ, Ngo ST, Ferraro E, Madaro L, Coccurello R, Valle C, Ferri A. (2020) Skeletal muscle metabolic reprogramming in ALS-SOD1G93A mice predates disease onset and is a promising therapeutic target. *iScience* 23, 101087.

Highlights

Throughout the year our group has continued patient-directed research at clinical sites around Brisbane; engaging with people living with MND, their families, caregivers and friends. We have been assessing body composition and metabolic rate, as well as dietary intake, appetite regulation, and gut dynamics to understand the effects of altered whole-body metabolism and human physiology on the clinical features of MND and patient outcomes.

Our ongoing research uses i) mouse models of MND, ii) human myosatellite cell-derived muscle fibres, and iii) human-induced pluripotent stem cell (iPSC)-derived neurones. Using these models, we aim to understand the mechanistic nature of MND and conduct pre-clinical testing of potential therapeutic compounds. The combined use of mouse and human-derived models is integral to our goal of translating research findings into clinical trials for MND.

This year, two members of our group received prestigious travel awards. Tesfaye Tefera received the International Brain Research Organisation international travel award to attend Neuroscience 2020, and Jeryn Chang received the BioC 2020 travel award to attend Bioconductor. Group Leader Dr Shyuan Ngo won the Motor Neurone Disease Research Australia Charcot Award in November. Also, our talented PhD student, Timothy Tracey, was conferred his PhD in November and has been accepted into the UQ Medicine program, commencing in 2021.

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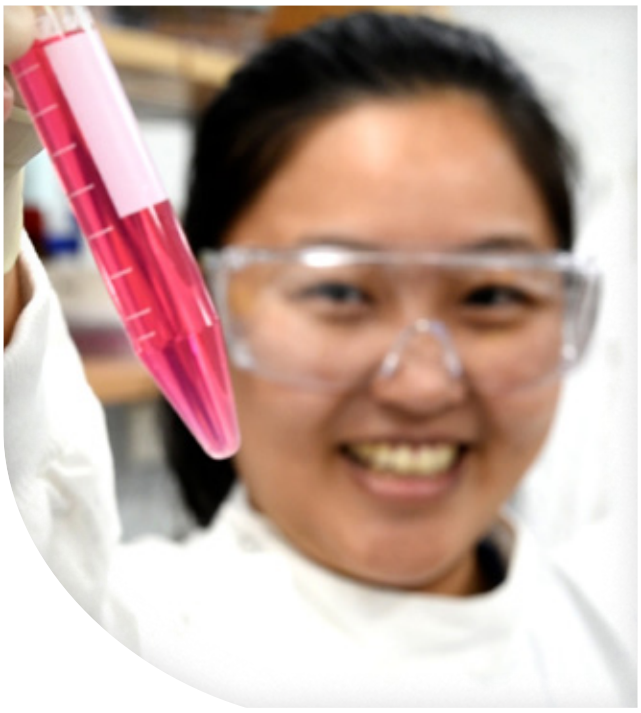
Rolfe Group

Immunology and cell biology: myeloid cells, the complement system and the innate immune response in disease processes



The Rolfe group, led by Group Leader Dr Barbara Rolfe, is investigating the role of the innate immune system in tissue engineering, wound healing and cancer. Major research interests include 1) the mechanisms by which the innate immune system influences an anti-tumour response, 2) the biomedical applications of nanomaterials and how the immune response to nanoparticles influences their fate in vivo, and 3) how this information can be translated into novel therapeutic approaches.

Key Publications

Akhir, F., Noor, M., Leong, K., Nabizadeh, J. A., Manthey, H. D., Sonderegger, S. E., Fung, J., McGirr, C. E., Shiels, I. A., Mills, P. C., Woodruff, T. M., & Rolfe, B. E. (2021). An Immunoregulatory Role for Complement Receptors in Murine Models of Breast Cancer. Antibodies (Basel, Switzerland), 10(1), 2.

Rolfe BE, Pio R, Woodruff TM, Markiewski MM, Manthey HD. (2020) Editorial: The role of complement in tumors. *Frontiers in Immunology* 11, 139.

Nabizadeh J, Manthey HM, Panagides N, Steyn F, Akhir F, Chen W, Boyle GM, Taylor SM, Woodruff TM, Rolfe BE. (2019) Complement C5a Receptors, C5aR1 and C5aR2, mediate opposing pathologies in a mouse model of melanoma. *FASEB Journal* 33, 11060–11071.

Highlights

Our group's ongoing goal is to gain a better understanding of the mechanisms by which complement proteins alter immune cell function. We are on a path to develop complement-targeting drugs as a novel immunotherapeutic approach for intransigent cancers, including melanoma, lung and brain cancer. This year we have been testing RNA-based inhibitory drugs in animal tumour models.

During 2020, research in the Rolfe Group has been directed towards determining the role of the complement system in cancer, and identifying novel therapeutic approaches for cancer treatment. We continue to use mouse models, and small peptide agonists and antagonists to investigate the role of the complement system in tumour development and growth. In exciting new developments, we have found that complement proteins promote tumour growth by suppressing effective anti-tumour immune responses. In line with this, inhibition of complement receptors limits tumour growth—primarily due to a reduction in immunosuppressive cells—and increases T cell infiltration of the tumour.

We have been working in collaboration with Professor Trent Woodruff (SBMS), Ruben Pio (University of Navarra, Spain), Andrew Barbour (School of Medicine, PAH), Lindy Jeffree (Queensland Health, RBWH), Bryan Day (QIMR), Dr Richard Clark (School of Biomedical Sciences), and Simon Puttick (CSIRO). Our research continues to be funded by NHMRC and industry grants.

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Rowan Group

Synergy of material- and bio-sciences

The Rowan Group, led by AIBN Director and ARC Laureate Fellow Professor Alan Rowan, brings together the seemingly distant disciplines of physics, material- and bio-sciences to understand the intricacies of cell behaviour and extracellular environments.

Comprised of scientists with backgrounds in cell biology, chemistry, physics and materials science, the Rowan Group tackles the fundamental biophysical questions behind cell and extracellular matrix behaviour.

With access to state-of-the-art equipment we are taking on the challenge of understanding how the material properties of extracellular matrices are translated into intracellular responses and signalling. We are focused on the synthesis of synthetic polymeric, well-defined natural and hybrid matrices and the development of methodologies to study cell-material interactions in close detail.

Highlights

Our Group continues to focus on the development of novel biomaterials and their application to physiologically relevant microenvironments for cells in 3D. The dynamic reciprocity between cells and extracellular matrix means that mechanical properties of matrices play a key role in regulating mechanotransduction and cellular responses. Therefore, we have ongoing investigations into how the biophysical features of biomaterials can regulate quintessential cellular behaviour.

This year we have been using synthetic and natural, well-defined materials with tuneable biophysical properties to investigate cellular mechanisms. Our aim is to apply the knowledge from this research to develop instructive matrices for medical translation. Our research is supported by the broad expertise of Group members, collaborations with Neutron Scattering facility (Australian Nuclear Science and Technology Organisation) and Centre for Microscopy and Microanalysis (UQ), and state-of-the-art in-house developed instruments. Some of these instruments include, a confocal–rheology setup (first to Australia), a fully custom designed Brillouin microscope (developed by Dr M. Taylor), and a microgravity simulation device (collaboration with UT Sydney).

Outstanding recognition was made this year to Dr Nasim Amiralian, who received an Advance Queensland mid-career fellowship to develop cellulose-based antimicrobial materials to fight global pandemics. Also, Group Leader Professor Rowan was elected as a fellow to the Australian Academy of Science for his broad contribution to world-leading research.

Key Publications

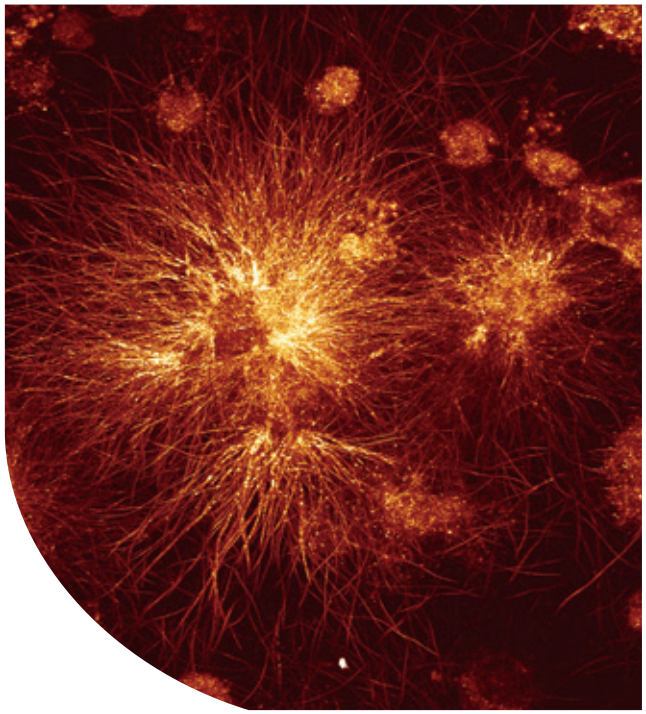
Zhang Y, Tang C, Span PN, Rowan AE, Aalders TW, Schalken JA, Adema GJ Kouwer, PHJ, Zegers MMP, Ansems M. (2020) Polyisocyanide hydrogels as a tunable platform for mammary gland organoid formation. *Advanced Science* 7, 2001797.

Yuan H, Zhan Y, Rowan AE, Xing C, Kouwer PHJ. (2020) Biomimetic networks with enhanced photodynamic antimicrobial activity from conjugated polythiophene/polyisocyanide hybrid hydrogels. *Angewandte Chemie International* Edition 59, 2720.

Bradbury P, Wu H, Choi JU, Rowan AE, Zhang H, Poole K, Lauko J, Chou J. (2020) Modeling the impact of microgravity at the cellular level: Implications for human disease. *Frontiers in Cell and Developmental Biology* 8, 96.

Liu K, Mihaila SM, Rowan A, Oosterwijk E, Kouwer PHJ. (2019) Synthetic extracellular matrices with nonlinear elasticity regulate cellular organization. *Biomacromolecules* 20, 826–834.

de Almeida P, Jaspers M, Vaessen S, Tagit O, Portale G, Rowan AE, Kouwer PHJ. (2019) Cytoskeletal stiffening in synthetic hydrogel. *Nature Communications* 10, 609.



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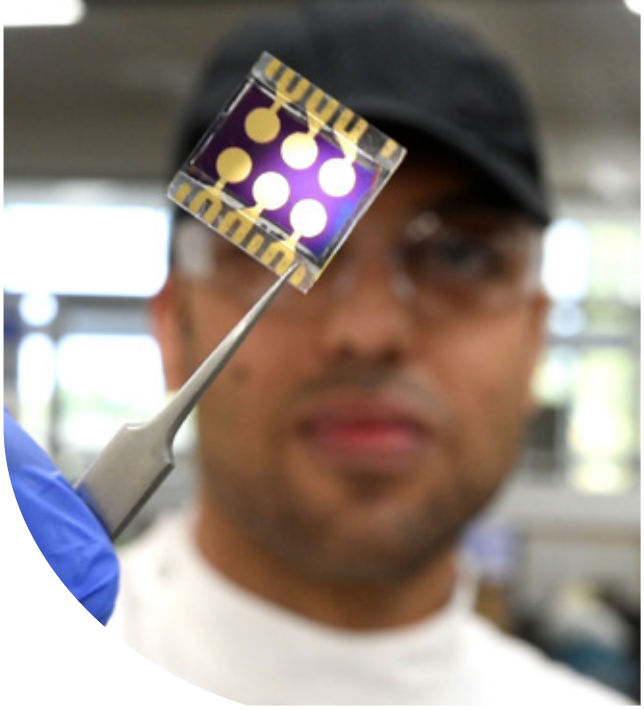
Shapter Group

Exploring ways to make novel nanomaterials and applying them in areas such as photovoltaics, catalysts or sensors



The Shapter Group, led by Senior Group Leader Professor Joe Shapter, works in the area of nanomaterials. They use various techniques to make new materials, make materials more efficiently and to combine these materials to enhance their properties. The group uses many physical techniques to examine properties of these systems, and are interested in carbon nanomaterials, phosphorene and recently, MXenes.

The Shapter Group works to incorporate nanomaterials into a variety of devices and applications. They have made solar cells with various architectures including dye-sensitised cells, carbon nanotube (CNT)-Si cells and perovskite cell. Their materials have also been used to make electrochemical sensors and electrodes for photocatalysis.

Key Publications

Corletto A, Shapter JG. (2020) Discontinuous dewetting, template-guided self-assembly, and liquid bridge-transfer printing of high-resolution single-walled carbon nanotube lines for next generation electrodes and interconnects. *ACS Applied Nano Materials* 3, 8148–8160.

Bat-Erdene M, Xu G, Batmunkh M, Bati ASR, White JJ, Nine MJ, Losic D, Chen Y, Wang Y, Ma T, Shapter JG. (2020) Surface oxidized two-dimensional antimonene nanosheets for electrochemical ammonia synthesis under ambient conditions. *Journal of Materials Chemistry* A 8, 4735–4739.

Wu C, Wang K, Batmunkh M, Bati ASR, Yang D, Jiang Y, Hou Y, Shapter JG, Priya S. (2020) Multifunctional nanostructured materials for next generation photovoltaics. *Nano Energy* 70, 104480.

Shepelin NA, Sherrell PC, Goudeli E, Skountzos EN, Lussini VC, Dicinoski GW, Shapter JG, Ellis AV. (2020) Printed recyclable and self-poled polymer piezoelectric generators through single-walled carbon nanotube templating. *Energy & Environmental Science* 13, 868–883. (Front Cover)

Bati ASR, Batmunkh M, Shapter JG. (2020) Emerging two-dimensional layered materials for perovskite solar cells. *Advanced Energy Materials* 10, 1902253.

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Highlights

Ammonia (NH_3) is one of the most produced chemical materials in the world owing to its importance in agriculture, medicine, mining and the household. NH_3 has drawn increasing attention as an energy carrier with high hydrogen density and low liquefying pressure. However, today's NH_3 production requirements are responsible for large amounts of CO_2 emission. Therefore, our lab continues its search to find alternative methods to produce NH_3 that are energy-efficient and environmentally friendly. This year, we published that few-layer antimonene nanosheets prepared using a liquid-phase exfoliation method under ambient conditions, can be an efficient N_2 reduction reaction electrocatalyst for NH_3 synthesis.

CNTs have been extensively studied and used for fabricating next-generation devices and applications. They are a leading material for developing flexible, biocompatible and cheap electronics. Cheap, high-performance electronics are critical to emerging technologies, like big data, machine learning, artificial intelligence and the Internet-of-Things, as they provide more data inputs. There are techniques that can achieve nanoscale lateral resolution, affording CNTs impressive precision and high throughput. However, these are often slow, expensive or have poor lateral resolution (>10 µm).

This year, PhD student Alex Corletto developed a template-guided, self-assembly patterning technique called discontinuous dewetting and liquid bridge transfer to successfully pattern single-walled carbon nanotubes (SWCNTs)—the first one-dimensional nanomaterials patterned using this technique. The technique efficiently and simply patterned SWCNTs with 2.5–10 µm resolution using little energy and low temperatures (≤90 °C) at a low cost. Furthermore, it is potentially compatible with roll-to-roll manufacturing.

Thurecht Group

Molecular imaging, polymer chemistry, multimodal imaging, theranostics, drug delivery

The Thurecht Group, led by Group Leader Professor Kristofer Thurecht, has a focus on the development of polymer and nanoparticle-based devices for nanomedicine. In particular, they are interested in the design, synthesis and preclinical evaluation of nanomaterials for molecular imaging and drug delivery.

For polymers to be truly effective in nanomedicine, they must incorporate new therapies while maintaining their physical and chemical integrity. This is achieved by developing a strong understanding of the fundamental properties of the nanomaterial-delivery system, while identifying and successfully delivering new therapies. Central to the development of these future therapeutic platforms is the field of theranostics, where molecular imaging plays a key role in understanding the dynamics of polymeric nanomedicines.

The Thurecht Group works across the boundaries of chemistry and materials, biology and imaging science to probe how nanomaterial properties affect their function in living animals.

Highlights

In 2020, our research led to new projects with international and national collaborators. We also filed five patents around the development of new diagnostic and therapeutic agents with partners, Clarity Pharmaceuticals and Starpharma.

We continued our drive towards establishing translational nanomedicine programs. Multiple patients have now been successfully treated with nanomedicines developed in our group. Importantly, using our group's patented bispecific antibody technology we have developed the first successful personalised nanomedicine therapy for immunocompetent animals with spontaneous and naturally-occurring cancer. Our canine study is ongoing, and a proposed first-in-human trial of the nanomedicine technology is expected to follow.

This year, we were nominated as finalists in the Australian Museum Eureka Prize for innovative use of technology. Further, Dr Craig Bell was awarded an Advance Queensland Fellowship, in collaboration with industry partner Aegros, to develop new membrane technology for separation of high value proteins. In 2020, we are also proud to report the successful graduation of four PhD students from our team.

Key Publications

Sivaram AJ, Wardiana A, Alcantara S, Sonderegger SE, Fletcher NL, Houston SH, Howard CB, Mahler SM, Alexander C, Kent SJ, Bell CA, Thurecht KJ. (2020) Controlling the biological fate of micellar nanoparticles: Balancing stealth and targeting. *ACS Nano* 14, 13739–13753.

Houston ZH, Bunt J, Chen K, Puttick S, Howard CB, Fletcher NL, Fuchs AV, Cui J, Ju Y, Cowin G, Song X, Boyd AW, Mahler SM, Richards LJ, Caruso F, Thurecht KJ. (2020) Understanding the uptake of nanomedicines at different stages of brain cancer using a modular nanocarrier platform and precision bispecific antibodies. *ACS Central Science* 6, 727–738.

Ediriweera GR, Simpson J, Fuchs AV, Venkatachalam TK, Van De Walle M, Howard CB, Mahler SM, Blinco JP, Fletcher NL, Houston ZH, Bell CA, Thurecht KJ. (2020) Targeted and modular architectural polymers employing bioorthogonal chemistry for quantitative therapeutic delivery. *Chemical Science* 11, 3268–3280.

Akhter DT, Simpson JD, Fletcher NL, Houston ZH, Fuchs AV, Bell CA, Thurecht KJ. (2020) Oral delivery of multicompartment nanomedicines for colorectal cancer therapeutics: Combining loco-regional delivery with cell-target specificity. *Advanced Therapeutics* 3, 1900171.

Daniel S, Houston Z, Fletcher NL, Bell CA, Atcheson N, Al-Najjar A, Howard C, Mahler SM, Straw R,Thurecht KJ. (2020) Canine PET-CT imaging with 64Cu Nanomedicines. *Journal of Nuclear Medicine* 61, 3128.

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Trau Group

Nanoscience, Nanotechnology, Molecular diagnostics

The Trau Group, led by Senior Group Leader Professor Matt Trau, is dedicated to developing improved point-of-care diagnostics from the benchtop to bedside, with the goal to significantly enhance patient outcomes and help transition the medical system towards early disease detection and personalised treatment.

By understanding disease processes thoroughly at a molecular level, and applying innovative nanoscience, nanotechnology, chemistry and bioengineering, the Group's research aims to enable an entirely new generation of diagnostic technology to dramatically enhance the global medical system.

Key Publications

Koo K, Mainwaring P, Tomlins S, Trau M. (2019) Merging new-age biomarkers and nanodiagnostics for precision prostate cancer management. *Nature Reviews Urology* 16, 302–317.

Wang J, Wuethrich A, Sina A, Lane R, Lin L, Wang Y, Cebon J, Behren A, Trau M. (2020) Tracking extracellular vesicle phenotypic changes enables treatment monitoring in melanoma. *Science Advances* 6, 9.

Ahmed M, Koo K, Mainwaring P, Carrascosa L, Trau M. (2020) Phosphoprotein biosensors for monitoring pathological protein structural changes. *Trends in Biotechnology* 38, 515. (Front Cover)

Li J, Wuethrich A, Dey S, Lane R, Sina A, Wang J, Wang Y, Puttick S, Koo K, Trau M. (2020) The growing impact of micro/nanomaterial-based systems in precision oncology: Translating "Multiomics" Technologies. *Advanced Functional Materials* 30, 1909306. (Front Cover)

Sina A, Lin T, Vaidyanathan R, Wang Z, Dey S, Wang J, Behren A, Wuethrich A, Carrascosa L, Trau M. (2020) Methylation dependent gold adsorption behaviour identifies cancer derived extracellular vesicular DNA. *Nanoscale Horizons* 5, 1317. (Front Cover)

Highlights

Since the COVID-19 outbreak, we have pivoted to help with the pandemic. We are leading research on (i) a simple, cheap to manufacture, programmable molecule that can report the presence of an intact and infective SARS-COV-2 virus and; (ii) a nano-scaled chip that could detect the earliest signs of dangerous adverse immune events called 'cytokine storms'.

Our success for 2020 includes the publication of a novel nanotechnology platform that enables real-time monitoring of the nanoparticles emitted by cancer cells into the blood during cancer therapy. The work received significant local and international media attention, with headlines like 'Scientists spy golden opportunity to intercept cancer cell's "emails" ', published by The Australian, Sydney Morning Herald, Perth Now and the Brisbane Times.

Also in 2020, we published a paper describing a novel approach to blood-based diagnostics for cancer patients. Together, this technology, approach and novel molecular insights have activated new avenues for research and clinical translation.

It has been an excellent year for funding in our Group. We secured an NHMRC Ideas grant, two NHMRC Emerging Leadership grants (Dr Abu Sina and Alain Wuethrich), a CSIRO R+ Fellowship (Dr Shuvashis Dey), an Industry Research Fellowship (Dr Chris Howard), and we have ongoing philanthropic support for fundamental discovery-based research from our core partners.

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Wang Group

Characterisation and application of functional nanomaterials

The Wang Group, led by Senior Group Leader and ARC Laureate Fellow Lianzhou Wang, is focused on the clean energy sector, developing new functional materials for solar energy conversion and storage systems. One of the Group's main research areas has been in semiconductor design for efficient solar hydrogen and electricity generation.

Professor Wang also has a joint appointment with the School of Chemical Engineering, in strong partnership with multiple industry partners on the development of new energy storage solutions.

Key Publications

Hao MM, Bai Y, Zeiske S, Ren L, Liu J, Yuan Y, Zarrabi N, Cheng N, Lyu M, He D, Yun J, Du Y, Wang Y, Ding S, Armin A, Meredith P, Cheng H, Wang LZ. (2020) Ligand-assisted cation exchange engineering for high-efficiency colloidal Cs1-xFAxPbI3 quantum dot solar cells with reduced phase segregation. *Nature Energy* 5, 79–88. (Front cover).

Hu YX, Pan YY, Wang ZL, Lin T, Luo B, Hu H, Fan F, Liu G, Wang LZ. (2020) Lattice distortion induced internal electric field in TiO2 photoelectrode for efficient charge separation and transfer. *Nature Communications* 11, 2129.

Xiao M, Zhang L, Luo B, Lyu MQ, Wang ZL, Huang HM, Wang SC, Du A, Wang LZ. (2020) Molten salt mediated synthesis of atomic Ni co-catalyst on TiO2 for improved photocatalytic H2 evolution. *Angewandte Chemie International Edition* 132,7297–7301.

Wang S, He T, Chen P, Du A, Ostrikov K, Huang W, Wang LZ. (2020) In situ formation of oxygen vacancies achieving near-complete charge separation in planar BiVO4 photoanodes. *Advanced Materials* 32, 2001385.

Hou J, Wang Z, Chen P, Chen V, Cheetham AK Wang LZ. (2020) Intermarriage of halide perovskites and metal-organic framework crystals. *Angewandte Chemie International Edition* 59, 19434–19449.

Highlights

In 2020, we made a major breakthrough, achieving a new certified record efficiency of 16.6 per cent for quantum dot solar cells, using a novel surface ligand engineering strategy. This record surpasses the previous world record by about 25 per cent. This was the first time in the 21st century for an Australian institution to be marked in the highly influential Best Research-Cell Efficiency Chart of the National Renewable Energy Lab. These findings provide a solid foundation for next-generation PV, lighting, and imaging technologies.

In collaboration with Australian industry partners, we are working on a major Cooperative Research Centre Project program to develop flexible printed batteries. The UQ team have developed a comprehensive understanding of the electrochemical reactions and decay mechanism of the electrodes, and have developed innovative methods to suppress detrimental side-reactions. The printed batteries have been integrated with Radio Frequency Identification and trialled in many road races recently. The new technology also represents exciting opportunities to further develop integrated solar powered–smart flexible electronics.

In another highlight, this year, Dr Bin Luo from the Wang Group was awarded a highly competitive ARC Future Fellowship to develop a new sustainable power source for future wearable electronics.

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Whittaker Group

Polymer chemistry, nanotechnology, photolithography, biomaterials science, magnetic resonance

The Whittaker Group, led by Senior Group Leader Professor Andrew Whittaker, applies synthetic methods to develop technologies for health and the modern technological society. These include, advanced next generation molecular imaging agents for disease detection, and polymers to be used in advanced lithography for the fabrication of integrated circuits.

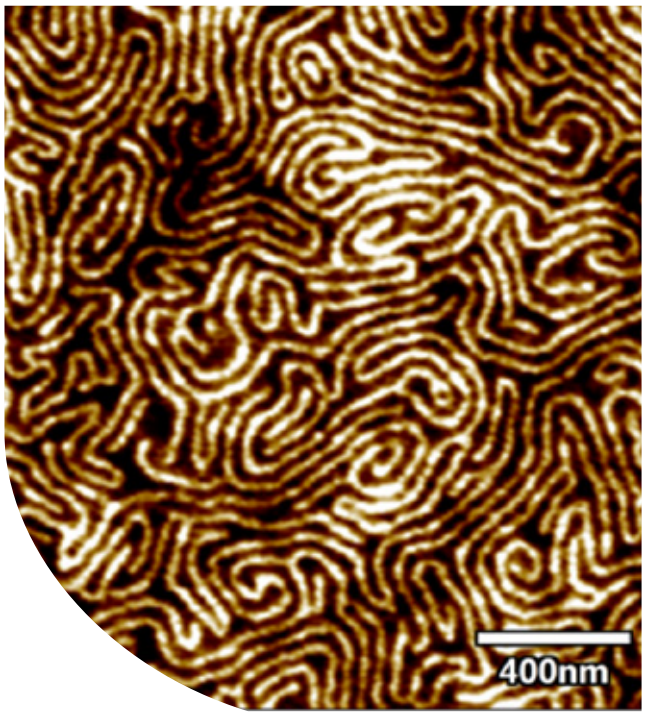
Polymer chemistry is the underpinning science of modern materials and biomaterials. The Group is building and studying new materials to solve practical problems facing society. Working with Professor Whittaker is a team of senior researchers (Idriss Blakey, Hui Peng, Dave Hill) combining experience in synthetic chemistry, physical chemistry, biomaterials science, nanomaterials science, photolithography, NMR and MRI.

Highlights

This year we have continued to build on our reputation for innovation in fluoropolymers. In 2020, we patented our perfluoropolyether technology for the removal of fluorinated organic pollutants from the environment. We published important studies on a new class of fluoropolymers capable of tracking circulating cells in vivo, introduced a novel thermo-sensitive fluoropolymer for biomedical applications, and continued to develop 19F MRI agents for disease detection.

Dr Changkui Fu was successful in his application for an NHMRC Investigator Grant in the 2020 round. Dr Fu will lead a program of work aiming to reduce biofouling on injected therapeutic molecules. The project entitled "Improving the Delivery Efficiency of Nanomedicines to Tumour Tissue" received funding of $645,205 over the next five years.

In other great news, Professor Whittaker was elected President of the Pacific Polymer Federation, an organisation representing around 100,000 polymer scientists and engineers from 16 nations adjacent to the Pacific Ocean. He will hold this position until the end of 2022.



Key Publications

Zhang C, Liu TM, Wang W, Bell CA, Han Y, Fu C, Peng H, Tan X, Kral P, Gaus K, Gooding JJ, Whittaker AK. (2020) Tuning of the aggregation behavior of fluorinated polymeric nanoparticles for improved therapeutic efficacy. *ACS Nano* 14, 7425–7434.

Zhang C, Bates MW, Geng Z, Levi AE, Vigil D, Barbon SM, Loman T, Delaney KT, Fredrickson GH, Bates CM, Whittaker AK, Hawker CJ. (2020) Rapid generation of block copolymer libraries using automated chromatographic separation. *Journal of the American Chemical Society* 142, 9843–9849.

Fu C, Yu Y, Xu X, Wang Q, Chang Y, Zhang C, Zhao J, Peng H, Whittaker AK. (2020) Functional polymers as metal-free magnetic resonance imaging contrast agents. *Progress in Polymer Science* 108, 101286.

Fu C, Demir B, Alcantara S, Kumar V, Han F, Kelly HG, Tan X, Yu Y, Xu W, Zhao J, Zhang C, Peng H, Boyer C, Woodruff TM, Kent SJ, Searles DJ, Whittaker AK. (2020) Low-fouling fluoropolymers for bioconjugation and in vivo tracking. *Angewandte Chemie International Edition* 59, 4729–4735.

Chen T, Zhao Q, Meng X, Li Y, Peng H, Whittaker AK, Zhu S. (2020) Ultrasensitive magnetic tuning of optical properties of films of cholesteric cellulose nanocrystals. *ACS Nano* 14, 9440–9448.

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Wolvetang Group

Induced pluripotent stem cells, in vitro disease models, novel regenerative medicine approaches

The Wolvetang Group, led by Senior Group Leader Professor Ernst Wolvetang, uses human stem cell models to understand and find cures for diseases that primarily affect the brain. With a focus on stem cell therapies, the group studies common disorders like Alzheimer's disease, and rarer conditions like childhood leukodystrophy.

The Wolvetang Group are particularly interested in the complex interconnectivity of cells in the brain and how a breakdown in these connections contributes to disease. They use high content real-time imaging, gene expression analysis tools, and a range of cell biology techniques to identify disease phenotypes. This knowledge is leveraged to identify and test potential therapeutics using automated robotic screening platforms.

Key Publications

Ovchinnikov DA, Withey SL, Leeson HC, Lei UW, Sundarrajan A, Junday K, Pewarchuk M, Yeo AJ, Kijas AW, Lavin MF, Wolvetang EJ. (2020) Correction of ATM mutations in iPS cells from two ataxia-telangiectasia patients restores DNA damage and oxidative stress responses. *Human Molecular Genetics* 29, 990–1001.

Tursky ML, Loi TH, Artuz CM, Alateeq S, Wolvetang EJ, Tao H, Ma DD. (2020) Direct comparison of four hematopoietic differentiation methods from human induced pluripotent stem cells. *Stem Cell Reports* 15, 735–748.

Shaker, M., Cooper-White, J., & Wolvetang, E. (2020). Self-Organizing 3D Human Choroid Plexus-Ventricle-Cortical Organoids bioRxiv 2020.09.30.321554. *Advance Online Publication*.

Martin S, Poppe D, Olova N, O'Leary C, Ivanova E, Pflueger J, Dechka J, Simmons RK, Cooper HM, Reik W, Lister R, Wolvetang EJ. (2020) Conserved and divergent features of DNA methylation in embryonic stem cell-derived neurons. bioRxiv. *Advance Online Publication*.

Setoh YX, Amarilla AA, Peng NYG, Griffiths RE, Carrera J, Freney ME, Nakayama E, Ogawa S, Watterson D, Modhiran N, Nanyonga FE, Torres FJ, Slonchak A, Periasamy P, Prow NA, Tang B, Harrison J, Hobson-Peters J, Cuddihy T, Cooper-White J, Hall RA, Young PR, Mackenzie JM, Wolvetang EJ, Bloom JD, Suhrbier A, Khromykh AA. (2019) Determinants of Zika virus host tropism uncovered by deep mutational scanning. *Nature Microbiology* 4, 876–87.

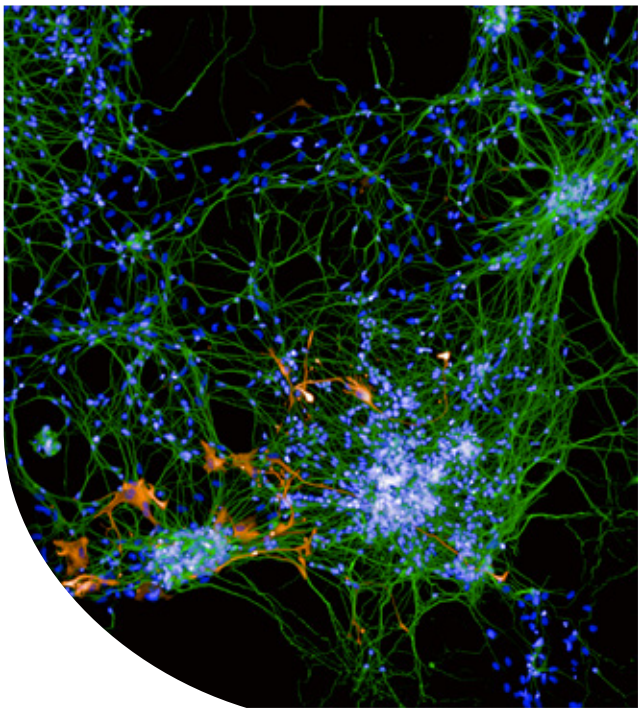
Highlights

2020 has been business as usual for the Wolvetang Group. We have been creating three-dimensional representations of the human brain, termed brain organoids, and using lineage tracing technologies to investigate how and when specific brain cell types are formed. We have also been busy reprograming cells from patients with neurological diseases into pluripotent stem cells, and using genome engineering technologies to correct or introduce DNA mutations in order to understand the link between genes and disease – the study of functional neurogenomics.

In 2012, we established the first stem-cell model for the fatal childhood neurodegenerative disease, Ataxia-telangiectasia. This year this has culminated to result in a successful MRFF Clinical Trials grant worth $2,459,666. This will be the first clinical trial for the disease, and will be done in collaboration world-leading specialists. Our previous work, establishing human brain organoids with effective CSF-brain barriers, contributed to a successful phase one of the 2019–2020 Frontiers MRFF program, which brought in $1 million.

We were also awarded $403,830 (2019–2022) by the National Multiple Sclerosis Society to fund our study "Modulating microglial activity for treatment of demyelinating diseases of the CNS".

We were excited to commence a project with Associate Professor Vadlamudi, which employs brain organoids from epilepsy patients to identify more effective personalised treatments. Also this year, early career researcher Dr Aguado was awarded a two-year research fellowship by the Lejeune Foundation to investigate senescence in down syndrome stem cell models.



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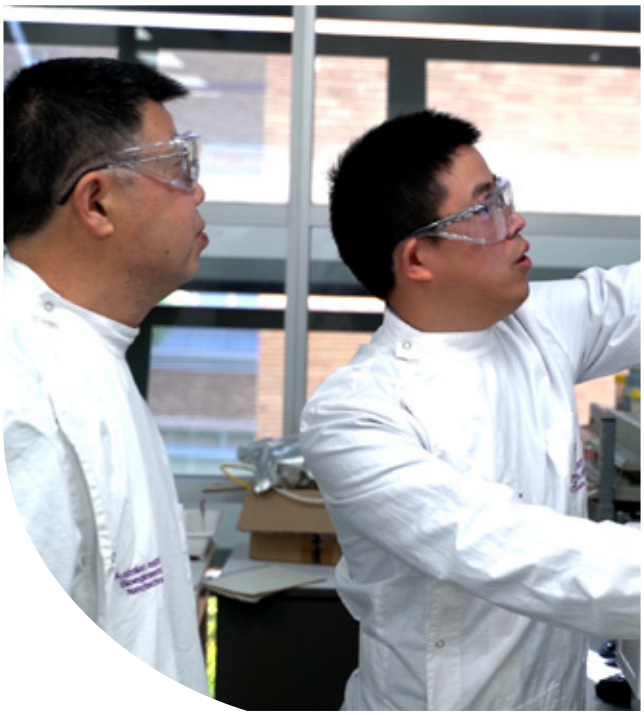
Xu Group

Clay nanomaterials for drug delivery and vaccines

The Xu Group, led by Senior Group Leader Professor Zhi Ping (Gordon) Xu, is a multidisciplinary research team with strengths in the controlled preparation of anionic clay nanomaterials and other nanomaterials for diverse applications, including drug delivery, gene delivery, protein delivery, vaccine adjuvants and bioimaging.

The group is developing a fundamental understanding of the interactions between clay-drug nanoparticles and proteins in serum and target cells, while building knowledge around their biological effects. This understanding enables the design and synthesis of improved nanomaterials for therapeutic applications to diseases such as cancer.

Group members and key collaborators cover a range of disciplines, including nanomaterials science and technology, colloidal chemistry, cellular and molecular biology, biomedicine, biosensor, immunology and neuroscience.



Highlights

This year our group has been optimising clay nanoparticle-based nanomedicines by elegantly co-loading two to three therapeutic agents to synergise the anti-cancer effects of particular drugs. This allows drugs to be used at minimal doses for effective combination cancer therapy. In a recent publication, we showed that the surface modification of clay nanoparticle-based nanomedicines doubles tumour accumulation of nanomedicines following intravenous administration. Therefore, we have significantly enhanced the therapeutic efficacy of these drugs.

The Xu Group, has also been dedicated to optimising the administration route of nanovaccines. Our recent investigation revealed that priming vaccination via intravenous injection of monodispersed nanovaccines and then boosting vaccination via subcutaneous injection, can promote quick and durable anti-tumour immunity for effective immunotherapy.

In ongoing research, clay nanoparticle-based gene delivery systems are being trialled for RNAi delivery to crops for protection from viruses, insects, fungi and bacteria. This important work is funded by a $4.8 million grant from the ARC Industrial Transformation Research Hub (Hub for Sustainable Crop Protection), which was secured in October 2019.

Key Publications

Li B, Hao GY, Sun B, Gu Z, Xu ZP. (2020) Engineering a therapy-induced immunogenic cancer cell death amplifier to boost systemic tumor elimination. *Advanced Functional Materials* 30, 1909745.

Liu JP, Wu YL, Fu C, Li B, Li L, Zhang R, Xu TF, Xu ZP. (2020) Charge reversion simultaneously enhances tumor accumulation and cell uptake of layered double hydroxide nanohybrids for effective Imaging and Therapy. *Small* 11, 202002115.

Zhang LX, Sun XM, Jia YB, Liu XG, Dong MD, Xu ZP, Liu RT. (2020) Nanovaccine's rapid induction of anti-tumor immunity significantly improves malignant cancer immunotherapy. *Nano Today* 35, 100923.

Wu YL, Liu JP, Movahedi F, Gu WY, Xu TF, Xu ZP. (2020) Enhanced prevention of breast tumor metastasis by nanoparticle-delivered vitamin E in combination with Interferon-gamma. *Advanced Healthcare Materials* 9, e1901706.

Yang JX, Hou MF, Sun WS, Wu QH, Xu J, Xiong LQ, Chai YM, Liu YX, Yu MH, Wang HL, Xu ZP, Zhang CF, Liang XW. (2020) Sequential PDT and PTT using dual-modal single-walled carbon nanohorns synergistically promote systemic immune responses against tumor metastasis and relapse. *Advanced Science* 7, 2001088.

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Yamauchi Group

Nanoarchitectured inorganic materials

The Yamauchi Group, led by Senior Group Leader Professor Yusuke Yamauchi, has a research focus on discovering practical applications for batteries, fuel cells, solar cells, chemical sensors, field emitters, and photonic devices using nanoarchitectured design of nanocrystals and nanoporous materials with controlled compositions and morphologies. Specifically, nanoporous metals with metallic frameworks can be produced by using surfactant-based synthesis with electrochemical methods. Owing to their metallic frameworks, nanoporous metals with high electroconductivity and high surface areas hold promise for a wide range of electrochemical applications.

Furthermore, the Group have developed several approaches for orientation controls of tubular nanochannels. The macroscopic-scale controls of nanochannels are important for innovative applications, such as molecular-scale devices and electrodes with enhanced diffusions of guest species.

Professor Yamauchi has a joint appointment with SCE.

Key Publications

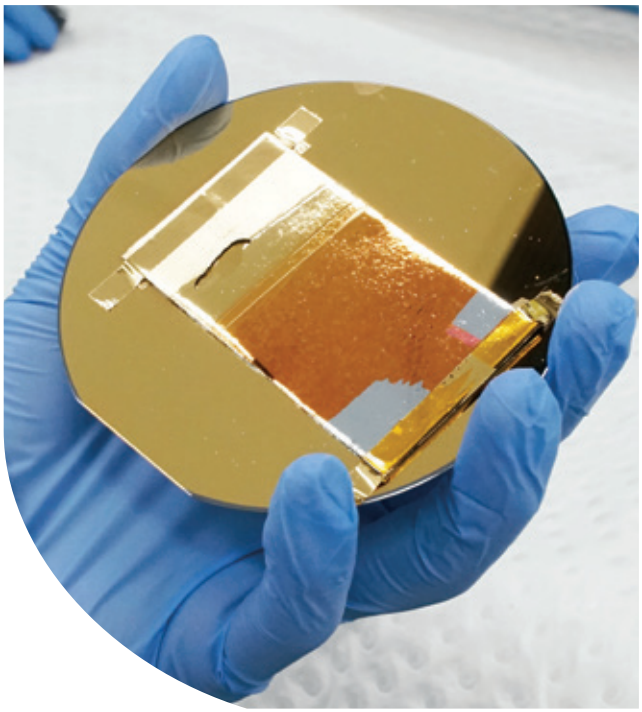
Lim H, Kani K, Henzie J, Nagaura T, Nugraha AS, Iqbal M, Ok YS, Hossain MSA, Bando Y, Wu KCW, Kim H-J, Rowan AE, Na J, Yamauchi Y. (2020) A universal approach for the synthesis of mesoporous gold, palladium and platinum films for applications in electrocatalysis. *Nature Protocols* 15, 2980–3008.

Hou D, O'Connor D, Igalavithana AD, Alessi DS, Luo J, Tsang DCW, Sparks DL, Yamauchi Y, Rinklebe J, Ok YS. (2020) Metal contamination and bioremediation of agricultural soils for food safety and sustainability. *Nature Reviews Earth & Environment* 1, 366–381.

Cao L, Dai P, Tang J, Li D, Chen R, Liu D, Gu X, Li L, Bando Y, Ok YS, Zhao X, Yamauchi Y. (2020) Spherical superstructure of boron nitride nanosheets derived from boron-containing metal–organic frameworks. *Journal of the American Chemical Society* 142, 8755–8762.

Malgras V, Shirai Y, Takei T, Yamauchi Y. (2020) Coalescence-driven verticality in mesoporous TiO_2 thin films with long-range ordering. *Journal of the American Chemical Society* 142, 15815–15822.

Wang C, Kim J, Tang J, Na J, Kang Y-M, Kim M, Lim H, Bando Y, Li J, Yamauchi Y. (2020) Large-scale synthesis of MOF-derived superporous carbon aerogels with extraordinary adsorption capacity for organic solvents. *Angewandte Chemie International Edition* 59, 2066–2070.



Highlights

This year we published over 80 papers in international refereed journals (two in Nature sister journals, two in *Journal of the American Chemical Society*, two in *ACS Nano*, three in *Chemical Science*, three in *Angewandte Chemie International Edition* and three in *Advanced Materials*). Together, these have over 40,000 citations (*h*-index > 108, Google Scholar; h-index > 100 Web-of-Science). Also this year, as with the last five years, Professor Yamauchi was selected as one of the Highly-Cited Researchers in Chemistry and Materials Science. He was, once again, in the Top 40 Australian superstars of 2020.

This year, we have further been establishing a new Australian Materials Tectonics Centre, which will enhance the strategic relationship between Japanese and Australian organisations. By engineering novel materials, our team is leading the way to create human connections that will enrich Japanese and Australian science and technology. These efforts were featured in Nature and highlighted by ARC, in the ARC news.

Our conductive porous materials (the world's first porous system) is available to many applications, such as surface enhanced Raman scattering (a kind of sensing application, Korean National Institute Fund, totalling AU$500,000); biomarkers (NHMRC Medical Research Future Fund Emerging Priorities and Consumer Drive Research – Ovarian Cancer Research, totalling AU$1,200000); and anti-corrosion coating (Baosteel Australia Fund, totalling AU$250,000).

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Yu Group

Synthesis and application of advanced functional materials

The Yu Group, led by Senior Group Leader Professor Chengzhong (Michael) Yu, focuses on the designed synthesis of advanced functional materials and their applications in drug delivery, bio-analysis, environmental protection and energy storage. The group collaborates with a number of partners to explore commercial applications of their work through innovation in nanomaterials.

The Yu Group is focused on two research areas, Nanobiotechnology and Advanced materials.

Highlights

This year, our research has led to several key discoveries including, the discovery of a thermal reductive perforation technique. This technique engineers few-layer surface perforated–graphene materials, and leads to record-high performances in aluminium-ion battery applications. Our discovery has led to a pending patent, and is supported by a one linkage project application. In addition, our previously patented spiky silica nanoparticle, has progressed towards translation as a next-generation DNA nano-vaccine. We have also developed a novel copper nanochelator as a new adjuvant therapy.

In 2020, we are proud to have published over 30 papers with more than half of them in top-ranking journals. Our work has further been recognised by several prestigious awards to lab members, including an NHMRC Investigator Grant for Dr Hao Song, an Advanced Queensland Fellowship for Dr Jie Tang, a Frontiers in Chemistry Rising Stars 2020 award for Dr Xiaodan Huang, and a GC Australasia Dental Pty Ltd Minimum Intervention Dentistry Research Award for Dr Chang Lei.

2020 has also been a very successful year for grants. We secured two ARC grants, one NHMRC Investigator grant, one Advanced Queensland grant and several contract research grants.

Key Publications

Yang YN, Zhang M, Song H, Yu CZ. (2020) Silica-based nanoparticles for biomedical applications: From nanocarriers to biomodulators. *Accounts of Chemical Research* 53, 1545–1556.

Liu C, Sun Q, Lin LN, Wang J, Zhang CQ, Xia CH, Bao T, Wan JJ, Huang R, Zou J, Yu CZ. (2020) Ternary MOF-on-MOF heterostructures with controllable architectural and compositional complexity via multiple selective assembly. *Nature Communications* 11, 1–8.

Tang J, Meka AK, Theivendran S, Wang Y, Yang Y, Song H, Fu J, Ban W, Gu ZY, Lei C, Li S, Yu CZ. (2020) Openwork@Dendritic mesoporous silica nanoparticles for lactate depletion and tumor microenvironment regulation. *Angewandte Chemie International Edition* 59, 22054–22060.

Wang Y, Tang J, Yang YN, Song H, Fu JY, Gu ZY, Yu CZ. (2020) Functional nanoparticles with a reducible tetrasulfide motif upregulate mRNA translation and enhance transfection in hard-to-transfect cells. *Angewandte Chemie International Edition* 59, 2695–2699.

Yang Y, Tang J, Song H, Yang Y, Gu Z, Fu J, Liu Y, Zhang M, Qiao Z, Yu C. (2020) Binuclear aluminum complex modified dendritic mesoporous silica nanoparticles as unprecedented adjuvants: Coordination chemistry dictates adjuvanticity. *Angewandte Chemie International Edition* 59, 19610–19617.

aibn.uq.edu.au/yu

Zhao Group

Biomimetic materials and bioinspired devices

The Zhao Group, led by Group Leader Associate Professor Chunxia Zhao, focuses on the discovery and development of new knowledge and new approaches for making bio-inspired functional micro/nano materials, based on biomimetic engineering and microfluidic technology, for drug delivery and controlled release.

The Group has developed facile and scalable methods for producing libraries of multifunctional materials (liposomes, polymeric nanoparticles and core-shell nanomaterials) for drug delivery and controlled release, and has been developing tumour-on-a-chip and organs-on-a-chip to evaluate these systems with the ultimate goal to accelerate their clinical translation. The Group has also been working with industry partners and collaborators to translate their patented technologies into commercial applications.

Highlights

Our group is developing new biomimetic materials for drug delivery and bioinspired devices (e.g. organs-on-a-chip models), for use in drug screening and evaluation. Inspired by natural design, we apply biological methods and systems from nature to the design and study of newly engineered systems and technologies. We push the boundaries of bioinspired engineering by designing biomolecules with minimum parts for maximum diversity, and develop one-step or one-pot synthesis strategies for multiple functions. We are driven to move scientific discoveries and cutting-edge technologies out of the laboratory and into the world.

Our research has led to six patented technologies. Our biomimetic nanocapsule technology has entered the national phase. Our new technology for making nanoparticles with extremely high drug loading (65 per cent) was licensed to an international pharmaceutical company for commercialisation. This technology addresses the urgent need for new formulations of hydrophobic drugs, as 40 per cent of approved drugs, and 90 per cent of pipeline drugs, are water-insoluble. We were awarded an ARC Discovery project (2020–2023) to further develop this technology.

Our research in bioinspired engineering has also made impact in traditional engineering disciplines. Associate Professor Zhao leads the design of new biomolecule-based separation technologies to achieve fast and effective separations between valuable metals and wastes, thus transforming mineral processing.

Key Publications

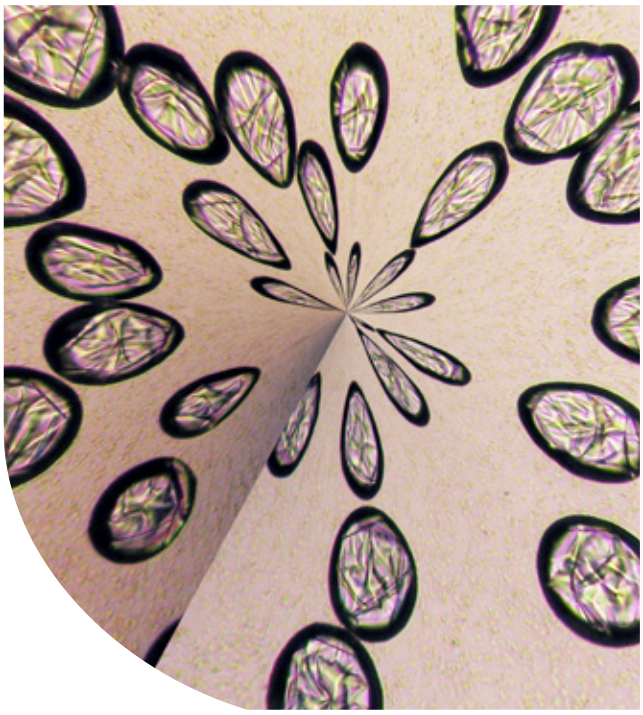
Hui Y , Yi X, Wibowo D, Yang G, Middelberg APJ, Gao H, Zhao C-X. (2020) Nanoparticle elasticity regulates phagocytosis and cancer cell uptake. *Science Advances* 6, eaaz4316.

Liu Y, Yang G, Baby T, Tengjisi, Chen D, Weitz DA, Zhao C-X. (2020) Stable polymer nanoparticles with exceptionally high drug loading by sequential nanoprecipitation. *Angewandte Chemie International Edition* 59, 4720–4728.

Lu L, Li B, Ding S, Fan Y, Wang S, Sun C, Zhao M, Zhao C-X, Zhang F. (2020) NIR-II bioluminescence for in vivo high contrast imaging and in situ ATP-mediated metastases tracing. *Nature Communications* 11, 4192.

Liu Y, Yang G, Jin S, Zhang R, Chen P, Tengjisi, Wang L, Chen D, Weitz DA, Zhao C-X. (2020) J-aggregate-based FRET monitoring of drug release from polymer nanoparticles with high drug loading. *Angewandte Chemie International Edition* 59, 2–12.

Yang G, Liu Y, Wang H, Wilson R, Hui Y, Yu A, Wibowo D, Zhang C, Whittaker A, Middelberg A, Zhao C-X. (2019) Bioinspired core-shell nanoparticles for hydrophobic drug delivery. Angewandte Chemie International Edition 58, 2–10.



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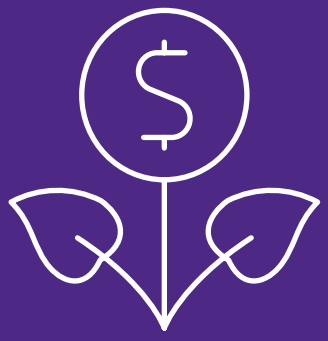


Funding and recognition

Funding and recognition

Fellowships

ARC Future Fellowship

Dr Bin Luo: Solar rechargeable batteries for wearable electronics

ARC DECRA

Dr Hao Song: Engineering nanoparticles with enhanced adhesion at the nano-bio interfaces

NHMRC Investigator Grants

Professor Tom Davis: Novel approaches to Nanomedicines for future therapies

Dr Changkui Fu: Improving the Delivery Efficiency of Nanomedicines to Tumour Tissue

Dr Ruirui Qiao: Biocompatible Gadolinium-free contrast agents for molecular targeted MR imaging

Dr Hao Song: A Long-Lasting Oral Drug Delivery System Using Spiky Silica Nanoparticles

Advance Queensland Industry Research Fellowships

Dr Nasim Amiralian: Nanofibers with antiviral activity: potential applications for improving personal protective equipment safety (Industry Partners: Sunshine Sugar, Evolve)

Dr Craig Bell: Application of separation technologies for rapid treatment of COVID-19 and related outbreaks (Industry Partner: Aegros)

Dr Chris Howard: Novel Virus Trap Nanotechnology for COVID-19 Detection (Industry Partner: Xing)

Dr Yusuf Kaneti: Point-of-care diagnostics device incorporating microfluidics technology and electrochemical biosensing platform for COVID-19 detection (Industry Partner: AI Fluidics Pty Ltd)

Fondation Jerome Lejeune Fellowship

Dr Julio Aguado Perez: Elucidating the genetic drivers of accelerated cellular ageing in Down syndrome.

Awards and Prizes

Professor Yusuke Yamauchi and **Professor Lianzhou Wang** have been named as Highly Cited Researchers. The list, garnered from the Web of Science Group, recognises scientists who have published a high number of papers that rank in the top 1 per cent most-cited in their respective fields.

Associate Professor Jessica Mar has received a Mid-Career Researcher Award from the Australian Bioinformatics and Computational Biology Society (ABACBS). She was also awarded a Georgina Sweet Award for Women in Quantitative Biomedical Science. The prestigious annual award celebrates outstanding female scientists who demonstrate excellence in biological or biomedical research that employs a quantitative approach. Only six Georgina Sweet Awards were given nationally. Associate Professor Mar received her award for both Excellence in Research and Excellence in Inclusivity.

Professor Darren Martin has been named as a New Fellow for 2020 by the Australian Academy of Technology and Engineering. ATSE is an independent body of more than 800 Australian scientists and engineers seeking to enhance Australia's prosperity through technological innovation. These Fellows – who are drawn from academia, government, industry and research – are some of Australia's leading figures in their fields

Mr Filip Radenkovic has been awarded an Alexander Steele Young Memorial Lions Foundation Scholarship via the Australian Red Cross Service.

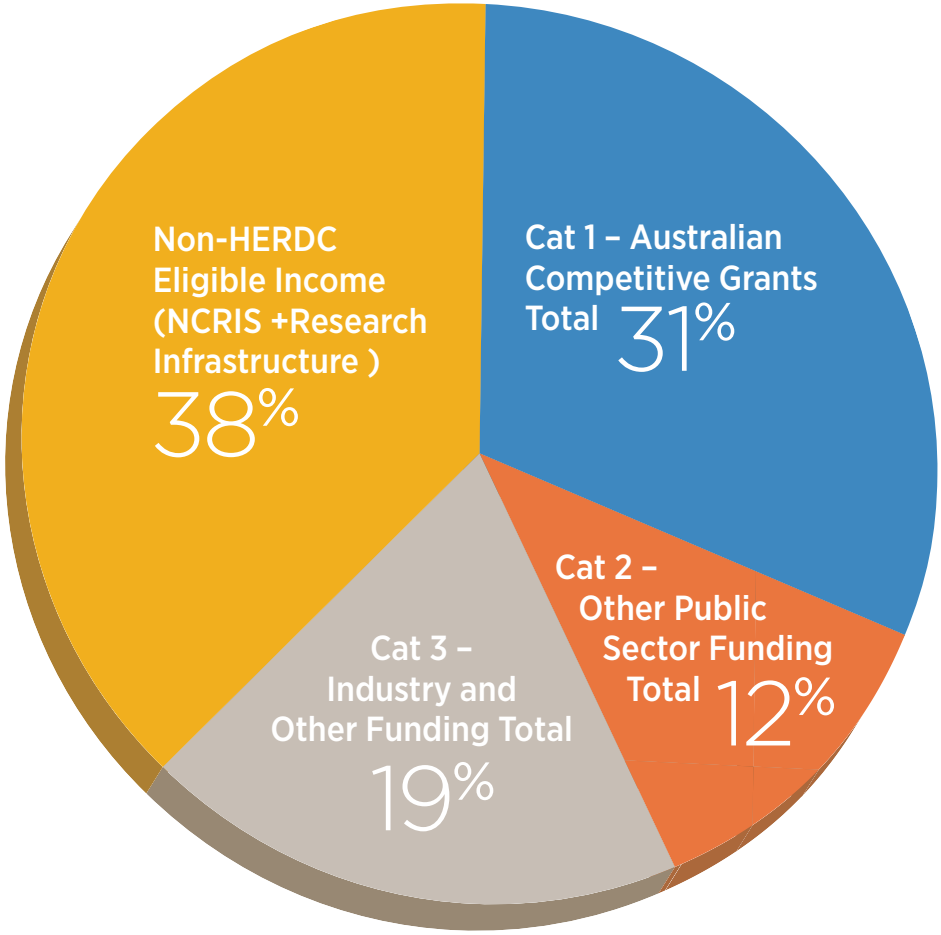
Dr Shyuan Ngo, **Dr Mohammed Shaker** and their UQ colleagues **Dr Frederik Steyn** and **Dr Quan Nguyen** received the Motor Neurone Disease Research Australia (MNDRA) Charcot Award for the highest-ranking Innovator grant application.

Professor Linda Lua and **Associate Professor Chunxia Zhao** have been recognised by the Faculty of Science for their teaching skills. Each semester, high-achieving students receiving a Dean's Commendation for Academic Excellence are asked to nominate a teacher who they believe should be commended for excellent teaching. Professor Lua and Associate Professor Zhao were both nominated and have been commended by the Executive Dean of the Faculty of Science for their outstanding efforts to support students through effective teaching.

Professor Lars Nielsen and **Professor Yusuke Yamauchi** have been recognised in *The Australian's* newly published *Special Report: Research*. Professor Nielsen was named as Australia's Field Leader in Biotechnology Research. Professor Yamauchi was named as one of Australia's top 40 researchers – one of only five in the category of Chemical and Material Sciences.

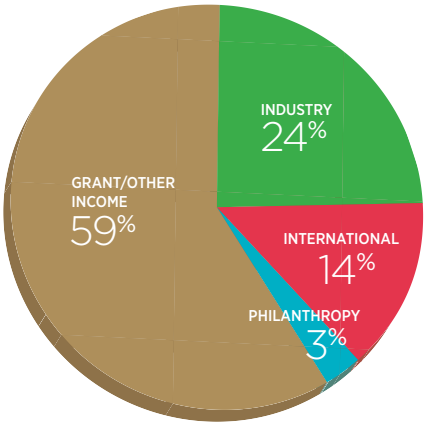
Professor Alan Rowan was elected as a Fellow of the Australian Academy of Science for his sustained contribution to research and scientific endeavour. The academy provides independent, authoritative and influential scientific advice, promotes international scientific engagement, builds public awareness and understanding of science and champions, celebrates and supports excellence in Australian science. Professor Rowan was one of 24 new Fellows elected in 2020.

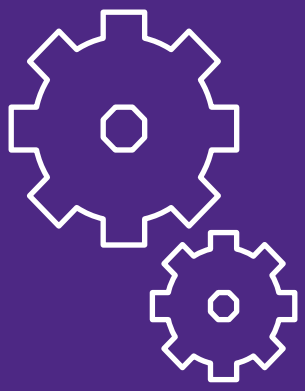
AIBN 2020 Income



Cat 1 - Australian Competitive Grants Total	$8,278,720.30
Cat 2 - Other Public Sector Funding Total	$3,201,168.56
Cat 3 - Industry and Other Funding Total	$4,882,179.52
Non-HERDC Eligible Income (NCRIS +Research Infrastructure)	$10,093,481.00
TOTAL HERDC Income	**$16,362,068.37**
TOTAL AIBN External Income in 2019	**$26,455,549.40**

TOTAL HERDC Income	**$16,362,068.37**
Industry (24%)	$3,892,264.37
International (14%)	$2,287,859.07
Philanthropy (3%)	$495,583.00
Grant/other income (59%)	





Facilities and Centres

AIBN's ability to drive medical and technological breakthroughs that will contribute to leading longer, healthier lives and building a more sustainable future is underpinned by a truly remarkable collection of interdisciplinary research facilities. These facilities, co-located within AIBN, are equal to any in the world and offer unique opportunities to undertake industry-relevant research and development. The expertise and equipment of these facilities are available to the broader university and Australian research community, including academia, industry and small and medium enterprises.

AIBN Centres

Centre for Theoretical and Computational Molecular Science

CTCMS brings together leading researchers developing and using theories and computational techniques for molecular science from across UQ. Our goal is to facilitate world-leading education and research in theoretical and computational molecular science to accelerate advances in science and engineering.

ARC Training Centre for Biopharmaceutical Innovation

The centre is a multi-million dollar Australian Government initiative that aims to transform Australia's growing biopharmaceutical industry. It partners with leading Australian stakeholders in the biologics industry and aims to blend research excellence with industry partner experience and know-how.

Centre for Materials nanoTectonics (CemanTec)

This centre establishes a new research area in Australia by proposing a new conceptual paradigm "materials space-tectonics" which involve the creation of novel nanoporous functional materials with precisely controlled internal nanospace, morphology and composition with the assistance of "materials and process informatics (MI and PI)".

CemanTec brings together renowned scientists, academics, government stakeholders and established industry links into one umbrella and also develop an active approach to translate laboratory discoveries to commercial products.

Centre for Personalised Nanomedicine (CPNM)

By bringing together cutting-edge research from the fields of Nanotechnology, Molecular Biology, Clinical Research and Health Economics, the vision of the Centre for Personalised Nanomedicine (CPNM) is to become a knowledge leader as well as a catalyst for change in medical practice. This Centre drives one the three themes of the AIBN and comprise of two components, NanoDiagnostics and NanoMedicine Delivery. The former is supported by CSIRO, with a CSIRO-UQ Chair in Personalised Nanodiagnostics and aims to develop and translate the next generation of real time ultra-sensitive biofluid diagnostics for early detection and personalised treatment. The second area, is in the study and development of novel nanomaterials for specific delivery of medicines and theragnostics, enabling precise personalised targeting of drug therapy. The Centres partners are also member of the ARC Center of Excellence, CBNS (Convergent for Bio-nano Science and Technology). By detecting earlier and having the molecular tool box to specifically deliver treatment, the AIBN CPNM, works closely with industry and clinicians being next technology to the patient by revolutionizing current medical practice.

Australian Advanced Biomanufacturing Centre (AABC)

The AABC is a key enabler for clinically driven translation of Australia's expanding biologic based therapeutic pipeline. Protein and nucleic acid-based therapeutics and vaccines continue to be the primary drivers of the innovative Biotechnology sector, both in terms of novel modalities and commercial revenue. This centre has a primary goal of driving tomorrow's life-saving therapies out of Australia's leading Biomedical laboratories and into early-stage translation, spanning mechanism of action validation and clinical evaluation, while ensuring a long-term view of manufacturability and differentiated activity.

The centre is a collaboration across AIBN researchers and NCRIS capabilities including the National Biologics Facility (NBF) and the UQ node of Bioplatforms Australia (BPA), supported by capabilities such as TetraQ and Clinical Trial providers. The centre's expertise and infrastructure capabilities span novel molecule discovery, protein engineering, manufacturing process development and establishment of clinically enabling manufacturing platforms. NBF is part of a national network of nodes based in Sydney and Melbourne as part of Therapeutic Innovation Australia, with expanded capabilities across small molecules and cell and gene therapies.

Research within the centre is focussed on solving key bottlenecks and technical challenges experienced by the biotechnology industry, around manufacturing efficiency and speed to market. AABC provides access to highly refined multi-omics based analytics and genome-scale models for rationale engineering and incorporation of cutting-edge synthetic biology tools for custom iterative engineering and strain development.

The Centre also incorporates the ARC Training Centre for Biopharmaceutical Innovation (CBI). CBI brings together University researchers and HDR students with key industry partners; CSL, Patheon, Lifeblood and Cytiva (formerly GE Healthcare). The CBI is focussed on industry-driven research projects ensuring industry ready graduates and scientists ready to deploy into workforce to propel the Biomanufacturing sector.

The AABC provides a unique cluster of skilled staff, equipment and infrastructure to enable bioengineering solutions for therapeutic translation and support of sovereign biomanufacturing capabilities.

NCRIS supported and UQ facilities

Australian National Fabrication Facility – Queensland node

ANFF-Q is a micro/nano-fabrication facility, operating as part of a national organisation offering academia and industry access to cutting-edge equipment, enabling research, development and prototyping of microfluidics, organic electronics, biomaterials and novel semiconductor materials complimented by a suite of advanced characterisation tools. Supported by our expert staff, ANFF-Q can facilitate access to a network of eight nodes, including 21 institutions throughout Australia.

Centre for Microscopy and Microanalysis (CMM)

CMM is an interdisciplinary research, teaching and service centre that plays an integral role within the research programs of UQ and participates in both undergraduate and postgraduate education. The centre provides a comprehensive suite of analytical instrumentation and a high standard of training programs for university researchers. Its highly experienced, specialist staff are committed to providing a supportive and resourceful working environment where clients receive expert advice and training that equips them to achieve their research goals.

Bioplatforms Australia

Bioplatforms Australia builds research capabilities and expertise in the specialist fields of genomics, proteomics, metabolomics and bioinformatics. BPA enables Australian life science research by investing in state-of-the-art infrastructure and projects that build 'omic datasets relevant to Australian scientific challenges.

National Biologics Facility – Queensland node

NBF is one of three specialist laboratories across the country that supports the development of novel, complex therapeutics and vaccines through advanced biomanufacturing. It is supported by NCRIS and administered by Therapeutic Innovation Australia (TIA). The facility consists of a team of highly skilled staff, a specially designed suite of laboratories, clean rooms and state-of-the-art equipment designed to assist Australian researchers and small-to-medium innovative companies wishing to bridge the gap between discovery research and clinical translation.

Protein Expression Facility

The Protein Expression Facility enables researchers to deliver scientific excellence, develops innovative solutions in protein technology for the bioeconomy and fosters the next generation workforce in biomanufacturing. As a global leader positioned for protein research services, technologies and training, PEF offers comprehensive capabilities with four expression platforms (bacteria, yeast, baculovirus/insect cell and mammalian cell). With a track record in cross-sector engagement with researchers in academia, industry and government, PEF designs protein-specific strategies for targeted end-use. PEF's highly skilled specialists engage, inform and innovate to enable others to achieve greater impact, and are recipients of multiple awards in service excellence.

Australian Research Data Commons (ARDC)

ARDC brings to the research sector over 10 years of experience on research data infrastructure and services such as the Nectar Research Cloud, persistent identifiers including DOIs and ORCiD, data curation, policy development, and access to national data collections. The purpose of the ARDC is to provide Australian researchers with competitive advantage through data, providing access to leading-edge data-intensive infrastructure, tools, services, and collections of high-quality data.

Queensland Metabolomics and Proteomics (PA-Q & MA-Q)

PA-Q provides high throughput proteomics and protein biochemistry using mass spectrometry and high pressure liquid chromatography. Services are offered in protein characterisation, quantification and identification, protein sequencing, protein separation, post translational modifications, biomarker discovery, screening and multiplexing assays, amino acid analysis and N-terminal sequencing. MA-Q provides expertise in targeted and untargeted metabolomics as well as in metabolic engineering, directed to understanding and manipulating cellular behaviour at a system level. MA-Q's facilities provide support for projects requiring the characterisation of biochemical metabolites and develop fluxomic models that are used to analyse and engineer fermentation systems and optimise product development.

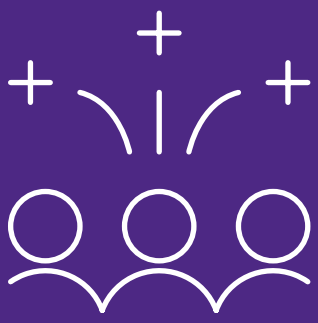
Transgenic Animal Service of Queensland

The Transgenic Animal Service of Queensland (TASQ) is a core service facility and a division of The University of Queensland Biological Resources (UQBR) department. TASQ utilises the latest and most up-to–date techniques to provide a wide range of services for UQ and Australian researchers for the production, maintenance, rederivation, genotyping, importing, and the cryopreservation of genetically modified (GM) mice.

Together with the Queensland Facility for Advanced Genome Editing (QFAGE), we provide expert gene modifications using CRISPR gene editing techniques. Associated transgenic technologies of IVF enable the rapid large-scale expansion of breeding and experimental mouse colonies, the re-animation of strains from cryopreserved sperm and increased embryo production for the cryopreservation of GM strains. We also serve as a source of knowledge, experience, and instruction in the use of genetically modified mice for research questions and training.

StemCore

StemCore is a state-of-the-art, not-for-profit comprehensive pluripotent stem cell and human functional genomics core facility that offers a wide range of services to public and private sector researchers. These services include the provision of human embryonic stem cell lines (hESCs), off-the-shelf and custom-generated induced pluripotent stem cells (iPSCs), targeted differentiation of stem cells to a range of cell types, genetic engineering of stem cells using CRISPR/Cas9 and other approaches, and training on stem cell generation, maintenance and downstream applications.



Our People

Gender Equity and Diversity Commission (GEDC)

AIBN's Gender Equity and Diversity Commission (GEDC) serves to develop and implement gender equity and diversity goals, strategies and targets with the aim of implementing best practice in the institute. Throughout 2020, the GEDC had three key focus areas:

Career Development Week

For the third year in a row, the GEDC ran AIBN's Career Development Week in collaboration with the Early and Mid-Career Association committee. Due to restrictions around COVID, in 2020 the event pivoted to a virtual form, to great success.

Career Development Week saw speakers from a range of backgrounds across academia, industry and other areas share their experience and advice. The speakers covered topics ranging from leadership, entrepreneurialism, grant writing, and tips for transitioning to industry.

2020 also featured a new event – a Q&A panel session with AIBN senior academics, which allowed EMCAs and students to ask questions related to career development. Of the questions fielded, there was a focus on gender equity issues including balancing being a parent/mother while maintaining productivity as a scientist.

We had over 300 registrations, an increase of 145 per cent from previous years, and received overwhelmingly positive feedback in the follow-up survey. We also ensured we showcased females in our program, achieving a figure of 70 per cent female speakers.

Increasing visible support for LGBTQIA+ Community Members

During 2020, the GEDC sought to improve visible support for LGBTQIA+ community members. The main focus of this goal was to increase the amount of UQ Ally Network members present in the building. Through consistent promotion of the network across a range of mediums, we were able to double the amount of members at AIBN from 4 to 8. We also ran a number of events on LGBTQIA+ awareness days, such as IDAHOBIT with guest speaker LGBTQIA+ Activist Johnny Valkyrie.

The GEDC also began development of an AIBN-centric LGBTQIA+ Community group. This group would serve as a virtual place for members of the LGBTQIA+ community to engage with other members of the community at AIBN and share knowledge, events and discussions.

Focus on supporting mental health

In part due to the high stress situation around COVID, in 2020 the GEDC sought to build on work from previous years to develop activities that would support the mental health of AIBN staff and students. The main thrust of this was to get members of the committee to sign up to become mental health champions, and promote the network within AIBN.

The GEDC also ran a number of social events aimed to assist in mental health. These included Zoom happy hour parties that ran virtually during the early stages of lockdown, and activities for R U OK Day.

Early and Mid-Career Academics Committee

Our Early-and-Mid Career Academics (EMCA) Committee aims to provide a support network for our academics to enable their professional development and assist in reaching their career goals. EMCAs include Level A, B and C research, teaching, and professional staff and final-year PhD students.

Since its re-launch in 2019, EMCA@AIBN has advocated diversity and equality, and aimed to build a community that supports and works towards AIBN's values including ***respect, support, collaboration, honesty*** and ***integrity***. In line with these values, EMCA has organised series of career development and networking events in collaboration with various committees.

In 2020, we collaborated with the AIBN Executive Office and the Gender Equity and Diversity Commission to establish a virtual 'Happy Hour' via Zoom, where we could connect with each other and support one another despite most of us working remotely.

We also ran a virtual Career Development Week in collaboration with the AIBN Executive Office, Gender Equity and Diversity Commission and the Early and Mid-Career Researchers Committee from the School of Chemistry and Molecular Biosciences.

Moreover, EMCA@AIBN has been supporting the early and mid-career researcher community UQ-wide through the EMCR@UQ committee. This committee organises career and skill development workshop series and networking events including symposiums and appreciation days. They are also responsible for drafting the EMCR@UQ Roadmap, which describes the specific career development needs of our cohort.

Our objectives:

- Build and represent the EMCA community at AIBN
- Promote and advance professional development for EMCAs across all disciplines both within AIBN and UQ-wide
- Facilitate and increase collaboration between EMCAs
- Act as a contact point and liaison for matters relating to EMCAs to the wider AIBN community
- Advocate, advance and support women in science at the EMCA stage of their career
- Support and connect EMCAs and students through peer- and EMCA-student mentorship program
- Organise and promote career development workshops, including teaching and grant opportunities, that are accessible to the EMCA community at AIBN

The committee:

- Dr Atefeh Taherian Fard, Co-chair
- Dr Chris Howard, Co-chair
- Dr Craig Bell
- Dr Julio Aguado Perez
- Dr Mahdie Mollazade
- Dr Naatasha Isahak

Higher Degree by Research

160 students

66 female

94 male

New Higher Degree by Research Students in 2020

Joanne Allard
Aditya Ashok
Wenhuang Ban
Naga Chandra Bandari
Larry Cai
Yixin Chang
Ping Cheng
Dan Cheng
Jonathon Egan
Marco Antonio Enriquez Martinez
Jad Farouqa
Xin Gao
Lauren Geurds
Lauren Hammond
Cory Holdom
S M Azad Hossain
Kristoffer Hua
Michelle Hunter
Jayendran Iyer
Kartik Jain
Sophie Kenny
Zeyu Lu
Francis McCallum
Asep Nugraha
Amber Prior
Karthik Shanmugasundaram
Manoj Kumar Sharma
Hao Wang
Jingjing Wang
Yilun Weng
Ruijing Xin
Xin Xu
Sidong Yang

156 PhD

4 MPhil

58 domestic

102 international

43 scholarships awarded

33 new students

AIBN Student Association

The AIBN Student Association (ASA) forged ahead with our goal of providing support and encouragement to our postgraduate, masters and undergraduate research students in 2020. In a year beset by challenges on multiple fronts, our association was largely consigned to a virtual presence.

The 2020 team began the year with a breakfast fundraiser to support the valiant efforts of firefighters during Australia's devastating bushfire crisis. Through this event, we raised $892 for the Rural Fire Brigades Association Queensland.

This fundraiser built upon the success of ASA's weekly student breakfast started in 2019, led by Ebony and Cecilia, where students were given the opportunity to socialise together over a free meal and coffee. Once the pandemic hit, these sessions transitioned into Zoom chats from our respective homes. Naturally, this had an impact on engagement and the social dynamic (as we'd all be aware by now), but the supportive environment remained present.

Another event that was consigned to online was the morning yoga and meditation sessions run by Jordan in the hour before breakfast in 2019 & early 2020. These sessions entailed the ASA's endeavour to consider & manage the mental health of AIBN students – especially in a time of crisis.

This initiative even involved an inter-institute collaboration with UQ's Institute for Molecular Bioscience (IMB) for the few weeks between restrictions being lifted and re-imposed, with the ASA inviting IMB students to join yoga and breakfast, led by IMB student and trained yoga instructor Zeenat Rupawalla.

On the more academic side, the ASA ran weekly science writing session on Friday mornings, giving advice to students about writing anything from journal articles to 3 Minute Thesis scripts. In August, three workshop sessions were run over three weeks to help improve the engagement of students' 3MT presentations, run by Jordan, eventual winner of the AIBN 3MT competition. The AIBN had a total of 11 entrants that presented their PhD projects in short, sharp 3-minute recorded presentations.

With this forced transition to online events, the ASA proposed a solution to the lack of in-person networking & social events –establishing our online ASA Slack workspace. 42 members joined the workspace across 8 channels, including:

- general-chat
- hdr-questions
- scicomm-sciart
- bioeconomy-chat

A platform of this type was requested by AIBN students during the 2019 Student Forum; we hope that its uptake and engagement will increase in 2021.

While it saddened us that the strengths of the ASA in previous years were thwarted in 2020 – namely monthly social mixers, inter-institute sport and industry networking events – we hope that these are re-established in 2021 and that the ASA continues to provide a fun, supportive and valuable community for research students at AIBN and UQ.

2020 AIBN Student Association Team

President - James Hefferan

Vice President - Jordan Pennells

Treasurer – Ebony Watson

Secretary – Anna Cameron

Academic Representative – Cecilia Gomez

OHS Representative – Katelyn Richards

Student Engagement - Aiden Beauglehole

Inter-Institute Liaison – Serena Ekman

2020 Graduates

Waqas Aslam
Value-adding to stranded carbon resources via catalytic conversion of syngas into oxygenated fuels

Caterina Brighi
Neuroimaging Studies Evaluating Effective Therapies for High-Grade Glioma

Rebecca Chesterfield
A synthetic biology toolbox for examining and engineering strigolactone biosynthesis

Arukattu Ediriweera
Development of polymeric theranostics using bioorthogonal chemistry

Anna Gemmell
Polymeric micelle nanomedicines for monitoring therapeutic efficacy

Jing Geng
Engineering Surface-Enhanced Raman Scattering Strategies for Liquid Biopsy Analyses: A Step Towards Precision Medicine in Cancer Management

Zhengying Gu
Engineered iron-based nanomaterials for macrophage-centred anti-cancer application

Matthew Henry
Engineering Chinese Hamster Ovary Cells for Improved Monoclonal Antibody Productivity by Modulating Feedback Regulation of the Secretory Pathway

Kamil Reza Khondakar
SERS-Microfluidic Assay for Rapid Profiling of Cancer Biomarkers

Hyunsoo Lim
Synthesis of Mesoporous Au, Ag, and Cu Nanostructures for Surface-Enhanced Raman Spectroscopy

Rebecca Emily Lane
Extracellular Vesicles as Circulating Breast Cancer Biomarkers

Juan Li
A versatile microfluidic platform for vector free intracellular delivery

Yun Liu
Polymeric Nanoparticles for Drug Delivery

Mostafa Kamal Masud
Nanoarchitectured Point-of-Care Detection System for Clinically Relevant Biomarkers

Amal J Sivaram
Design and synthesis of nanomaterials as combination therapeutics

Timothy Tracey
Exploring the neurometabolic component of amyotrophic lateral sclerosis through the generation of human cell-derived in vitro models

Haofei Wang
Biomimetic chip platforms for studying drug delivery systems

Jing Wang
Engineering Surface-Enhanced Raman Scattering Strategies for Liquid Biopsy Analyses: A Step Towards Precision Medicine in Cancer Management

Yue Wang
Designed synthesis of silica based nanocarriers for mRNA delivery

Andri Wardiana
Development of novel bioconjugation strategies for creating cancer-targeting nanomaterials

Yanheng Wu
Developing inorganic nanoplatforms for efficient siRNA delivery to improve cancer immunotherapy

Guangze Yang
Core-Shell Nanomaterials for Drug Delivery and Controlled Release

Nicolas Eugenio Zaragoza
Understanding toxin production in Clostridium tetani: a systems approach

Engagement

Engagement Report

Engagement had a different look in 2020 compared to other years, but we continued to share our research with our scientific peers and with the community. In particular, our involvement in UQ's COVID-19 vaccine project meant we hosted a series of VIPs throughout the year.

One of the highlights of our scientific calendar was the eighth ICONN and ICBNI conference, the largest biennial Australian conference in nanoscience. Being held early in the year, it was able to proceed, with over 800 participants from 29 countries attending. Please see next page for more details on this conference.

Our scientific seminars managed three in-person events at the start of the year, when we hosted visiting researchers from Brazil, the US and China. We resumed seminars mid-year in a virtual format, which allowed more people to attend. Our speakers were a mix of international and interstate guests and our own PhD students.

We welcomed members of the community, including school students, science teachers, government officials and leaders to the institute. We hope to boost our community engagement in 2021, when conditions are more amenable to in-person events.

VIP Visitors

Prime Minister The Hon. Scott Morrison

Queensland Premier The Hon. Annastacia Palaszczuk

(Federal) Minister for Health The Hon. Greg Hunt

Deputy Premier (Queensland) and Minister for Health The Hon. Dr Steven Miles

Queensland Minister for Innovation The Hon. Kate Jones

Australian Chief Scientist Dr Alan Finkel

International research speakers

Professor Danielle Pedrolli, UNESP, Brazil

Associate Professor Jeremiah Gassensmith, University of Texas at Dallas, USA

Professor Lei Jiang, Beihang University, China

Professor Mitsuo Sawamoto, Kyoto University, Japan

Professor Krzysztof Matyjaszewski, Carnegie Mellon University, USA

Professor Kristi Anseth, University of Colorado, USA

Major Conferences

International Conference on Nanoscience and Nanotechnology (ICONN)

This is the eighth year that the International Conference on Nanoscience and Nanotechnology (ICONN) in conjunction with the International Conference on BioNano Innovation (ICBNI) has been held. ICONN is the largest biennial Australian conference series in the field of nanoscience since 2006. The 2020 event returned to Brisbane and featured a diverse array of multidisciplinary talks designed to connect world-leading scientists, students, engineers, industry participants and entrepreneurs working in the field of nanoscale science and technology to discuss new and exciting advances in the field. We warmly welcomed over 800 participants from 29 countries including a long list of outstanding plenary/keynote/invited speakers to present their outstanding research, to learn new ideas, to interact with colleagues and to foster new collaborations.

Many excellent events were offered, in addition to the ten first-rate technical symposia and a pre-conference workshop, ICONN 2020 also offered five panel discussion sessions focusing on our next generation researchers, end-user engagement and research impact including What Makes a Great Leader, How to Get Published, Women in Leadership, How to find the First Job, and Academy-Industry Partnership.

We were very appreciative of the strong support from our participants and many generous sponsors as well as our numerous symposia organisers, Australian Nanotechnology Network (ANN) staff and volunteers who contributed their time and talents to make ICONN another success this year.

International Conference on Bionano Innovation (ICBNI)

ICBNI 2020 presented the latest advances in the most exciting and commercially-promising areas of science and engineering, i.e. The interface between the biological and physical sciences at the nanoscale. Science and technology at the BioNano interface are delivering not only new understanding of our world, but are being translated into valuable products in a vast array of areas, such as microelectronics, biologics and other therapeutics, stem cell therapies, new vehicles and approaches to delivering drugs, advanced diagnostics tools, nanocomposites. The ICBNI brought world leaders in the relevant fields to discuss their latest results and the latest advances in the field.

The program of ICBNI 2020 was organised around six sub-themes: Bioinspired Nanomaterials; Fundamentals of BioNano Interactions; Diagnostics and Molecular Imaging; Nanomedicine; Biosensors; Tissues Regeneration and Renewal. The parallel sessions across the four days of the conference provided opportunities to learn of the latest advances in these cutting-edge fields. The sessions were arranged in partnership with our symposia co-organisers Barbara Rolfe, Swaminatha Iyer, Kris Thurecht, Leslie Yeo, Rona Chandrawati and John Forsythe.

Publications

Publications

Book Chapters

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Thank you

We thank our donors and supporters for their continued generosity. Our research has been enriched and enabled by ongoing contributions, and we are grateful for the opportunities that community support provides.

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REPORT 2020

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