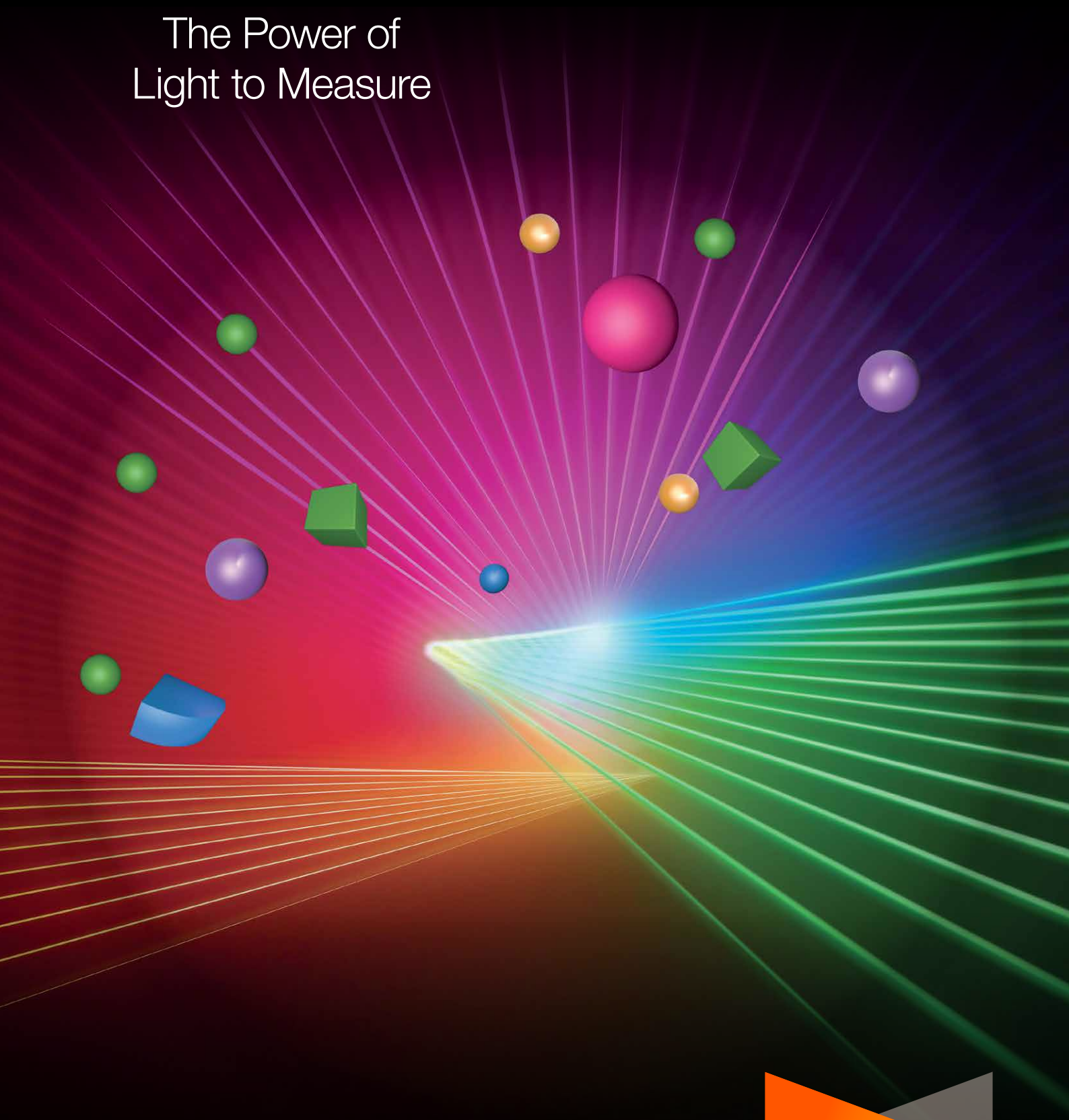




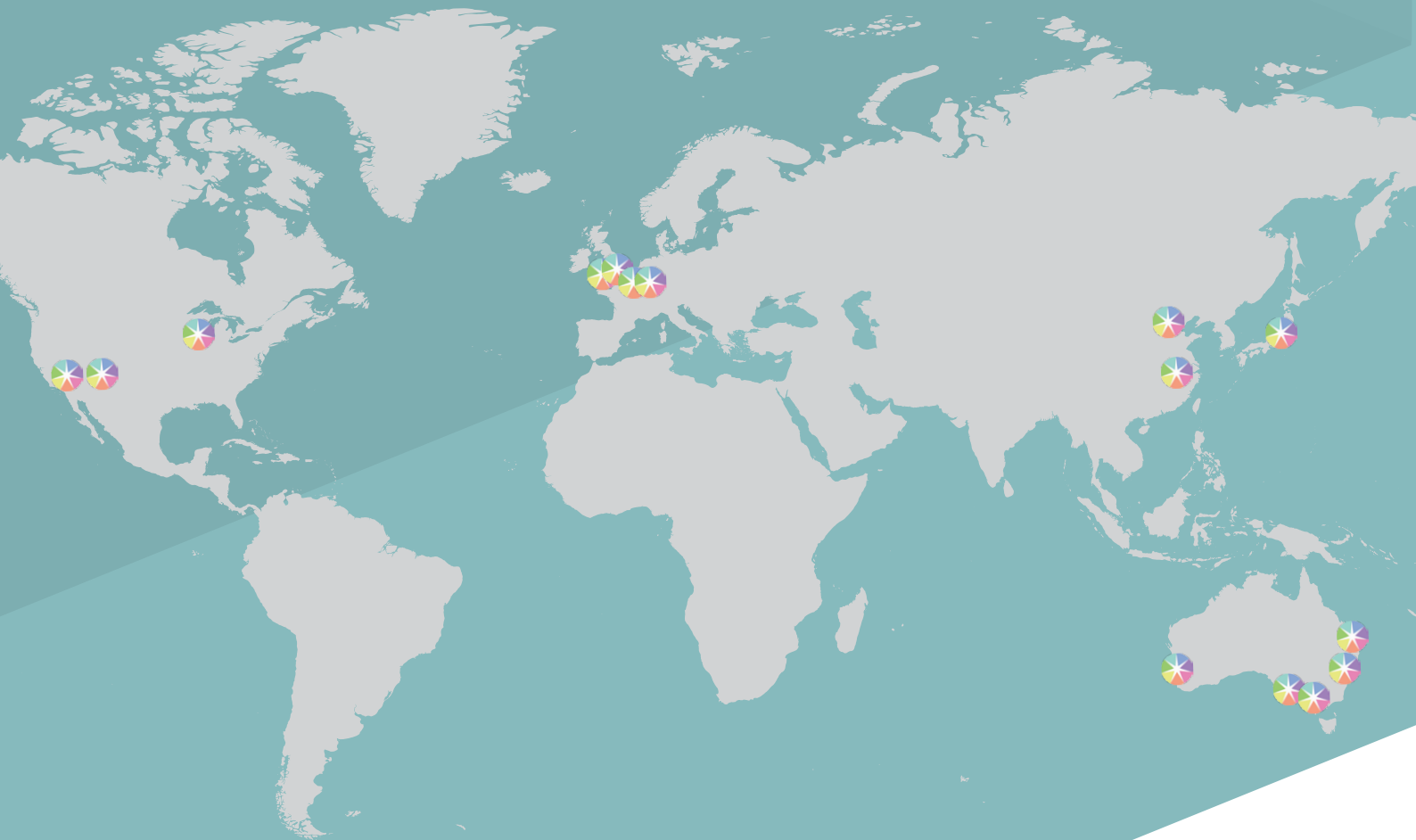
Centre for
**Nanoscale
BioPhotonics**
ARC CENTRE OF EXCELLENCE

The Power of Light to Measure



2018
ANNUAL
REPORT

CNBP links Australia's key nanophotonics groups and builds on Global Collaborations with a focus on doing the science required to advance biology.



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Welcome to the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP) 2018 Annual Report.

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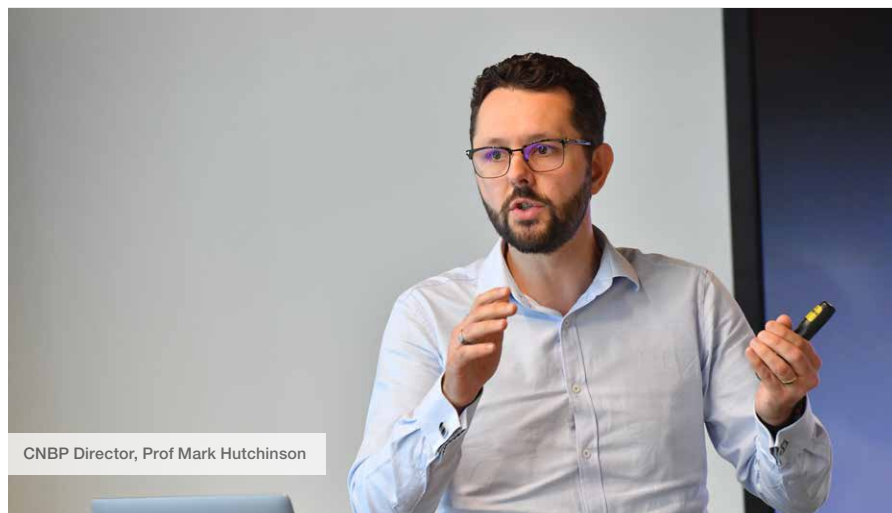
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Director's Report

Welcome to the 2018 annual report of the Australian Research Council Centre of Excellence for Nanoscale BioPhotonics, a highlights package of the scientific and translation journey we have been on for the past 12 months. In now our fifth year of operation, the CNBP team have stepped into a new domain of scientific convergence, enabling some amazing scientific and organisational outcomes and continuing to deliver more ground-breaking firsts for our Centre.

The journey of the CNBP began by asking questions at the nanoscale of biological life with a focus towards understanding fundamental human physiology. These challenges of advancing technology were set forth because it is at the nanoscale that we can begin to guide light to interact with biology. It is at the nanoscale where we can create light where we need it to sense and image the inner workings of diverse cells. It is at the nanoscale that we can observe life begin, watch the triggers of pain be activated, and heart disease evolve. During 2018 this human focus has scaled to meet the opportunities and measurement needs of our colleagues in the clinical and agriculture sectors. Within the CNBP we are exploring mammalian biology at the nanoscale and translating these discoveries into high impact scientific outcomes and industry ready technologies. I am very excited to see the commercial legacy of our high impact



academic activities; CNBP research translated into end-user products by our clinical and agricultural collaborators.

Our Centre's science program continues to focus on the three domains of Imaging, Sensing and Discovery. Underpinning these areas of research are our fundamental motivations to capture images and make sensing measurements in 1) ultrasmall volumes; 2) in defined spatial compartments; 3) *in vitro*, *ex vivo* and *in vivo*, in behaving models; 4) at the relevant timescale, including in real-time; 5) at new limits of a resolution, sensitivity and specificity level; 6) using deployable devices. All research projects within the CNBP supported program are on a trajectory to reach one or more of these aspirational targets and are linked to our key biological challenges in IVF technologies, neuroscience and cardiology.

As we expand this narrative of academic excellence through our growing list of academic publication and conference presentations we are being increasingly engaged by industry who are seeking similar solutions in their own domains. This has seen the CNBP team undertake over 21 Industry engagements during the year leading to 7 joint industry projects. The start-ups that have sprung from the Centre's activities continue to thrive in the vibrant and supportive environment that our host institutions promote. To compliment this the CNBP ran our inaugural Entrepreneurial program culminating in a competition for the best pitch. Congratulations to Woven Optics who were selected as the 2018 winners. It will be exciting to see where all these teams take their new skills in the future.

The CNBP hosted numerous events in 2018 including Scientific and Clinical engagement workshops; Community

ACADEMIC
EXCELLENCE



NURTURING
ENVIRONMENT



QUALITY
COMMUNICATION



COMMERCIAL
IMPACT



CNBP's philosophy of convergence, both people and their science, is laying the foundation for CNBP's legacy by delivering amazing new talent and ideas that will persist well into the future.

engagement linking with National Science Week, University Open Days and School visits. CNBP also hosted industry networking events in three states and was a key leader at the STA 'Science meets Business' event in Brisbane. These events saw engagement with representatives of the State and Federal Governments, industry, members of the University communities and the general public. These collective activities exemplify our key pillars of Academic Excellence, Commercial Impact, Quality Communication and a Nurturing Environment. Since the beginning of CNBP, these principles have grown from an organisational initiative into meaningful actions. This can be seen in our amazing science programs and has been reflected in the ways we have conducted our science through open communication channels with industry and government during 2018.

The Fifth Centre Scientific Conference was a resounding success with nearly 100 Centre members in attendance for the three-day event. At this year's conference presentations were themed to highlight CNBP's success in building cross-nodal transdisciplinary research projects. Once again the retreat highlighted and strengthened CNBP's vibrant culture of nurturing and mentoring members across all career levels.

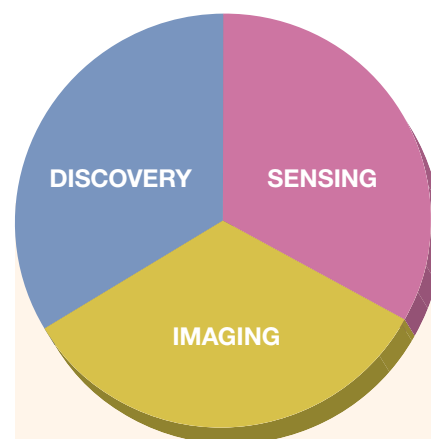
CNBP has intentionally evolved from: building the team; extending CNBP's science across disciplines; moving planning to actions; and creating intentionality in project delivery. In 2018 (and as we look to 2019) we are focused on active TEAMING, by engaging in dynamic activity, not a bounded, static team structure. Our thematic research focus areas bring together the diverse scientists of the CNBP to encourage regular and persistent team engagement. This research journey encourages regular sharing of information and knowledge. CNBP's philosophy of convergence, both people and their science, is laying the foundation for CNBP's legacy by delivering amazing new talent and ideas that will persist well into the future.

I would like to congratulate all of the Centre's personnel for a highly successful and productive year. Thanks to our wonderful CNBP leadership team for all their hard work in 2018. These are exciting times!



Prof Mark Hutchinson
Director, CNBP

Light to Measure



Our Fundamental Motivations are to Make Imaging and Sensing Measurements

- 1 in ultrasmall volumes;
- 2 in defined spatial compartments;
- 3 *in vitro*, *ex vivo* and *in vivo*, in behaving models;
- 4 at the relevant timescale, including in real-time;
- 5 at new limits of a resolution, sensitivity and specificity level;
- 6 using deployable devices.

Impact Areas

- 7 visualise and sense the working neuroimmune interface;
- 8 quantify and diagnose pain;
- 9 create *in vivo* tools for cardiology;
- 10 detect and monitor cellular responses in atherosclerotic plaques;
- 11 quantify sperm/embryo/oocyte quality;
- 12 visualise and sense the working reproductive tract.

Who We Are

CENTRE DIRECTOR

Prof Mark Hutchinson



JOINT DEPUTY DIRECTORS

Prof Ewa Goldys



JOINT DEPUTY DIRECTORS

Prof Brant Gibson
RMIT University
Node Director



PROFESSIONAL TEAM

Dr Kathy Nicholson
Chief Operations
Officer



PROFESSIONAL TEAM

Mrs Melodee
Trebilcock
Partnerships, BD
& Events Manager



PROFESSIONAL TEAM

Mr Tony Crawshaw
Comms & Outreach
Co-ordinator



SCIENCE LEADERSHIP TEAM

Prof Andrew Abell
The University
of Adelaide
Node Director



SCIENCE LEADERSHIP TEAM

Prof Jim Piper^{AM}
Macquarie
University
Node Director



SCIENCE LEADERSHIP TEAM

A/Prof Daniel
Kolarich
Griffith University
Node Director



SCIENCE LEADERSHIP TEAM

Prof Tanya
Monro



SCIENCE LEADERSHIP TEAM

Prof Heike
Ebendorff-
Heidepriem



SCIENCE LEADERSHIP TEAM

Prof Stephen
Nicholls



SCIENCE LEADERSHIP TEAM

Prof Andrew
Greentree



SCIENCE LEADERSHIP TEAM

Prof Jeremy
Thompson



SCIENCE LEADERSHIP TEAM

Prof Nicolle
Packer



SCIENCE LEADERSHIP TEAM

Prof Robert
McLaughlin



SCIENCE LEADERSHIP TEAM

Dr Christina
Bursill



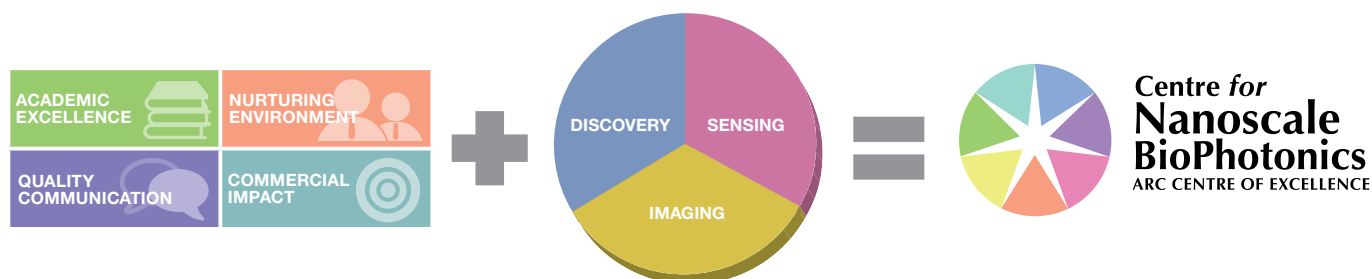
ASSOCIATE INVESTIGATORS AI

PARTNER INVESTIGATORS PI

RESEARCH TEAMS

CNBP Strategy

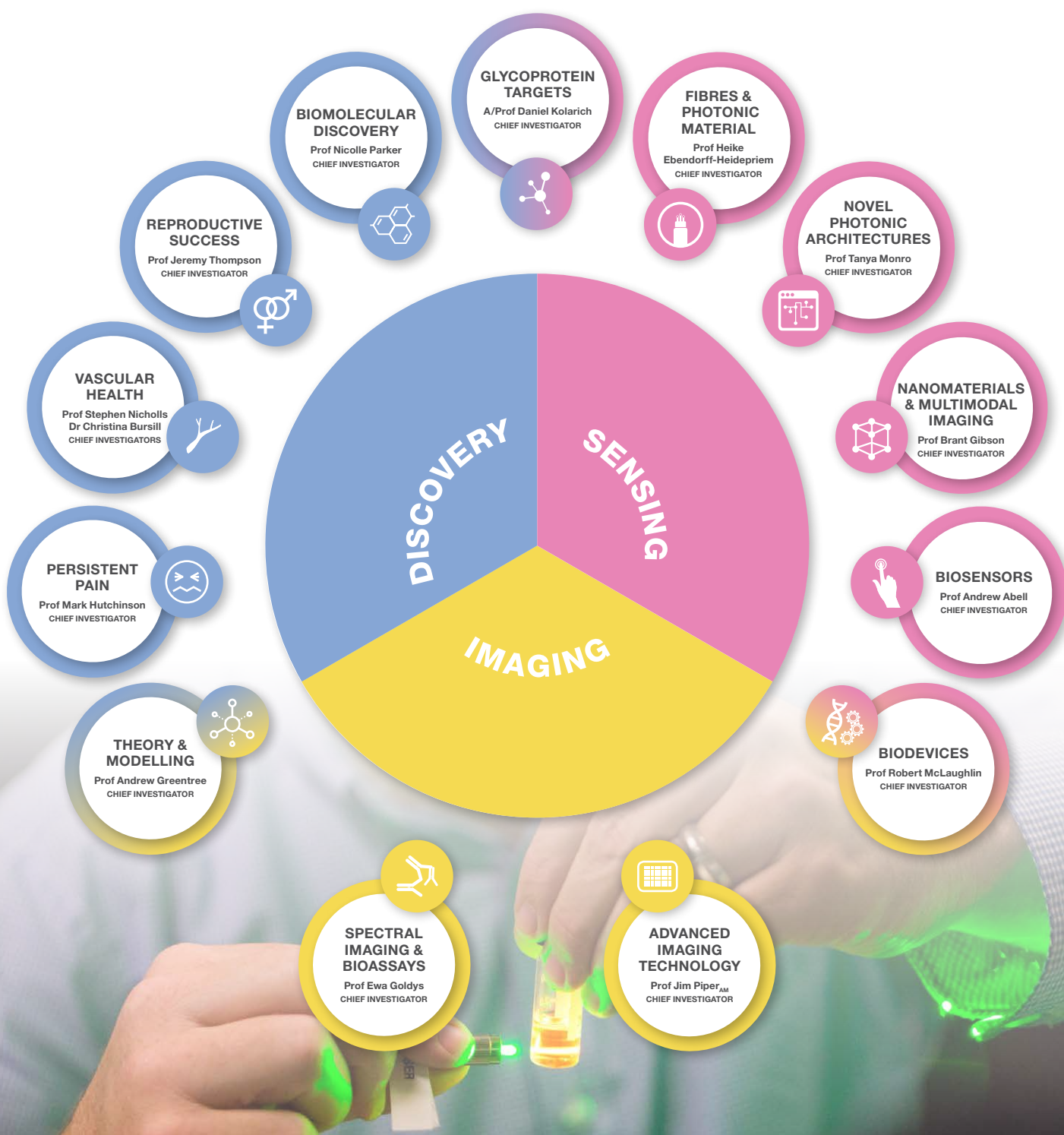
CNBP will drive the development of new devices to measure and sense at the nanoscale level, providing powerful new ways of understanding cellular processes within the human body.



	ACADEMIC EXCELLENCE	NURTURING ENVIRONMENT	QUALITY COMMUNICATION	COMMERCIAL IMPACT
Strategic	<ul style="list-style-type: none"> • Delivering research excellence in Nanoscale BioPhotonics; • International recognition of the Centre and its researchers as leaders in Nanoscale BioPhotonics; • Focussed research priorities. 	<ul style="list-style-type: none"> • Provide individually tailored career development focusing on traditional and non-traditional pathways; • Encourage children and young adults to pursue careers in research; • Foster resilience; • Growth from positive failure. 	<ul style="list-style-type: none"> • Increase public awareness of value of science; • Engage with stakeholders to demonstrate impact and relevance of CNBP research; • Bridge communication gaps between disciplines and geographic locations; • Increase reputation and collaboration for new opportunities. 	<ul style="list-style-type: none"> • Translate research in a timely manner; • Deliver needs-driven research; • Capture high-value IP portfolio; • 20 Outcomes from 20 ventures by 2020.
Tactical	<ul style="list-style-type: none"> • Attract best people to produce impactful research outcomes; • Set and contribute to International research agenda; • Develop research synergies to address centre flagships. 	<ul style="list-style-type: none"> • Provide supervision and project management opportunities; • Drive transdisciplinary research; • Mentor ECRs and students; • Champion equal opportunity policy. 	<ul style="list-style-type: none"> • Benchmark best practice; • Leverage technology; • Leverage existing and grow new networks with prioritised relationships; • Ensure consistent brand identity; • Develop internal and external 'go to' spokespeople. 	<ul style="list-style-type: none"> • Build collaborative projects with large companies; • Spin out small companies; • Engage with end users throughout projects; • Train ECRs about commercialisation.
Operational	<ul style="list-style-type: none"> • Build large transdisciplinary teams to solve major challenges; • Engage with key international and national stakeholders; • Structure connecting networks of researchers; • Develop research integrity policy and scrutinise research. 	<ul style="list-style-type: none"> • Enable workshops and professional development; • Support 5% time for non-research activities; • Train individuals based on interest, strength and existing capabilities; • Offer awards and travel grants; • Implement gender equity and diversity policy. 	<ul style="list-style-type: none"> • Tailored communications and activities for target audiences; • Build common language; • Develop key messages and consistently branded communications; • Identify and train individuals; • Convene expert advisory committees and workshops including key stakeholders. 	<ul style="list-style-type: none"> • Market CNBP to potential partners; • Attract collaborative funding for new projects; • Build partnerships with end-users; • Develop internships with industry and end users; • Grow technology readiness levels.
Contingency	<ul style="list-style-type: none"> • Grow strategically, rewarding existing organisational support; • Secure expert advisor network from industry, communication, academia and policy to ensure sound governance and maximum impact; • Structure outputs for maximum benefit across multiple domains. 			
Legacy	<ul style="list-style-type: none"> • Setting the agenda for Nanoscale BioPhotonics research with foundational papers in the public domain; • Resource the Australian community with examples of how to deliver bold science successfully; • Disruptive tools using light to measure - allowing biologists to ask new questions / solve hard problems; • Knowledge and tools for work in transdisciplinary and/or translational research; • CNBP alumni are trained to be transdisciplinary science leaders and communicators in and out of Academia; • End Users have an increased awareness about the research / clinical / commercial opportunities created by Nanoscale BioPhotonics; • Job creation through spin-out companies and exposure of scientists to entrepreneurial and Industry practices; • Legacy partners continue CNBP work beyond current funding. 			

CNBP Focus Areas within Discovery, Sensing & Imaging

CNBP carries out fundamental research strategically directed at the **discovery** of molecular-nanomaterial- and optical fibre-based light-responsive tools that **sense** and **image** the molecular origins of health and disease. Our cohesive program is focussed on research challenges in **Persistent Pain, Reproductive Success** and **Vascular Health**. We seek to understand the complexity of the living body, casting new light on how life begins and how our brain works.

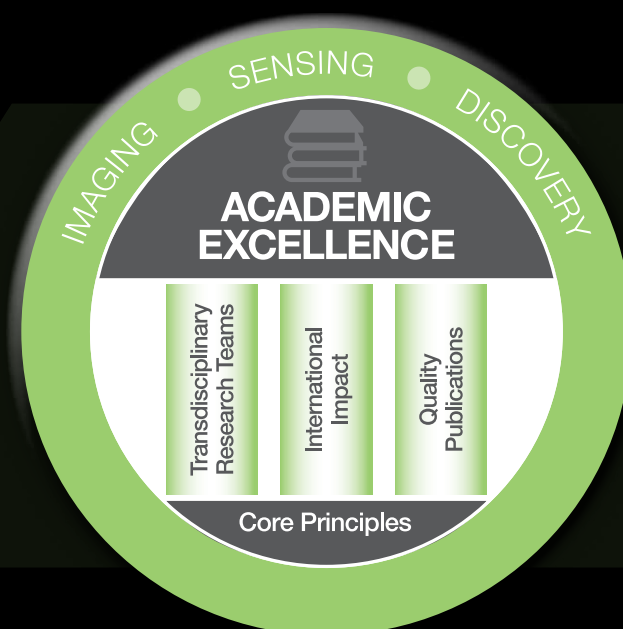


KPIs at a Glance





Academic Excellence



The Centre for Nanoscale BioPhotonics (CNBP) carries out fundamental research strategically directed at the **discovery** of molecular-nanomaterial- and optical fibre-based light-responsive tools that **sense** and **image** the molecular origins of health and disease.

Our cohesive program is focussed on research challenges in **Persistent Pain, Reproductive Success and Vascular Health**. We seek to understand the complexity of the living body, casting new light on how life begins and how our brain works.

This year it has been exciting to witness the continuous evolution of CNBP fibre technology as well as see significant achievements in making real time measurement within *in vivo* systems.



Advances in Fibre Sensor technology

Monitoring baby health during delivery remains an outstanding challenge within medicine, as the best techniques to date rely on subjective monitoring of the baby's ECG to indicate any potential stress from lack of oxygen. One possible solution to this is to directly measure stress within the baby, by looking at the acidification of blood to rapidly identify any potential issues during delivery. This was the subject of a successful NHMRC grant, which investigates using a pH sensitive optical fibre, previously used for differentiation between cancerous and healthy tissue, to measure blood pH to create an *in vivo* probe which can be used during delivery.

A second application related to this involves the combination of imaging (optical coherence tomography, OCT) and fluorescence sensing, by modifying a probe such that OCT can be performed through the sensing layer enabling precise location of the probe, or measurements of blood flow and tissue structure while measuring chemical species or temperature in the local environment. Preliminary work was published in 2018 in *Biomedical Optics Express*, looking at combining OCT and temperature sensing within an *ex-vivo* setting.

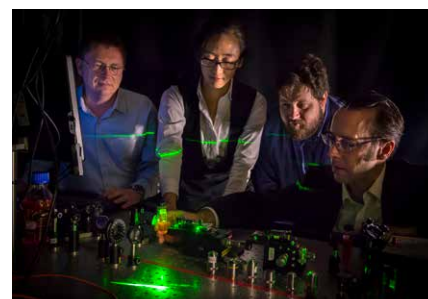


Image-guided sensing

Optical fibre sensors, able to detect everything from temperature to the presences of specific chemicals, are used throughout industry. Increasingly, they are finding applications in medicine and biology to monitor disease. Researchers at the CNBP have developed a new generation of image-guided fibre sensor that can see where it is going. Published in the journal *Optics Letter* (Li et al., 43(8):1682-1685, 2018), a multi-disciplinary team combined experts in fibre sensors, imaging and neurophysiology to develop a tiny probe able to measure temperature and simultaneously acquire a high-resolution image of the tissue around it, and then demonstrated this in a brain. 'Fibre sensors need to be positioned in the right place to take an accurate measurement,' said lead author Dr Li. 'We created a fibre sensor that measured subtle changes in temperature through variations in fluorescence of the glass, and could also focus a second type of light into the tissue to image its microstructure. This way, we can see if the sensor is in the right place.' The team is now extending this work to detect the presence of a range of chemicals, based on research from other groups in the CNBP.

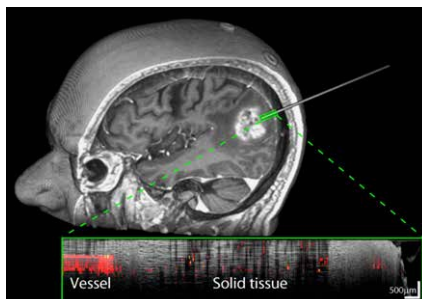
Project Highlights

Taking Fibre Tools *in vivo*



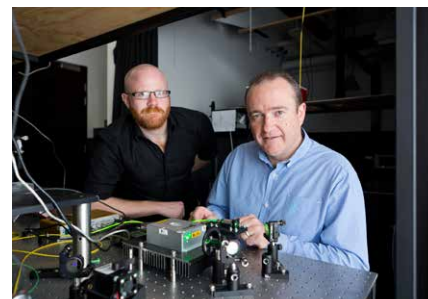
Spatial Protein Release

Mounting evidence indicates that cytokines secreted by innate immune cells in the brain play a central role in regulating neural circuits that subserve mood, cognition, and sickness responses. A major impediment to the study of neuroimmune signalling in healthy and disease states is the absence of tools for *in vivo* detection of cytokine release in the brain. We have developed a cytokine detection device capable of serial monitoring of local cytokine release in discrete brain regions. The immunocapture device consists of a modified optical fiber labeled with a capture antibody specific for the pro-inflammatory cytokine interleukin-1 beta (IL-1 β). Using a sandwich immunoassay method, *in vitro* data demonstrates that the sensing interface of the modified optical fiber has a linear detection range of 3.9 pg mL⁻¹ to 500 pg mL⁻¹ and spatial resolution on the order of 200-450 μ m. We have also demonstrated that the immunocapture device can be introduced into a perforated guide cannula for repeated analyte measurements *in vivo*. An increase in fluorescence detection of spatially localized intrahippocampal IL-1 β release was observed following a peripheral lipopolysaccharide challenge in Sprague-Dawley rats. This novel immunosensing technology represents an opportunity for unlocking the function of neuroimmune signaling.



Safer brain surgery with a smart needle

CNBP researchers from the University of Adelaide have developed a smart brain biopsy needle and brought it into a world-first human trial. Containing a tiny imaging probe, the thickness of a human hair, the researchers have built a brain biopsy needle that can see where it is going and warn the surgeon before they damage delicate blood vessels. Working with neurosurgeons from Sir Charles Gairdner Hospital in Western Australia, they tested their needle with 11 patients undergoing brain surgery, and were able to detect blood vessels with a sensitivity and specificity of 91% and 97%, respectively. Project lead Prof. Robert McLaughlin said 'It's exciting to bring a device like this all the way from the research bench and into human surgery.' Reported in the journal *Science Advances* (Ramakonar et al., 4:eaav4992, 2018), the smart needle technology has applications in a wide range of surgeries. 'This research has great commercial potential, and we've already identified other applications in neurosurgery where a smart needle could really make brain surgery safer,' says Prof. McLaughlin.



Microendoscope *in vivo* Trial

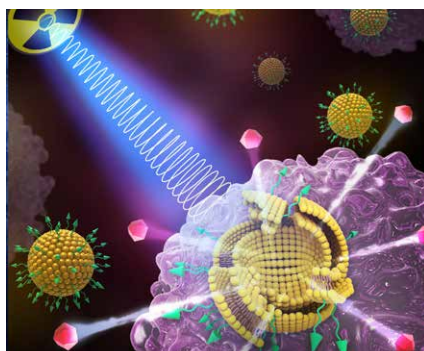
A new collaboration with clinicians at the Royal Melbourne Hospital, Royal Children's Hospital and Murdoch Children's Research Institute has enabled a first *in vivo* trial of the fluorescence microendoscope.

This endoscope uses new multi-modal imaging capabilities, enabling simultaneous presentation of two images. The OCT structural images can be captured alongside functional change, visualised by fluorescent biochemical sensors.

Future Plans

CNBP researchers are exploring new ways that optical fibres can help medical clinicians, biologists and physiologists. This includes creating biologically compatible coatings for fibres, developing highly-specific chemical sensors and integrating these with a range of fibre-optic imaging techniques. These multi-disciplinary projects are creating a new generation of highly miniaturised windows into the body.

Numerous small molecule sensors and probes have been developed within the CNBP, with specific measurement targets such as pH, ROS, nitric oxide and zinc sensing. While these sensors work well *in vitro*, we now need ways to take them into a true *in vivo* setting. With this in mind, current projects are focussed on conjugating our sensors to a carrier molecule, such as an antibody or nanoparticle, to allow delivery to a specific *in vivo* location.



Functionalisation of IgM

**Dr Edward Moh and
Prof Nicki Packer**

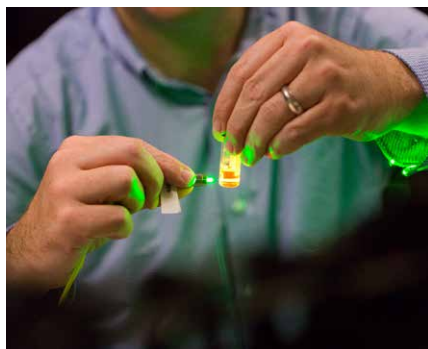
In this project specific enzymes have been used to attach azide functionalised sugar molecules to a glycan chain within the antibody IgM, generating a unique chemical group for conjugating other small sensor molecules by biocompatible click chemistry. Advanced mass spectrometric techniques have been used to quantify the amount of sensor loading to IgM, with the associated intellectual property protected by a recent provisional patent. Highly collaborative work across the CNBP is now underway to use this technology to functionalise silk protein as used in optical fibre-based sensing platforms.



Spiroparticle Delivery System

**Prof Andrew Abell, Dr Sabrina Heng
and Dr Michelle Zhang**

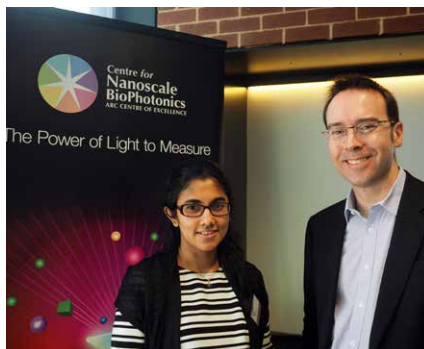
We have developed a new spiropyran-based stimuli-responsive delivery system (spiroparticle) that encapsulates and then releases an extraneous compound in response to elevated levels of Zn^{2+} , a critical factor in cell apoptosis. These spiroparticles have been shown to release an encapsulated proteasome inhibitor in Zn^{2+} -treated breast carcinoma cell line models. This then inhibits intracellular proteasome and induces cytotoxicity to the carcinoma cells. The work was recently published in Chem. Eur. J. 2018, DOI: 10.1002/chem.201804816 and ongoing work is concerned with developing its generality for target delivery of different sensors and therapeutics. In another delivery project, Tom Avery has led a collaboration with CNBP AI A/Prof Peter Grace from MD Anderson Cancer Centre to develop prodrugs of dimethyl fumarate that specifically target the dorsal root ganglia (DRG) in a neuropathic pain state. This prodrug is activated in the presence of reactive oxygen species to potentially avoid drug induced damage of healthy tissue, while delivering the active drug to the DRG. A provisional patent has recently been filed.



Controlling and Fine-Tuning Chemistry with Nanoenvironments

Roman Kostecky, The University of Adelaide & colleagues

Chemical reactions such as the ability of a host to bind a specific guest molecule and elicit a response is central to many biological processes, such as the action of an enzyme or hormone. Although these processes are primarily defined by the chemistry of both species, they are also influenced by the local molecular environment (nanoenvironment) that they experience. The potential influence of the nanoenvironment is poorly understood and underexplored as a means to control and fine-tune the way molecules react to each other. An ability to control these chemical interactions and resulting function, without changing chemical structure, is an attractive proposition with applications in advanced sensing and drug delivery. Our work demonstrates that we can design molecules which selectively bind to different chemical species depending on the nature of the associated nanoenvironment. This provides a basis for unique and relatively unexplored opportunities to control and fine-tune chemistry with nanoenvironments.



New Sensing Platforms

Achini Vidanapathirana

A highly collaborative study on the development of a potent sensor for nitric oxide (NO) was recently published in Scientific Reports. The sensor is stable and active after immediate freezing of plasma samples and subsequent freeze-thaw cycles. Based on these findings, clinical studies are now warranted to test the utility of the sensor to detect and quantify soluble circulating NO in cardiovascular health and disease.

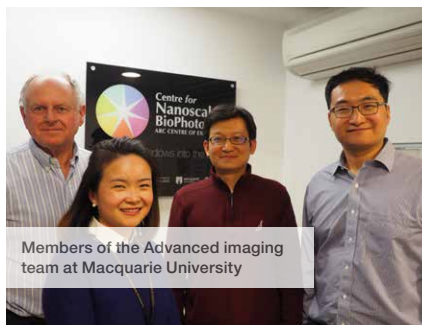


Future plans

Work is continuing on advancing the biology associated with these projects and research grants are currently being planned to support studies beyond that which is possible with CNBP funding. This will allow development of more medical aspects of the work. A new Masters research student will commence work on the studies in April with Tom Avery and International AI A/Prof Peter Grace.



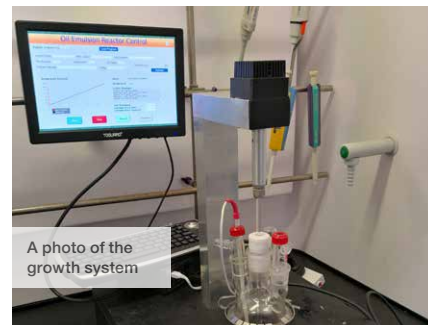
What a year it has been for the Advanced Imaging team! There have been significant breakthroughs in research and development across the areas of multiplexed molecular deep imaging through biological tissue, up-conversion nanoparticles, field-deployable imaging solutions and how quantum mechanics can improve microscopy. A summary of the results obtained from each of these highlighted research areas is described in this section. The significance and future implications of the work is also discussed towards the overarching goal of the CNBP to use the power of light to measure and create windows into the body.



Members of the Advanced imaging team at Macquarie University

Multiplexed lifetime imaging

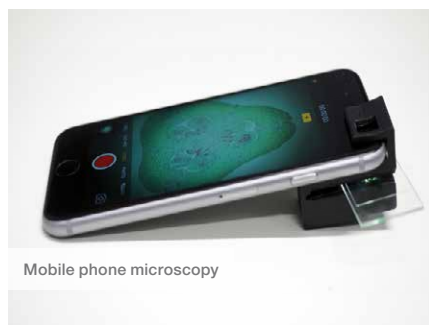
Accurate disease diagnosis generally relies on not one, but a plurality of biomarkers to be measured simultaneously (i.e. multiplexing). While it is routinely performed on samples taken out of the body, multiplexing remains a grand challenge to achieve directly in the body due to the complex interferences from a variety of biological tissues. In collaboration with Prof Fan Zhang's group at Fudan University, CNBP AI Dr Yiqing Lu, CI Prof Jim Piper and colleagues have developed a new technology that enables multiplexed molecular imaging deep through biological tissues. To do this, the team engineered a series of nanoparticles emitting at infrared wavelengths with tunable luminescence lifetimes, and an imaging system capable of decoding the lifetimes to recognize different biomolecules. The team demonstrated multiplexed imaging of breast cancer biomarkers *in vivo* using a mouse model, yielding consistent results to the standard assays performed on extracted samples, opening a new avenue to minimally invasive disease diagnosis.



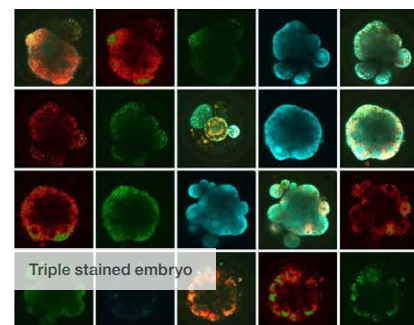
A photo of the growth system

UCNP Production

While upconversion nanoparticles (UCNPs) have found a broad range of novel applications that are infeasible using transitional fluorescent probes, their reproducible growth remains a major challenge as it is very sensitive to the reaction conditions. This has a significant impact on the consistency of their performance as well as functionalization, a key roadblock towards practical applications. CNBP CI Prof Jim Piper, AI Dr Yiqing Lu and colleagues have developed an automated growth system, which enables reliable and robust synthesis to yield UCNPs with consistent size, shape, structure and performance. Implementing a series of real-time sensors with fine-tuned feedback controls, the system can load any programmable growth protocol and execute it accurately with batch-to-batch variation below 5%. This new capability significantly advances the research on UCNPs at CNBP towards real-world applications, fostering several industrial partnerships to develop novel solutions in the areas of disease diagnosis and product authentication.



Mobile phone microscopy



Triple stained embryo

Mobile Phone Microscopy

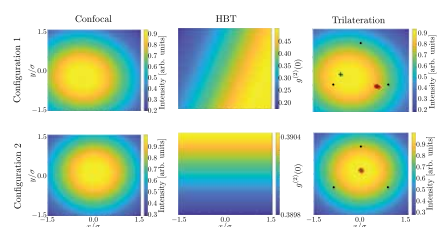
Dr Antony Orth, RMIT University

Microscope-enabled mobile phones have emerged as a platform technology for point-of-care diagnostics. These augmented consumer electronics allow the user to identify microscopic disease-causing parasites. In the CNBP, we have developed an ultra-simple microscope clip for mobile phones that enables brightfield and darkfield microscopy of living cells, parasites and plants. Our approach differs from previous mobile phone microscopes by relying on either sunlight or the camera's internal flash for illumination instead of an externally-powered light source. As a result, the CNBP microscope is extremely easy to assemble compared to other reported designs. Three-dimensional printing files have also been released open-source so that anyone with a 3D printer and a second mobile phone camera lens can build the device. The simplicity of the design should make the CNBP mobile phone microscope an attractive device for researchers in fields where on-site microscopy is required.

Quantum trilateration – counting photons for better microscopy

Prof Andrew Greentree, RMIT University

Microscopy is a familiar task to many of us, and the engine of much of our science. But interestingly, almost all microscopy uses the picture of light that is almost 350 years old. We have sought to understand what happens when we include the quantum description of light, photons, in our microscopes. Imagine the problem of trying to locate a single emitter in a plane. You would need to measure the intensity in at least three detector locations to work out where it is. This problem is called trilateration. However, if there are two particles, and only three locations at which to measure them, then classical physics precludes a unique solution, it is never possible to locate the two particles on the basis of three measurements, no matter how accurate. However, we have shown that by counting the number of photons that arrive at any point in time at just three locations, we can determine the particle positions. This represents a new quantum mechanical problem and shines a light on how quantum mechanics can improve microscopy.



Where to next...

The Advanced Imaging team at the CNBP is looking forward to the future with great anticipation regarding each of the research areas highlighted here and beyond. The next steps for the multiplexed lifetime imaging research area will focus on broadening the variety of different biomolecules which can be recognised deeply within an even wider range of biological tissues. Now that the production and characterisation of UNCPs within the CNBP has been standardised, the next steps for the use of these nanomaterials will focus on broadening their application in next-generation industrial areas specifically in disease diagnosis and product provenance. Regarding the mobile phone microscope, researchers within the CNBP are now focusing on broadening its use in fields where on-site microscopy is required such as the farming industry, water quality testing and management and reproduction applications. And finally, the next step for the quantum trilateration research project will focus on the experimental verification of the theoretical model with the aim of improving nanoparticle positioning resolution in challenging biological environments. The Advanced Imaging team at the CNBP is indeed looking forward to the year ahead.

The surface of every living cell is extensively decorated with specific sugar moieties, so called glycans. These glycans build the basis for a universal and absolutely essential language (glycome) that cells use to communicate. This glycan-based communication accompanies each living being for its entire life from the moment of fertilisation. This language, however, is also abused by pathogens and in diseases such as cancer, where cells change their glyco-language to change the function of their glyco-molecules to e.g. evade the immune system. We have been developing and applying novel tools that allow us to translate the glyco-language and the dialects to finally understand how cells speak to each other, and to others. This knowledge enables us to develop novel diagnostics or treatments and to develop novel tools to visualise cells by targeting an essential but previously underexplored molecular component of every biology.



The sugary path towards novel diagnostics.

A vast majority of protein-based disease markers are glycoproteins. Current protein-based diagnostics, however, do not evaluate the individual “glyco-stage” of these marker glycoproteins. Their specificity is additionally hampered as many of these disease-marker proteins do also occur in healthy people or as a consequence of benign conditions. For example, our systematic research on a specific cancer-marker glycoprotein such as carcinoembryonic antigen (CEA), a gastrointestinal tumour marker, allowed us for the first time to clearly uncover that its specific glyco-status can differentiate whether CEA is derived from a primary or metastatic tumour cell. We also identified novel, hitherto entirely unknown structural features on CEA glycans that bear the neglected potential to further improve the accuracy of this tumour marker that has been in use for more than 40 years, but that has still the reputation of having low specificity.



Sugar-coated nanoparticles for single cell imaging

Lanthanide doped upconversion nanoparticles (UCNPs) have a unique ability to upconvert near-infrared light of low energy (e.g. 980 nm) to emit in a higher energy, shorter wavelength. UCNPs have a low cytotoxicity, deep tissue penetration capability up to 3 cm², are highly photostable and have tunable long luminescence lifetimes. Therefore, they are ideal to use for background-free imaging, bioassays, and diagnostics in biological samples. However, one of the major challenges for adapting UCNPs in bio-applications is their hydrophobicity due to the presence of surface oleic acids (OA). In our study, we implemented the ligand exchange strategy, where hydrophobic surface molecules (OA) are replaced with an algal-derived hydrophilic polysaccharide, fucoidan. We developed hydrophilic, colloiddally stable, sugar coated UCNPs having a hydrodynamic size of 70-100 nm. Further, we have studied the uptake mechanism of these sugar-coated UCNPs in mouse cells and imaged them using confocal and STED microscopy. Using an in-house super-resolution imaging platform we observed single-particles inside the cells, which opens a new avenue to receptor trafficking studies in the future.

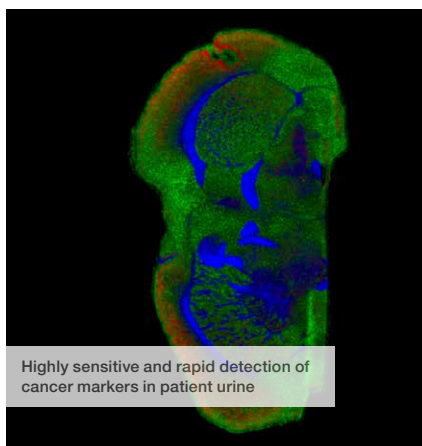


A/Prof Daniel Kolarich

Labelling of the Immunoglobulin M (IgM) glycans for targeted quantitative imaging and drug delivery

Immunoglobulin M (IgM) type antibodies are the largest antibody found in the body and have potential as new targeting and delivery molecules. Existing methodologies to functionalise IgG type antibodies are, however, not compatible with IgM type antibodies due to their larger size, multimeric structure and high glycosylation.

We have developed a novel method to functionalise IgM type antibodies by exploiting these unique characteristics of the antibody. Aiming at the numerous glycan chains, located away from the targeting region of the antibody, we introduced functionalised sugar molecules onto the glycan chains using enzymes. These functionalised sugar molecules provide unique chemical groups, enabling specific chemical attachment to small molecule drugs and imaging reagents. Using advanced mass spectrometry techniques, this approach also allows quantitation of the amount of drug or reagent on each functionalised sugar chain per IgM antibody. A provisional patent has been filed for this technology.



Highly sensitive and rapid detection of cancer markers in patient urine

Highly sensitive and rapid multiplexed detection of cancer marker in patients' urine

Prostate cancer is the most commonly diagnosed malignancy and the second leading cause of cancer deaths in the western male population. The current gold standard for diagnosis is prostate biopsy, a procedure informed by serum levels of prostate specific antigen (PSA). The biopsy procedure is invasive with more than 60% negative results. Detection of prostate cancer cells from the urine is non-invasive and can provide important information for biopsy decision. In a proof-of-principle study, we have successfully detected less than 10 cancer cells which express the proteoglycan antigen, from one ml of urine of prostate cancer patients using the two different imaging techniques of time-gated luminescence (TGL) and surface-enhanced Raman spectroscopy (SERS). This offers two new methods of early prostate cancer diagnosis from patient urine.

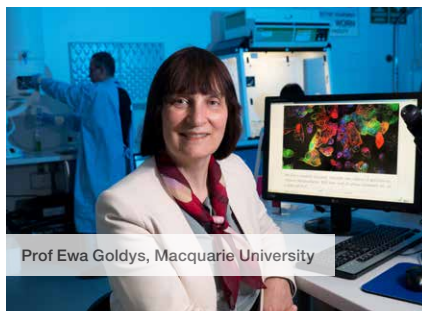
Goals and plans for 2019

The techniques which have been developed over the first five years of the CNBP are now being and will continue to be applied. Our newly developed technologies such as SERS (Surface Enhanced Raman Spectroscopy), time gated luminescence, sugar coated upconversion particles and nanodiamonds will be used and attached to sugar-recognizing molecules such as lectins and antibodies (IgG and IgM) to discover and image new markers of pain and cardiovascular disease as well as increasing our understanding of the reproductive process and the application of IVF in fertility. The underexplored areas of the extracellular matrix and the surface membrane glycolipids will form part of our continued discovery of the roles of sugars in cell biology, whilst the combination of MALDI- MS Imaging (MSI) with other CNBP molecular imaging techniques such as fluorescence, confocal Raman spectroscopy and hyperspectral imaging will be developed. This will provide highly relevant complementary information to enable the correlation of molecular histology and a snapshot of the tissue microenvironment to be obtained.

Pain is considered the “fifth vital sign” for monitoring medical care, yet the available methods to establish and quantify pain are highly subjective.

Current methods for rating pain are primarily based on patient self-scoring on a scale of one to 10, or by choosing from a series of faces depicting different levels of discomfort.

Children, dementia patients, and those unable to communicate verbally are often unable to meaningfully assess or communicate their discomfort. Self-scoring can also be manipulated by individuals for drug seeking behaviours. By identifying the ‘colour of pain’, our team is developing a blood test that will objectively identify if an individual is in pain. This will result in more accurate diagnosis and eventually, the ability to personalise pain treatments.



The colour of Pain – Hyperspectral imaging

The autofluorescent emissions from cells and tissues allows us to develop discriminatory models based on hyperspectral subtle colour measurements. We extended this approach to the study of brain and spinal tissue with interest in capturing a pain induced autofluorescence signature that generalises well across multiple animals.

We developed a new analysis approach that would help minimise the impact of local or animal specific spectral features and potential artefacts. We conducted a targeted projection pursuit to find a detection which was sensitive to the pain effect across multiple animals, while correlated with behavioural pain scoring. Having identified the best candidates for the “pain” signatures we then evaluated whether these signatures reflect a specific anatomy in the tissue, by mapping those segments onto the images of the slices.

Whilst further validation methods need to be built into the approach, we believe we now have a general pain-sensitive hyperspectral tissue model, which is far more discerning than a naive discriminatory analysis, and lays a foundation for exploring heterogeneous tissue samples containing sparse signal representation.



TLR4 pathway – not as simple as thought

Toll-like receptor 4 (TLR4) is a pattern recognition receptor that plays a critical role in pathogen recognition and activation of the innate immune system. TLR4 is also implicated in depression, chronic pain and opioid tolerance. Current understanding of the mechanisms controlling TLR4 signalling and regulation is limited due to its low expression levels.

We have adopted proteomics based approaches to detect and quantify TLR4 protein expression in a commercially available HEK293 cell line stably overexpressing TLR4 and its accessory proteins MD2 and CD14. Standard shotgun and targeted proteomics techniques were unable to detect TLR4 protein in the cell line tested. By utilising commercially available TLR4 peptides to generate a standard curve, the lowest detection level possible using targeted proteomics techniques was identified as 25 fmol.

A CRISPR transgenic mouse model has been generated. By genetically modifying the TLR4 gene to introduce a fluorescent protein to its C-terminal tail, the expression pattern and localisation of the receptor will be characterised. Concurrently, optimisation studies are being conducted to increase the expression of TLR4 in an *in vitro* system.

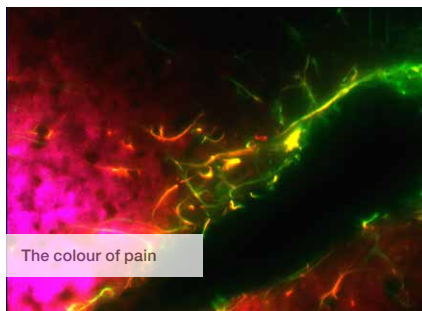


Detecting nitroxyl (HNO) using fluorescent chemical probes in biology

Many biological functions such as pain signalling within the spinal cord and brain, depend upon prolonged reactions between ligands and receptors, which can be measured at either the DNA, RNA or protein level. However, there are also important signalling events that occur which involve highly reactive molecules that are very short-lived and difficult to measure such as the nitric oxide species, nitroxyl (HNO).

CNBP chemist, Dr Michelle Zhang has created various “colours” of turn-on fluorescent probes that become activated in the presence of these short-lived molecules and allow direct detection of this species. These novel nitroxyl fluorescent probes are highly stable, very bright and low bleaching and are showing promising results for detecting biologically relevant levels of nitroxyl within cells and potentially tissue, in the presence of biological buffers.

Preliminary work shows that these probes can be detected using both plate reader and confocal imaging platforms with little interference from cell culture media. Future outcomes from this work could lead to potential commercialisation of these compounds.



Industry translation of CNBP pain technologies

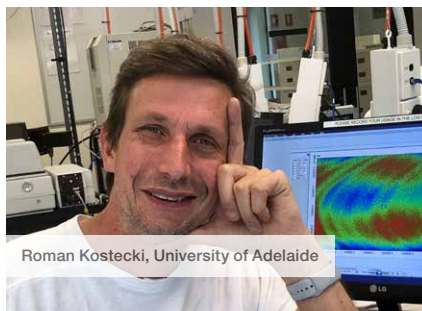
Owing to the lack of pain biomarkers our CNBP technologies have been eagerly received by the clinical and industry communities. This has seen the initiation of clinical trials in Australia and the USA employing our technologies to provide prospective validation data. These fundamental discoveries has also advanced ongoing collaborations with Novartis, St Jude Medical and Phebra. The opportunities to take these pain measurement tools into new animal species has also allowed work to getting in beef cattle and pigs, with the goal to provide the first objective assessment of pain in production animals.

Goals and plans for 2019

During 2019 the pain team will have new people and new datasets become available. We will have the American Australian Association CNBP Fellow Logan Jenkins work with us on the CNBP and AFOSR related neuroimmune pain control projects. This will bring Logan's expertise in light control of neuronal activity from Vanderbilt University, to explore the neuroimmune consequence of these approaches. We will also be embarking on new pain measurement projects in Rheumatoid and Osteoarthritis in Florence Lees' new PhD project. And finally, the results of two large clinical trials that have used CNBP technology will become available allowing us to take the next steps in translating our promising proof of principle data.



The 'Reproductive success' theme incorporates the Centre's photonics and other non-invasive, light-based technologies, to explore the critical events of early life, such as egg maturation, fertilization and embryo development leading to pregnancy establishment. Much of the research to date has investigated these events using *in vitro* models, especially measuring difference in critical ionic changes and determining the capacity of multispectral auto-fluorescence to assess normality of sperm and embryos. Excitingly, we are transitioning some of our work from the *in vitro* models to investigate what occurs *in situ*, inside the reproductive tract itself. One consequence of this transition is the development of new platforms to achieve this. Another consequence is leading us to create new devices that fulfil an ambition to ultimately automate the process of fertilisation and early development, providing standardised environment for all IVF laboratories.

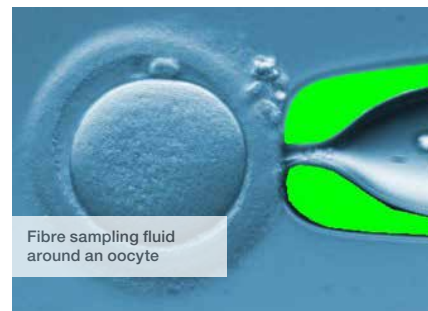


Photonic Device for Measuring Fertilisation Success during IVF Treatment

Intracytoplasmic sperm injection (ICSI) is used in more than half of all IVF treatments to help couples conceive when men are infertile. The process is extremely invasive and costly, and the lost opportunity to produce a viable embryo is the greatest fear for any infertile couple undergoing treatment.

We address the phenomenon of 'failed ICSI fertilisation' by providing the embryologist with a tool to measure successful or failed egg activation. Our new photonic device is able to tell if an egg is successfully activated by measuring the cascade of molecular signalling events that immediately follow fertilisation. By knowing if the ICSI treatment wasn't successful, the embryologist is able to salvage the egg.

Our platform approach provides ongoing opportunities to add a range of different sensing capability, including the ability to measure health of the sperm and to measure the eggs potential to become a viable and healthy embryo.



Imaging and 'Features' analysis of embryos is predictive of pregnancy

A long-desired aim in both livestock and human assisted reproduction is to accurately assess the pregnancy-forming potential of an embryo generated with IVF technology prior to transfer to the mother. With Meat Livestock Australia co-funding and collaboratively with the Davies Research Centre, University of Adelaide, we have worked closely with a company, Quantitative Pty Ltd (started by a former CNBP researcher), to undertake a bespoke algorithm approach, described as 'Features analysis', of images of cattle embryos immediately before embryo transfer into recipients. The results to date are very exciting; the predictive capacity of this new approach was over 95% accurate. Further validation is on-going, and we have significant interest from commercial entities already. In a parallel pathway funded by the University, human embryos developed and imaged with time-lapse are also showing similar exciting results.



A new platform for embryo development, leading to automation of IVF techniques

Embryologists have looked to microfluidic systems over the past 2 decades to provide a suitable platform that enables culture formulations to be altered during the culture period (5 – 7 days, depending on species) without removal from the incubation environment. Although achievable, no clinical uptake has occurred, due to the complexities of delivering microliter volumes and the limits in materials that have the right gas (to enable high CO₂ and low O₂ environments required) and water vapour permeability properties. During a sabbatical in the last half of 2018 at the RMIT University node, Jeremy Thompson, in collaboration with Tony Orth, Brant Gibson and Andrew Greentree, along with Al David Gardner at Melbourne University, created a new concept made possible by the RMIT's 'Nanoscribe', the world's only micron-scale 3-D printer. The advantages already identified include printing with a clear polymer, that when treated appropriately is not embryo toxic to early embryos. We are also confident of functionalising the polymer, to be able to "sense" events such as fertilization.



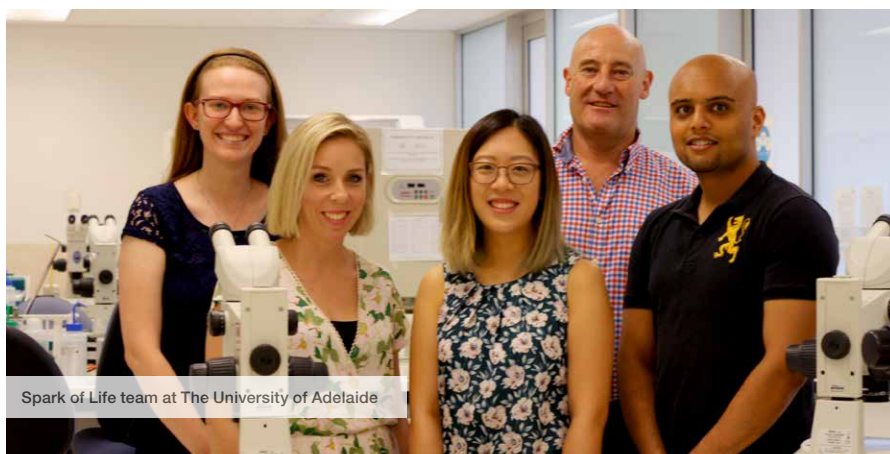
Photonic fibres to measure the reproductive tract environment

CNBP researchers Avi Saini, Hanna McLennan and Georgina Sykes have been modifying a pH sensing fibre, using an embedded pH fluorophore into polymer, to measure the change in pH of an oocyte surrounded by its nurse cells (the cumulus cells) as a marker of changes to metabolism of this oocyte-nurse cell complex. The differences in pH change is very small – around just 0.02 pH units, yet this system is able to quantify this change. The work is leading towards placing such probes in the female reproductive tract. A parallel path has been investigating the toxicity of light to embryo development, to enable us to use this technology as truly "non-invasive".



Why is haemoglobin found in ovarian cells?

Megan Lim has been following up on our serendipitous discovery that both haemoglobin messenger RNA and protein is found in ovarian follicle cells and oocytes (eggs). She has systematically investigated which of our three hypothesised roles for haemoglobin best explains its presence: regulation of O₂, regulation of NO, or acting as a scavenger of reactive oxygen species. While not discounting the first and last potential roles, her evidence is yet to show either of these are significantly involved, leaving the role of haemoglobin on NO regulation as the lead candidate. With the Centre's new NO fluorescence probes, we will pursue if haemoglobin influences NO signalling within ovarian follicles, potentially regulation ovulation and oocyte meiosis induction.





“Cage fighting” for Parkinson’s disease

Parkinson’s disease (PD) is a significant global problem, affecting 10 million people worldwide. A major contributor to the spread of PD throughout the brain is transmission of an abnormally folded protein called alpha synuclein. While alpha synuclein normally helps maintain normal communication between neurons, in PD, it begins to misfold and aggregate. This can be released from neurons into the extracellular space, where it is taken up by neighbouring cells, triggering misfolding/aggregation of alpha synuclein within those cells. Thus, PD pathology spreads throughout the brain.

We aim to pioneer a technology to target extracellular alpha synuclein and clear it from the brain. This novel treatment strategy could help to stop brain transmission of alpha synuclein, halting the spread of the disease.

In 2018, we were awarded funding from the Brain Foundation and the Neurosurgical Research Foundation to drive the development of this technology. We look forward to testing the technology in our *in vitro* neuronal models in 2019.



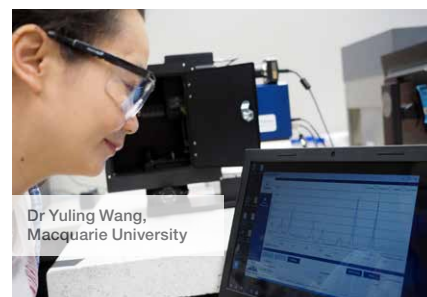
Diamond Implants

A/ Prof Kate Fox is leading a team looking into new materials for medical hard tissue implants. Using a combination of 3D printing and diamond she is developing new implants that appear to have characteristics superior to traditional bone implant materials like titanium. Traditional titanium implants have a surface oxide layer that makes them very inert but also means it cannot bond with hard tissue.

The human body is also 20% carbon so when the hard tissue (bones) makes contact with another carbon such as diamond, the body does not want to immediately reject it. Preliminary results suggest that diamond coatings appear to improve the interaction with cells whilst decreasing microbial populations.

Working with the CNBP team at RMIT, we are able to use the natural fluorescence of diamond to potentially see and track the implant interface *in vivo*. The research has been extensively covered within the media.

In 2019, Kate will further investigate these implants *in vivo* under a Ramaciotti Health Investment Grant with an aim to translate the technology within 5 years.



Simple cancer test to read a laser-based barcode

Cancers, and other diseases, can be detected early by tracking biomarkers, which are molecules found in the body that can indicate the presence of particular diseases. Yet the use of biomarkers is limited by a lack of technology that is sensitive enough to detect them.

Dr Yuling Wang has developed fast, inexpensive diagnostic technologies using the scattering of laser light from nanostructures that she’s designed and built. This pioneering research has enabled rapid detection of biomarkers by creating tiny tags, up to 100 nanometres in diameter, that attach to specific biomarkers if they are present in the patient’s sample. Then a surface-enhanced Raman scattering (SERS) can easily read these tags — like a retail barcode with an optical scanner — to rapidly diagnose multiple diseases simultaneously and so increase the chances of effective therapy.



GUI for the Hyperspectral image analysis: Big Data to graphics

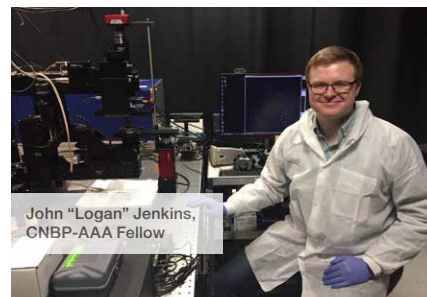
Through hyperspectral imaging, we obtain the big data of fluorescence images of live cells and tissues at a number of selected excitation wavelengths, capturing their fluorescence emission at multiple specified wavelength ranges. Unsupervised unmixing of this big hyperspectral data allows our team to non-invasively identify cell groups and analyse biochemistry to monitor the functional health conditions such as osteoarthritis, cartilage regeneration process, cell cycle and measuring the events of fertilization.

Dr Mahbub has developed the GUI (Graphical User Interface), supervised by Prof. Ewa Goldys, making it possible to visualize and pre-process the big data to produce a meaningful sub dataset (e.g. dominant spectra, molecular abundance map of cells and tissues as well as statistically significant spectral analysis for individual sample). This transitional technology allows the biologists to handle the user friendly graphics (simple correlation, graphs) with richly detailed information on the biomolecules of samples to differentiate the sick and healthy cells, and to see how they respond to different treatment; without using heavy computational analysis.



Sugar Biomarker of Pain

Polysialic acid (PolySia), a unique long homopolymer of the sugar, sialic acid, is present abundantly in the embryonic brain and plays a fundamental role in brain development. Its expression in the adult brain however is less abundant and localised in specific regions that exhibit plasticity. Some of its major functions in cell-cell interactions, migration and cytokine responses are similar to the functions that occur during neuroinflammation and pain. We revealed in 2D *in vitro* cultures that inflammation causes polySia upregulation distinctly in neurons but is not found in astrocytes, and modulates neuronal migration and oxidative stress. Conversely, using a new 3D *in vitro* cell-culture simulating the natural brain environment, polySia is found in astrocytes, and is markedly decreased under inflammation. *Ex vivo* studies using nervous system tissues of mice models of pain shows an overall reduction of polySia, which suggest that changes in polySia during pain may be due to the interaction of different cells in the nervous system and may provide a new biomarker for pain.



John "Logan" Jenkins, CNBP-AAA Fellow

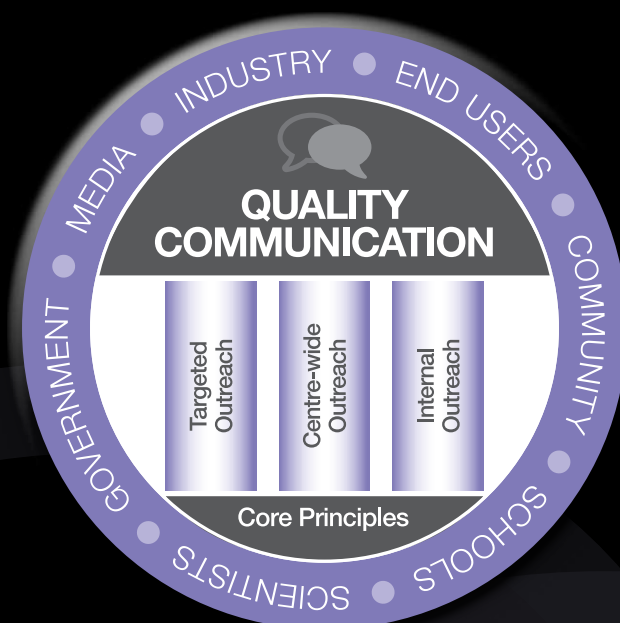
Logan is spending 6 months working with Prof Mark Hutchinson and CNBPs persistent pain team. Logan says "with about 20% of US adults having suffered from persistent pain, and similar statistics here in Australia, there is a clear need for international collaborations in finding novel treatments for this global issue."

His project entails investigating the effects of a novel neuromodulation technique on the neuroimmune system. Specifically, Logan has brought his expertise of infrared neural modulation (INM) from Vanderbilt University to the CNBP to understand its effects on microglia, the innate immune cells of the central nervous system.

Logan identifies highlights to date as including presenting at the CNBP seminar series, attending the 2018 CNBP conference, collecting sheep brains for a South Australian agriculture study, and working with a talented group of dedicated researchers.



Quality Communication



CNBP's communication and outreach strategy is focused on providing differing audiences with appropriate messaging, content and activities in support of the organisation, its world-leading biophotonic science and other aligned accomplishments.

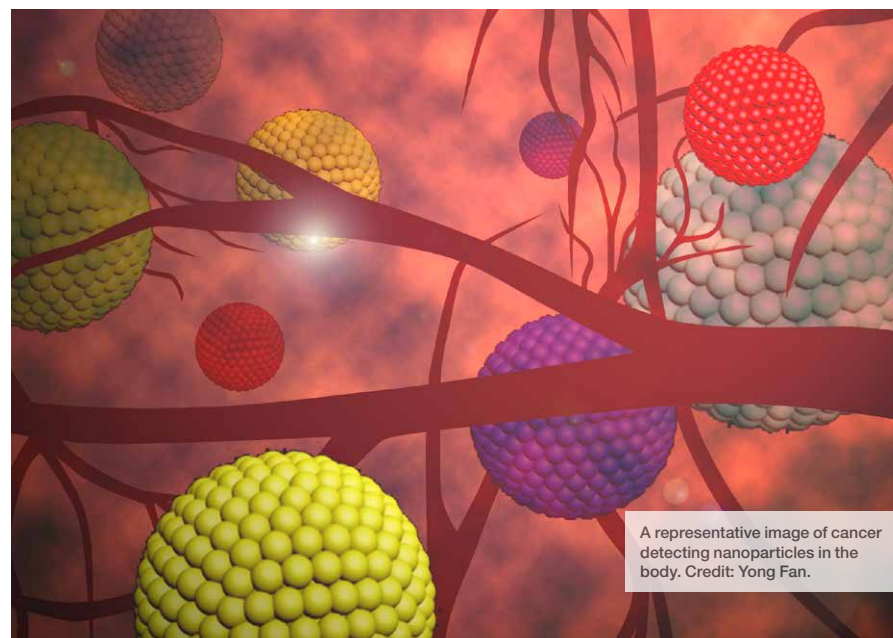
Our key audiences include the scientific community, general public (including young adults and school students), government & influencers; and end users and industry. Our 'quality communication' strategy also incorporates an internal communications component, supporting the effective transfer of knowledge, as well as operational updates, to researchers across the CNBP community.

Supporting Academic Excellence

New nanoparticles help detect deep-tissue cancers

CNBP communications activity is actively focused on promoting the high quality science that is generated by Centre researchers as well as Partner and Associate Investigators. Awareness and visibility of influential CNBP research aids Centre reputation, opens the door to potential new collaborations and demonstrates impact and relevance of CNBP research to external stakeholders.

Researchers at CNBP, Macquarie University and Fudan University, China developed a new form of nanoparticle and associated imaging technique that could detect multiple disease biomarkers, including those for breast cancer, found in deep-tissue in the body. Reported in the science journal 'Nature Nanotechnology', the research opened up a new avenue in minimally invasive disease diagnosis and will potentially have widespread use both for biomedical research and for clinical applications.

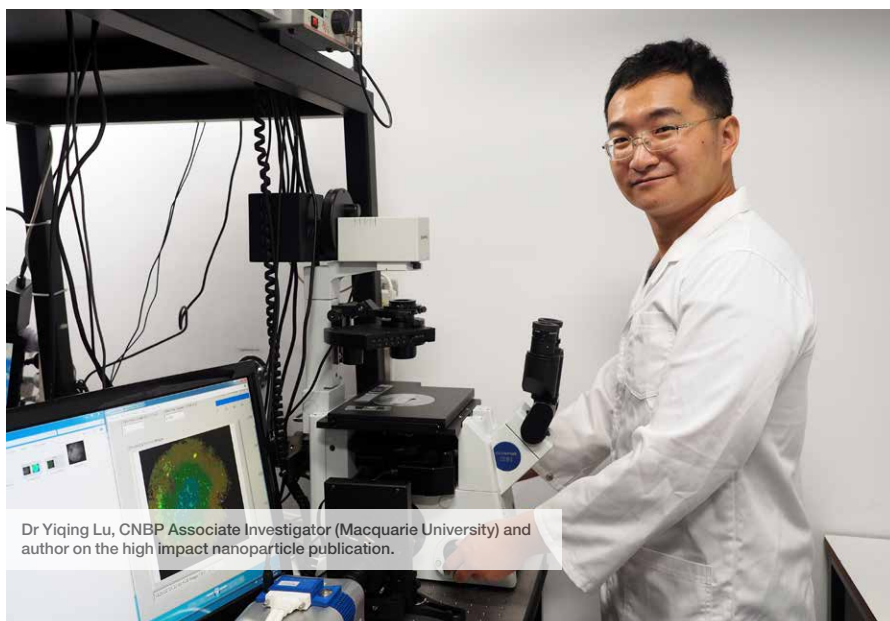


A representative image of cancer detecting nanoparticles in the body. Credit: Yong Fan.

CNBP took the lead in developing and coordinating a media release and associated promotional material for this ground-breaking high impact paper. This included working with CNBP authors Dr Yiqing Lu and Prof Jim Piper (Macquarie University) as well as liaising with

joint-lead author on the paper Prof Fan Zhang (Fudan University, China). CNBP then drove a marketing campaign for this research publication which included significant media, social media and online promotion.

The result was that this highly technical paper achieved an Altmetric research impact score of 169. This is in the top 5% of all research outputs scored by Altmetric. This included the paper being covered by 21 news outlets. Analytics noted that the paper received 5,735 impressions via the CNBP Twitter account as well as 67 positive engagements. On the platform PHYS.ORG the media release of the research achieved 8000+ views and 251 social shares.



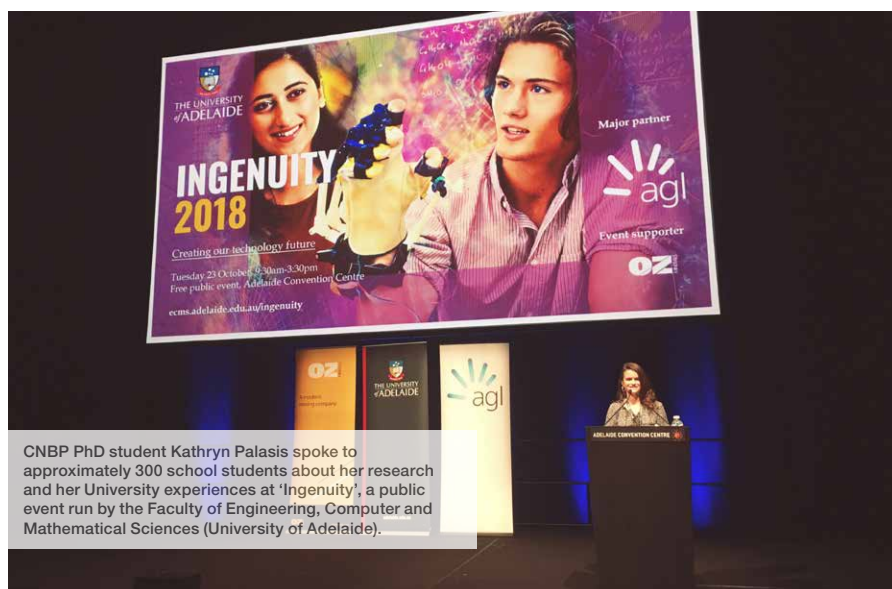
Dr Yiqing Lu, CNBP Associate Investigator (Macquarie University) and author on the high impact nanoparticle publication.

School Engagement

CNBP's outreach efforts to help excite and inspire the next generation of young scientist saw Centre researchers participate in 16 student sessions during 2018, including visits to schools, talks and presentations to students, the undertaking of light-based science demonstrations and the hosting of school visits at our University based laboratories. At the CNBP, we look to communicate the wonders and opportunities related to our science, to all of our school and student audiences, with an energy and enthusiasm that aims to motivate, educate and inspire.

A particular outreach highlight was the continued engagement with Concordia College (Adelaide) and the ongoing building of deep and meaningful outreach linkages between the school and Centre researchers. As a part of National Science Week, a team of Centre researchers took their light-focused science to Concordia College undertaking two separate outreach sessions to approximately 150 Year 9 and Year 7 students. Activity included demonstrations of propylene glycol bending light; a universal pH indicator; metal salts in flame; the illusion of holograms and discussion of the career opportunities that a science degree can provide.

Other CNBP outreach activities to students during 2018 included researcher visits to Loreto College and Adelaide High School and participation at events including the Sydney Science Festival.



CNBP In the Community

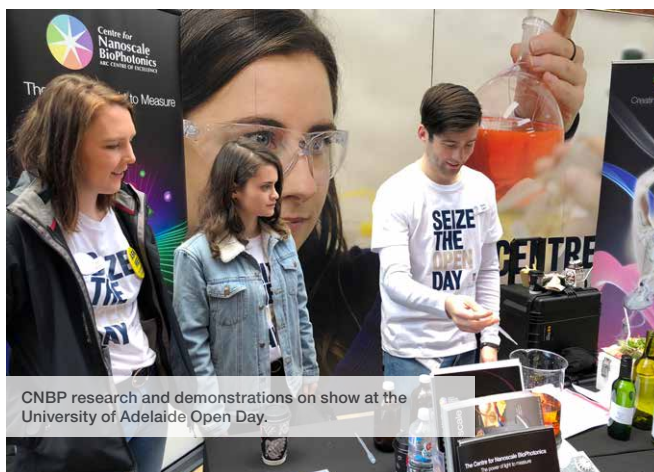
CNBP researchers are focused on communicating their amazing science to the wider community, encouraging the general public to engage with scientific thinking and to better appreciate the benefits that scientific research can provide.

In undertaking this activity, much of CNBP outreach activity is based around National Science Week. In 2018, this included CNBP University nodes participating in their respective University Open days, with researchers talking to prospective students and their families about CNBP science, and undertaking demonstrations around light-based science, including use of fully operational Centre microscopes.

Other significant community outreach activity included CNBP participation at the Melbourne AstroLight Festival where CNBP researchers gave talks and demonstrations on topics ranging from 'The wonders and delights of bees and how they see colour' (CNBP CI Prof Andrew Greentree) to 'Fluorescent Implants: 3D printing for the future' (CNBP AI Dr Kate Fox).

Additional highlights included CNBP researcher Dr Annemarie Nadort (Macquarie University) and CNBP student Marco Capelli (RMIT University) being selected to attend the 'Fresh Science' outreach program. This is a national program helping early-career researchers narrate, and then share, their amazing stories of discovery to the public.

CNBP researchers also participated in the Sydney Science Festival (Dr Annemarie Nadort and Dr Martin Ploschner), and at 'Science in the Pub' (Prof Jeremy Thompson).



CNBP research and demonstrations on show at the University of Adelaide Open Day.



CNBP student Marco Capelli (RMIT) presents his science (Studying the brain using ultra-small diamonds) to approximately 100 patrons at the Belgian Beer Cafe in Melbourne as part of the Fresh Science outreach program. Image courtesy of Science in Public



CNBP's Dr Lianmei Jiang and Dr Olivia Liang prepare for Open Day at Macquarie University

CASE STUDY

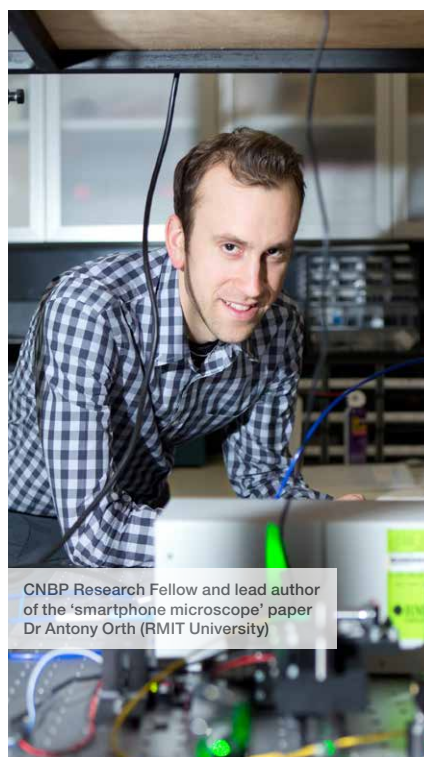
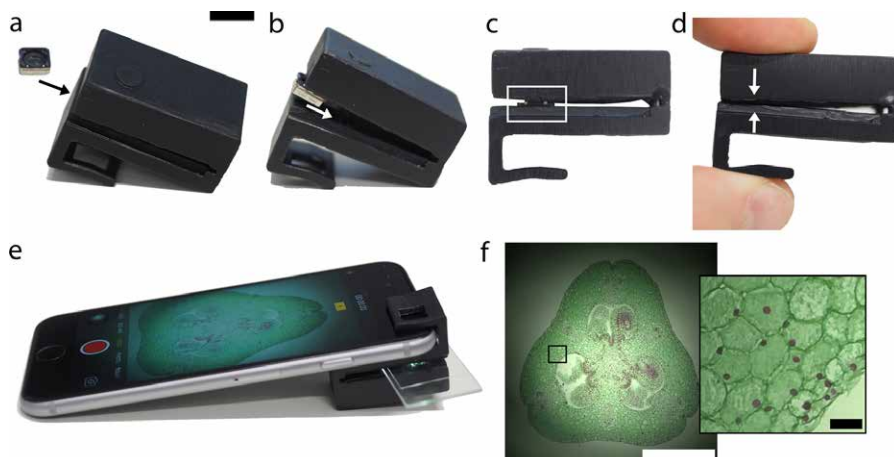
Media and Social Media Engagement

CNBP utilises traditional media, as well as the interactive and connected nature of social media to build up communities of interested audiences to aid promotion of CNBP, its research and activity, and to help build the organisation's reputation and impact.

A dual-mode mobile phone microscope using the onboard camera flash and ambient light.

CNBP researchers developed a 3D printable 'clip-on' that can turn a smartphone into a fully functional microscope. Reported in the research journal 'Scientific Reports', the smartphone microscope is powerful enough to visualise specimens as small as 1/200th of a millimetre, including microscopic organisms, animal and plant cells, blood cells, cell nuclei and more. In support of this publication CNBP developed a media release and promotional strategy which achieved the following high-impact communications outputs:

- An Altmetric score of 290 – In the top 5% of all research outputs scored by Altmetric
- 91 media hits including coverage on Newsweek, ZDNet, MSN.com and 4 radio interviews
- 1 million+ Twitter reach
- 20,000+ users driven to CNBP web site
- 66,000 views and 5,100 social shares on PHYS.ORG web site



at a glance

Media and Social Media Engagement

CNBP Media Releases: 8

CNBP Media Mentions: 216

CNBP Twitter Followers: 792

Most impactful Facebook post:

Meet CNBP researcher Dr. Lindsay Parker (video).
2,405 people reached;
886 engagements.

New CNBP Instagram channel launched

Government and influencers; and end-users and industry are key audiences targeted as a part of CNBP's multi-stakeholder and multi-faceted communications strategy. We look to reach out to these groups, to be able to contribute positively to policy, to better understand market needs, to look for commercial opportunities and to co-promote successful commercial collaborations as they take place, showcasing the value of CNBP translational science and research.



Highlights from 2018 include:

CNBP participation at the STA 'Science meets Parliament' (SmP) event in Canberra, with Centre researchers Dr Lindsay Parker, Dr Sanam Mustafa and Emma Wilson in attendance, together with CNBP Chief Operating Officer Dr Kathy Nicholson. SmP gives STEM professionals the chance to better understand politics and policy-making as well as to meet with politicians to

discuss their areas of research expertise.

Lindsay Parker was fortunate to meet and discuss her science (nanoprobes for use in neuro-imaging) with the MP Karen Andrews at the event. Karen Andrews has since become Federal Minister for Industry, Science and Technology. Emma Wilson met with Western Australian Senator Slade Brockman for her Parliamentary meeting, explaining her work with fluorescent nanodiamonds for use in biosensing and cellular discovery.



"I sat next to MP Craig Kelly at the Gala dinner - he's a member of the House of Representatives for the electorate of Hughes, New South Wales. I spoke to him about my neuroscience research and how hopefully one day we can better engineer anti-inflammatory drugs to target the correct cells with less side effects during chronic pain and Alzheimer's. I mentioned how CNBP is an excellent multidisciplinary Centre linking biology, chemistry and physics. He asked questions about how the drugs work and when they would be ready for use in humans." Dr Lindsay Parker.

CNBP for Government and End-Users

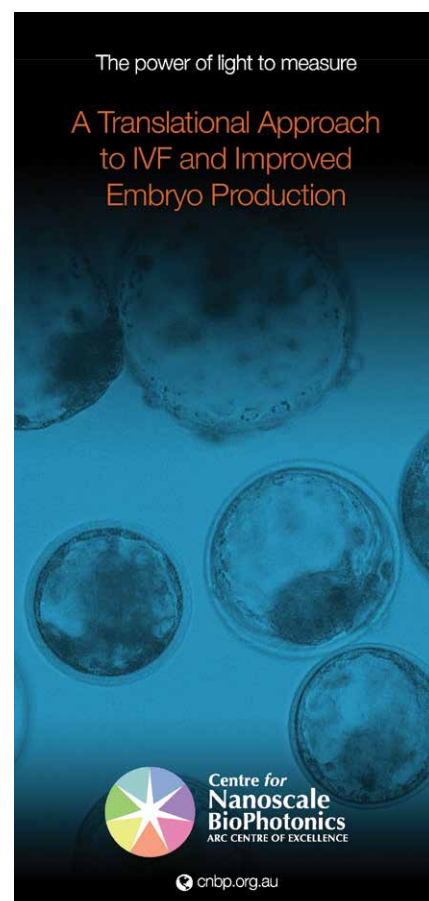
Science meets Business (Smb)

CNBP showcased its science and translation into exciting new commercial ventures at the STA 'Science meets Business' event held in Brisbane. The event brought national and international corporate leaders and entrepreneurs, venture capitalists and angel investors together with Australian research and commercialisation pioneers, to help advance activity in the science and translation space. CNBP presenters were Chief Investigator Prof Jeremy Thompson who shared his amazing start-up story in establishing the business 'ART Lab Solutions'. The venture uses advanced reproductive technologies to accelerate the improvement of livestock quality. Also featured at Smb was the CNBP inspired start-up 'MEQ Probe', which offers industry an advanced spectral analysis tool that can objectively measure the quality of meat.



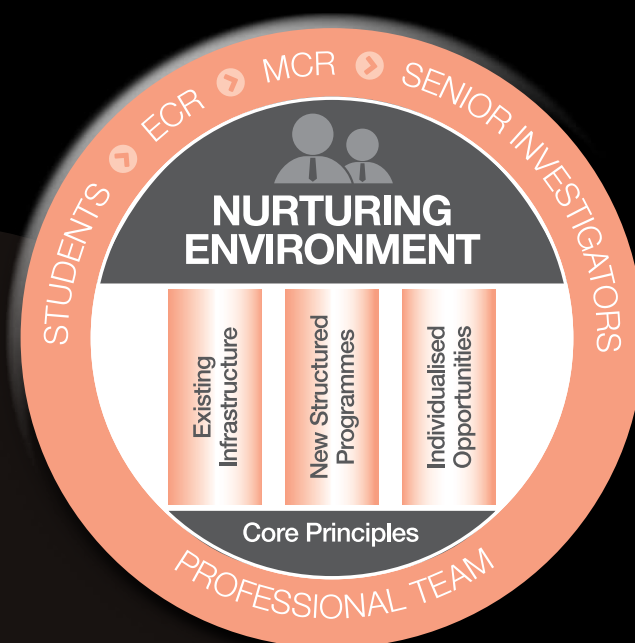
New CNBP Marketing Collateral

A CNBP marketing flyer 'A Translational Approach to IVF and Improved Embryo Production' targeting the end-user and IVF industry sector was produced in 2018. The flyer details CNBP research expertise in the human infertility and cattle breeding fields. The flyer is being used in support of new-business and potential partner collaboration interactions.



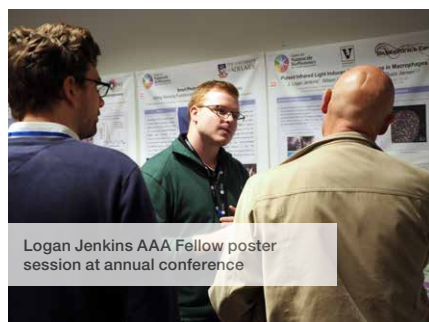


Nurturing Environment



CNBP nurtures next-generation scientific leaders to equip them with high-level skills to succeed in careers inside and outside of academia. CNBP colleagues across our Nodes and Partner Organisations have access to Centre-run workshops and mentoring programs.

Centre-run Programs



Logan Jenkins AAA Fellow poster session at annual conference



CNBPs youngest attendee at the annual conference



CNBP students at mid year workshop

CNBP Annual Conference

With 96 attendees from across CNBP's partners and nodes, the 2018 Annual conference combined scientific talks, poster sessions, networking, a shark tank competition and team building activities. Hosted over 4-days in Lorne, Victoria the annual conference built on the success of previous events to ensure that CNBP research continues to break down geographic and disciplinary barriers.

Mentoring: ISC Mentorship of Senior Investigators

CNBP were excited to welcome four members of the Centre's International Science Committee (ISC) at our Annual Conference. ISC members met with Senior Investigator in project groups to discuss challenges, successes and legacy plans for specific high impact projects. Now in its 5th year this mentoring program provides Senior Investigators with a rare opportunity to be mentored by a team of International experts.

GED: Caring for the Carer – Travel Support

CNBP believes that family commitments should not impact the ability of our researchers to participate in collaborative research. In 2018 two researchers embraced the Centre's Family Friendly policy by traveling with a child / carer to the 4-day Annual Conference. In addition one CNBP member received a CNBP travel award to enable her child (and carer) attendance at an International conference.

PD: PhD Publication Masterclass

Hosted by Professor Andrew Greentree, RMIT and Professor Tiffany Walsh at Deakin University, the two day masterclass took 18 CNBP PhD students through the publication writing process, provided tips on improving publication writing skills and included real time workshopping of manuscripts.

Workshop: Clinical Engagement

Over 75 CNBP researchers, students, partners and invited guests attended CNBP's two day 'Research Translation' workshop which was hosted across two Adelaide venues: The University of Adelaide and SAHMRI. As well as presenting CNBP science; researchers worked in small groups with senior clinicians to learn about clinical problems and discuss how their research could be translated. They also heard from several leading clinicians about what it's like to be part of a clinical translation project with technical researchers explaining the steps involved in translating a new technology, and drawing on their real-world experiences and outlining key learnings. A highlight of the workshop was the opportunity for researchers to visit Adelaide Universities' hospital simulation unit.



CNBP PhD MasterclassAttendees

Centre-run Programs



Yiqing Lu and Minakshi Das

PD: Use your phone to make science videos: Delivered by the AusSMC, this hands-on workshop focused on training Centre researchers to use their mobile devices to develop 'DIY' science videos.

PD: Commercialisation

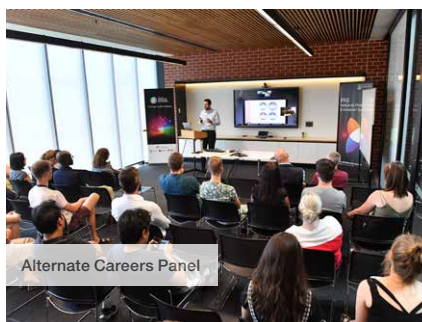
Workshop: The goal of this Adelaide-based workshop was to provide information, advice and discussion on commercialising technologies successfully, best-practice in starting and exiting start-ups, as well as tips for successful working relationships between academics and industry. The workshop was hosted in collaboration with Adelaide Enterprise and IPAS.

GED: CNBP Mum's Group & CNBP

Parents Group: Support networks for CNBP parents working towards the elusive work-life balance.

PD: Communication 101 with Talent

Academy: An interactive workshop hosted at both Macquarie and Adelaide Universities to support shark tank pitches. Presenter Sanja Yonovich from Talent Academy helped CNBP researchers to think about the multiple elements of communication. CNBP researchers practiced the use of tone, rhythm and body language to create auditory and visual cues to help them tell great science stories.



Alternate Careers Panel

PD: Alternate Careers

Panel Discussion: What does a lawyer, consultant, project manager and entrepreneur have in common? A PhD in Science! CNBP students and researchers spent a fascinating afternoon at RMIT University hearing from a collection of individuals who used skills developed from their PhD / postdocs to find satisfying STEM careers outside of Academia.

PD & Mentoring: CNBP Seminar

Series: A weekly seminar series streamed live to all Centre nodes provided an opportunity for students and postdocs to present their science to CNBP colleagues, facilitating discussion and the generation of ideas

Mentoring: Writers Gym: Activated by the ECR community in Adelaide, the writer's gym encourages researchers to gather together once a week for a 1 hour slot of sprint writing (with a scheduled break).



Prof Rob McLaughlin

Mentoring Entrepreneurs Network:

Coordinated by CNBP ECRs this network brings together CNBP entrepreneurs to learn about commercialisation, business development and small businesses; dream big about entrepreneurial ideas and support new initiatives.

PD: Shark Tank: Dreamed up by the entrepreneur's network the CNBP Shark Tank initiative provided CNBP researchers the opportunity to learn about pitching small business ideas, current projects and ideas to investors and culminated with 10 CNBP pitches delivered during a dedicated session at the CNBP Annual Conference.

Mentoring: ECR and Student

Network: Run by students and ECRs this network provides local support to the student/ ECR community. Responsibilities include running the weekly CNBP seminar series; professional development events and coordinating social activities.



Group presentation at mid year workshop

Meet our ECRs / Students

Dr Thomas Avery

Postdoctoral Researcher,
The University of Adelaide



It took only a few short months for experienced medicinal chemist and recent post-doctoral appointment, Dr Thomas Avery, to begin a collaboration with A Prof Peter Grace at CNBP partner the University of Texas MD Anderson Cancer Centre. Understanding the underlying mechanism and subsequent management of neuropathic pain is an incredible challenge, one that forms a research pillar of the CNBP. Peter and Thomas are working towards next generation targeted prodrugs for treating neuropathic pain, employing chemical sensor technology to activate the drugs with spatiotemporal precision in the body.

Thomas has enjoyed the support of the CNBP in his attending of the exclusive Bridge Program; an online and residential training program designed to upskill professionals in the science and art of pharmaceutical commercialization.

A highlight was attending the CNBP conference in Lorne which provided the invaluable opportunity to engage with CNBP researchers from across all nodes. Thomas came away from this with several cross-disciplinary multi-nodal collaborations to potentially solve research issues in projects he is involved in.

Emma Rankin Wilson

PhD Student, The RMIT
University



Second year PhD student Ms Emma Wilson has been with the CNBP since commencing honours in 2016.

Emma investigates the interaction of fluorescent nanodiamonds within biological systems, and studies how biology effect nanodiamonds behaviour and vice versa. This requires a transdisciplinary approach to bridge the gap between fundamental material science and the applied biology.

Emma's project is possible thanks to the internodal and cross-disciplinary supervision she receives through CNBP with supervisors with expertise in physics, materials science, and biology (as well as extensive transdisciplinary collaborations). Emma believes that this mentoring by example provides excellent role models as she builds her research career.

During 2018, CNBP travel funding enabled Emma to attend two overseas workshops; The Frontiers in Neurophotonics Summer School in Québec, Canada, and the Inaugural QST (National Institutes for Quantum and Radiological Science and Technology) Japan and Australia International Research Initiative workshop in Takasaki, Japan as well as represent CNBP at STA's annual 'Science meets Parliament' event in Canberra.

Congratulations to CNBP's 2018 Student Completions including:

PhD Completions:

- Dr Georgina Sylva, UA
- Dr Matthew Briggs, UA
- Dr Edward Moh, MQ
- Dr Wenjie Chen, MQ
- Dr Aziz Rehman, MQ
- Dr Shilun Feng, MQ
- Dr Chris Ashwood, MQ
- Dr Kashif Islam, MQ
- Dr Aniket Kulkarni, UA
- Dr Abbas Habibalahi, MQ
- Dr Shathili Mansour, MQ

Masters by Research Completions

- Mr Wang Qiang, MQ
- Mr Bhuwan Ghimire, MQ
- Mina Fard, MQ
- Menghe Han, UA
- Pdraig Fyfe, UA
- Dion Turner, UA

Honours Completions

- Mr Thomas Almond, UA
- Mr Car Adrian Campugan, UA
- Miss Bianca Jong, UA
- Mr Damian Stachura, UA
- Mr Jake White, SAHMRI
- Mr Darren Chow, UA

Awards

Congratulations to Centre Colleagues who received public recognition in 2018 including:

Prof Andrew Abell

- Editorial Board: Antibiotics

A/Prof Kate Fox

- 2019/2020 STA Superstar of STEM

Prof Ewa Goldys

- SPIE Fellow

Prof Ken Grattan

- OBE, Queens Birthday Honours 2018

A/Prof Guozhen Liu

- Innovation Competition: Government of Gongsu District, Hangzhou City (2nd Place)

Dr Jiawen Li

- FHMS Emerging Leadership Mentored Development Program
- University of Adelaide Health Science Faculty - ECR Award

Dr Yiqing Lu

- Centenary Institute Medical Innovation: Bayer Innovation Award

Prof Nicole Packer

- Distinguished Profession, Macquarie University

Ms Vicky Stailopolous

- CNBP Inaugural Shark Tank

Mr Benjamin Pullen

- CNBP Inaugural Shark Tank

Prof Tong Sun

- OBE, Queens Birthday Honours 2018



Independent Fellowships

- ARC Future Fellows: Dr Ivan Maksymov, RMIT; Prof Mark Hutchinson, UA; Dr Laura Weyrich, UA; Dr Steve Wiederman, UA
- Cancer Institute of NSW: Dr Andrew Care, MQ
- Heart Foundation Fellowship: Dr Jiawen Li, UA
- RMIT VC Fellowship: Dr Philipp Reineck, RMIT
- Ramsay Fellowship: Dr James Quach, UA

Travel bursaries

- AAS Travel Award: Science in the shine dome: Dr Yuling Wang, MQ
- Bridge Program: Dr Thomas Avery, UA
- UA Travel Bursaries: Mr Xuanzhao Pan, UA; Mrs Vicky Staikopoulos, UA; Mr Yunlei Wei, UA
- Women in Photonics conference, IPHT Jena: Dr Jiawen Li, UA

Awards for Presentations at Workshop and Conferences

- Ms Kathryn Palais, UA: Best Student Oral Presentation, IPAS 2017 Awards
- Ms Minakshi Das, MQ: Best Poster Presentation, 9th International NanoMed Conference
- Dr Nisha Schwartz, SAHMRI: Best ECR Presentation (SAHMRI research presentation)
- Dr Piotr Wargoki, MQ: Poster Prize, BioNetwork 2018
- Mr Shathili Abdulrahman: Oral Presentation: Third Saudi Scientific Symposium

New Grant Funding:

- Dr Andrew Care, MQ & Dr Anwar Sunna, MQ: CSIRO Synthetic Biology Future Science Platforms Initiative
- Dr Andrew Care, MQ & Dr Anwar Sunna, MQ : Sydney Vital Research Scholarship
- Dr Andrew Care, MQ; Dr Lindsay Parker, MQ: and Dr Lyndsay Praino Collins, UA: Australian Brain Foundation Research Gift
- Dr Andrew Care, MQ & Dr Anne-Marie Nadort, MQ: Bionetwork Symposium Collaborative Grant
- Prof Brant Gibson, RMIT: LIEF grant: National Volumetric Imaging Platform
- Prof Brant Gibson, RMIT: QST International Research Initiative
- Prof Ewa Goldys, MQ: Tour de Cure Pioneering Cancer Research Grant
- Dr Jiawen Li, UA & Prof Rob McLaughlin, UA: Australia - Germany Joint Research Cooperation Scheme
- A/Prof Kate Fox, RMIT: Ramaciotti Award
- Dr Lianmei Jiang, MQ: Sydney Vital Research Scholarship
- Dr Roman Kostecki UA: Starter Grants for Research Collaboration with NC State
- Dr Roman Kostecki, UA: National Science Week Grant
- Dr Lindsay Parker, MQ: MQ Research Infrastructure Scheme
- Dr Lindsay Parker, MQ: MQ Research Seeding Grant 2019
- Dr Sanam Mustafa, UA: National Science Week Grant
- Dr Sandhya Clement, MQ: Sydney Vital Seed Funding
- Dr Yuling Wang, MQ: Tour de Cure Ltd Grant

Personnel



CNBP Staff at the 2018 Conference

CENTRE PERSONNEL

Senior Investigators

Prof Mark Hutchinson, Director, UA
A/Prof Brant Gibson, Deputy Director
& RMIT Node Director
Prof Ewa Goldys, Deputy Director, MQ
Prof Andrew Abell, UA Node Director

Prof James Piper^{AM}, MQ Node Director
Prof Heike Ebendorff-Heidepriem, UA
Prof Andrew Greentree, RMIT
Prof Robert McLaughlin, UA
Prof Tanya Monro, UA & UniSA

Prof Stephen Nicholls, SAHMRI
Prof Nicolle Packer, MQ
Prof Jeremy Thompson, UA
A/Prof Daniel Kolarich, Griffith
Dr Christina Bursill, UA and SAHMRI

Professional Team

Kathy Nicholson
Chief Operating Officer, UA
Melodee Trebilcock
BD and Events Manager, UA

Tony Crawshaw
Comms Manager, MQ
Kathleen Zummo
EA to the Director & UA Node Admin

Jenny Morcom
MQ Node Administrator
Brooke Bacon
RMIT Node Administrator

CNBP Researchers

Akash Bachhuka, UA
Amanda Abraham, RMIT
Andrew Care, MQ
Antony Orth, RMIT
Arun Das, Griffith
Ayad Anwer, MQ
Benjamin Pullen, UA
Bryden Quirk, UA
Chrys Maoudis, UNSW
Daniel Drumm, RMIT
Denitza Denkova, MQ
Desmond Lau, RMIT
Erik Schartner, UA
Georgios Tsiminis, UA

Jacob Thomas, UA
Jared Campbell, UNSW
Jarrad Goyne, SAHMRI
Jiawen Li, UA
Jinxian Yu, UA
John Horsley, UA
Kylie Dunning, UA
Lianmei Jiang, MQ
Liisa Kautto, MQ
Lindsay Parker, MQ
Liu Jiajun, UA
Luen Liang, MQ
Nicole Cordina, MQ
Philipp Reineck, RMIT

Robyn Kievit, UA
Rodney Kirk, UA
Roman Kostecki, UA
Saabah Mahbub, MQ
Sanam Mustafa, UA
Sandhya Clement, MQ
Shi Xian (Edward) Moh, MQ
Sumudu Gandoga, MQ
Thomas Avery, UA
Tom Lawson, MQ
Victoria Peddie, UA
Xianlin Zheng, MQ
Xiaozhou (Michelle) Zhang, UA
Zofia Kautzka, MQ

Personnel

CNBP STUDENTS

PhD Students

Azim Arman, UA
Chris Ashwood, MQ
Rachit Bansal, MQ
Rouven Becker, UA
Matthew Briggs, UA
Yueying Cao, MQ
Marco Capelli, RMIT
Patrick Capon, UA
Wenjie Chen, MQ
Minakshi Das, MQ
Fei Deng, UNSW
Kasun Dissanayake, CUL
Samuel Evans, UA
Shilun Feng, MQ
Fang Gao, MQ
Kalpeshkumar Giri, MQ
Anna Guller, MQ
Abbas Habibalahi, MQ
Meng He, UA
Ashleigh Heffernan, RMIT
Aimee Horsfall, UA
Krystal Iacopetta, UA

Sameera Iqbal, MQ
Kashif Islam, MQ
Hong Ji, UA
Jagjit Kaur, UNSW
Zahra Khabir, MQ
Cheryl Suwen Lawson, UA
Aniket Kulkarni, MQ
Rahul Kumar, CUL
Inga Kuschnerus, MQ
Kwan Jun Lee, MQ
Florence Lees, UA
Yi Li, UNSW
Megan Lim, UA
Yuan Liu, MQ
Hangrui Lui, MQ
Shathili Mansour, MQ
Hanna McLennan, UA
Lauren Murray, UA
Stefan Musolino, UA
Kathryn Palasis, UA
Xuanzhao Pan, UA
Lu (Lucy) Peng, UA

John Pillans, RMIT
Layla Pires, UHNT
Mohammd Shafiqur Rahman, UA
Vlada Rozova, MQ
Nicholas Schumann, UA
Gianni Thalassino, RMIT
Vasiliki Staikopoulos, UA
Cheow Yuen (Tiffany) Tan, UA
Nicholas Charles Schuman, UA
Georgina Sylvia, UA
Victoria Wang, MQ
Fei Wang, MQ
Piotr Wargocki, MQ
Yunlei Wei, UA
Emma Wilson, RMIT
Josef Worboys, RMIT
Yuan Qi Yeoh, UA
Yunlei Wei, UA
Kaixan Zhang, MQ
Fuyuan Zhang, MQ
Nafisa Zohora, RMIT

Masters Students

Mustaf Bekteshi, UA
Mina Ghamini Fard, MQ
Padraig Fyfe, UA
Bhuwan Ghimire, MQ

Mengke Han, UA
Raymond Harrison, RMIT
Weikun Huang, UA
Wang Quiang, MQ

Avishkar Saini, UA
Daniel Stavrevski, RMIT
Dion Turner, UA
Lishun (Adam) Xie, UA

Honours Students

Carl Campugan, UA
Darren Chow, UA

Jong Bianca, UA
Damien Stachura, UA

Tahlee Stevenson, UA
Jake White, SAHMRI

Partner Investigators

Prof Gilberto Brambillo, SOTON
Prof Qingming Luo, HUST
Prof Steven Maier, Colorado
Prof Stephen Nicholls, SAHMRI
Prof Takeshi Oshima, QST

Dr Carolina Petrovic, CSIRO
Prof Juergen Popp, IPHT
Prof Peng Xi, Peking
Prof Tong Sun, CUL
Prof Yujie Sun, Peking

Prof Linda Watkins, Colorado
Prof Xiahui Wang, CIAC
Prof Brian Wilson, UHN
Prof Gang Zheng, UHN

Personnel (cont'd)

CENTRE PERSONNEL

Associate Investigators

Mr Shahraam Afshar, UniSA
A/Prof Igor Aharonovich, UTS
Dr Hannah Brown, UA
Dr Louise Brown, MQ
Dr Christina Bursill, SAHMRI
A/Prof Jennifer Cornish, MQ
Dr Arun Dass, Griffith
Dr Wei Deng, MQ
Dr MyNgan Duong, SAHMRI
Dr Alexandre Francois, UA
Dr Alfonso Garcia-Bennett, MQ
Dr Jonathan George, UA
Prof Bruce Hammock, UC Davis
Prof Stephen Hill, U of Nottingham
Dr Peter Hoffman, UniSA
Prof Irene Hudson, U of Newcastle
Dr David Inglis, MQ

Prof Dayong Jin, UTS
Dr Asma Khalid, RMIT
Dr Woei Ming (Steve) Lee, ANU
Dr Christian Leiterer, MQ
A/Prof Guozhen Liu, MQ
Dr Yiqing Lu, MQ
Dr Sally McArthur, Swinburne
Dr Dougal McCulloch, RMIT
Dr Anne-Marie Nadort, MQ
A/Prof Kevin Pflieger, UWA
Dr Martin Ploschner, MQ
Dr Mark Prescott, Monash
Dr Peter Psaltis, SAHMRI
Dr Malcolm Purdey, UA/SAHMRI
Dr Nicolas Riesen, UA
Dr Yinlan Ruan, UA
Dr Abel Santos, UA

Dr Nima Sayyadi, MQ
Dr Bingyang Shi, MQ
Dr Varun Sreenivasan, UNSW
Dr Anwar Sunna, MQ
Dr William Tieu, SAHMRI
Dr Johan Verjans, SAHMRI
Dr Achini Vidanapathirana, SAHMRI
A/Prof Tiffany Walsh, Deakin
Dr Yuling Wang, MQ
Dr Stephen Warren-Smith, UA
Prof Steven Wiederman, UA
Prof Marc Wilkins, UNSW
Dr Xiaoxue (Helen) Xu, MQ
Mr Run Zhang, Uni of Qld
Dr Tim Zhao, UA
A/Prof Andrei Zvyagin, MQ

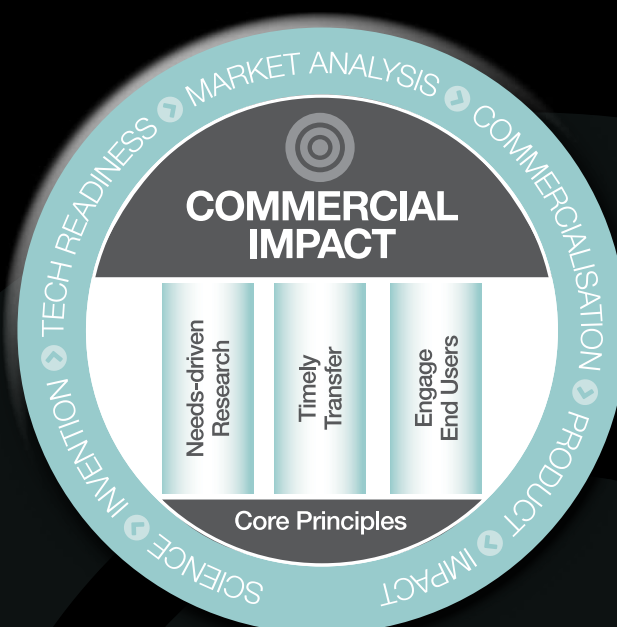
Legend

CUL: City University London
 Griffith: Griffith University
 MQ: Macquarie University
 RMIT: RMIT University
 SAHMRI: South Australian Health and Medical Research Institute
 UA: The University of Adelaide
 UniSA: The University of South Australia
 UHN: University Health Network, Toronto
 UNSW: The University of New South Wales
 UTS: University of Technology Sydney
 UWA: University of Western Australia

CNBP Members

	Female	Male	Total
Senior Investigators	29%	71%	12
Research Personnel	34%	66%	41
Students	41%	59%	83
Associate Investigators	40%	60%	43
Partner Investigators	15%	85%	13
Professional team	83%	17%	6
Total	38%	62%	198

Commercial Impact



The 23 million dollar ARC investment in CNBP over 7-years of fundamental science discovery, has enabled us to also create a significant legacy through our commercialisation and technology transfer, with 17 tangible commercial outcomes so far, and a goal of 20 outcomes from 20 ventures to be completed by 2020.

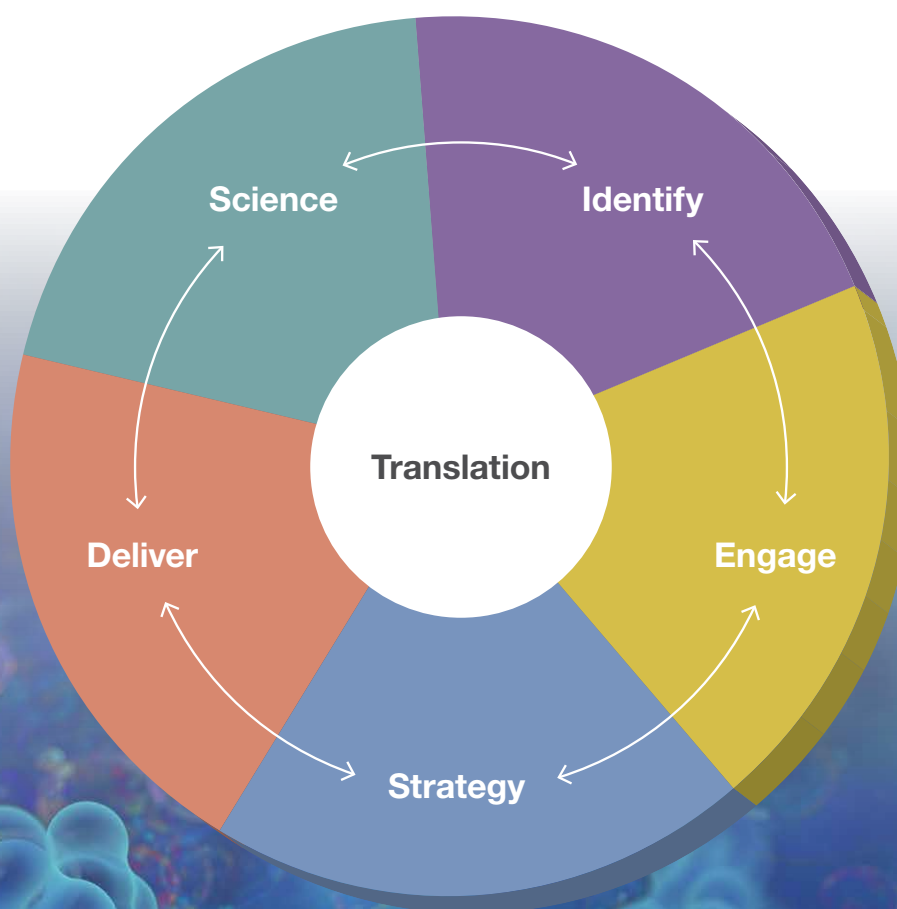
Through the creation of deployable biodevices, our research translation extends beyond biomedical and clinical communities, to veterinary care, agricultural and food manufacturing and industry processes, in perfect alignment with the goals of Australia's National Innovation and Science Agenda (NISA).

Commercialisation Strategy

CNBP Commercialisation strategy is to achieve 20 translational outcomes by 2020. To achieve this goal CNBP researchers are encouraged and supported to review their scientific projects regularly to identify potential translational outcomes.

Where relevant, researchers are encouraged to follow a series of steps:

- **Deliver Quality Science**
- **Identify Translational Opportunity**
- **Engage Early with Experts:** End-Users, Partners, Investors and Tech Transfer Office etc
- **Build a Strategy:** Secure IP, Proof of Concept, Business Plan, Regulatory Strategy etc.
- **Deliver Translational Outcome:** Patent, Open Source Software, Spin-Out Company etc



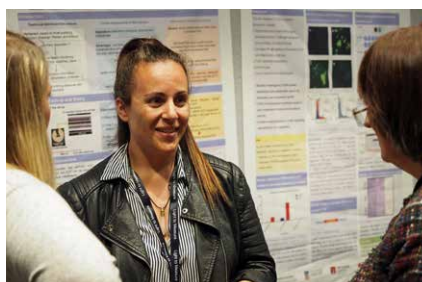
CNBP Entrepreneurs



CNBPs New Entrepreneurial Pitch Program Winners: Woven Optics

A new CNBP Professional Development program was launched in 2018 to encourage CNBP researchers to become entrepreneurs. Ten CNBP researchers nominated for the inaugural program involving: attendance at a “develop your pitch” workshop hosted in two locations (Macquarie University and the University of Adelaide). The goal of these workshops was to assist in developing clear narratives regarding how specific research/technology will meet an industry need and to develop investor-ready pitches. The program culminated with live pitches to the CNBP community during the 2018 Annual Conference.

The 2018 Winning pitch was presented to PhD student Mrs Vicky Staikopolous from the “Woven Optics” team, taking home the \$5000 in prize money to be invested into the company.



Who are the Woven Optics team?

Winning the Runners up award at the 2017 University of Adelaide ECIC Tech eChallenge encouraged CNBP PhD students Benjamin Pullen, Vicky Staikopolous and industry expert Tom Ashby (former president of the World Merino Federation) to create Woven Optics.

Woven Optics is developing a new solution to measure wool quality on farms in real-time by combining optics and machine learning algorithms into portable devices – to provide wool growers with independent, objective measures of wool fibre quality.

Cofounders Vicky Staikopolous and Ben Pullen says: ‘We at Woven Optics are grateful for the experience and support provided by the CNBP Entrepreneur’s Network. The communication workshop and pitch sessions provided valuable experience and a great opportunity to help progress the development of Woven Optics into the future.’



MEQ Probe

MEQ Probe was founded in 2016 through collaboration between Availer and the CNBP. Since inception, the company has had a ‘customer-first’ approach. By working closely with industry partners, MEQ technology has been designed to meet defined industry needs.

As sponsors of the STA ‘Science meets Parliament’ event, CNBP initiated an invitation for MEQ probes CEO, Mr Jordy Kitschke to join a panel discussion with Mrs Susan McDonald, Managing Director of Super Butcher, and Prof Mark Hutchinson, Director CNBP. Jordy used this opportunity to detail MEQ probes collaborative business journey, where researchers, industry experts and entrepreneurs have successfully developed? a piece of technology from the bench into the abattoir.



IMPACT: Spin Out Companies

Dairy Explorer

Dairy Explorer utilises spectral analysis to determine the fat, protein, and indicators of mastitis of milk on a cow-by-cow basis.

The technology utilises a blend of physics, chemistry and biology coupled with advanced analysis, proprietary algorithms and big-data sets, to provide dairy farmers with information that enables them to optimise the performance of their herd. 1.0 FTE Employees.

Founded in 2017 by Availer Pty Ltd, with support from the South Australian Rapid Commercialisation Initiative (SARCI).

www.dairyexplorer.com

Miniprobes

Miniprobes develops optical scanners for the livestock and research markets. Using their fibre-optic lens technology, they design low-cost optical coherence tomography scanheads for use in harsh environments. 1.0 FTE Employees.

Founded by CNBP researchers: Prof. Robert McLaughlin, Dr Bryden Quirk and Rodney Kirk, 2016.

www.miniprobes.com

Art Lab Solutions

Focused on developing and commercialising cattle reproductive technologies that feed into genetic improvement breeding programs. 0.5 FTE Employees.

Founded by A. Prof Jeremy Thompson, 2017.

www.artlabsolutions.com

MEQ Probe

MEQ Probe is a novel solution to a large meat and livestock industry pain point. It utilises spectral analysis and machine learning to objectively measure the eating quality of meat in seconds. The technology brings together physics, chemistry and biology coupled with advanced proprietary algorithms to provide the meat industry with an objective measure for eating quality. 4.5 FTE Employees.

Founded in 2017 by Availer Pty Ltd, with support from the South Australian Rapid Commercialisation Initiative (SARCI).

www.meqprobe.com

Woven Optics

Woven Optics is providing a new solution to measure wool quality on farm in real-time. The technology will combine optics and machine learning algorithms into a portable device and provide wool growers with an independent, objective measure of wool fibre quality.

Cofounded by Benjamin Pullen and Vicky Staikopoulos and Tom Ashby in 2018

<https://wovenoetics.com>

Life Whisperer

Life Whisper uses AI to better select healthy embryos for IVF, and ultimately improve outcomes for couples wanting to have children. 1.0 FTE

Cofounded by Dr Jonathan Hall, Dr Michelle Perugini and Dr Don Perugini, 2017

www.lifewhisperer.co

Spectral Change

Spectral Change has developed proprietary software, analytics, and food-grade devices. This gives winemakers a clear insight into the maturity of wine across every barrel, in an unobtrusive model, so that the age-old process of wine making can continue, with a next-generation solution. 1.0 FTE Employees

Founded in 2017 by Availer Pty Ltd, with support from the South Australian Rapid Commercialisation Initiative (SARCI).

www.spectralchange.com

Lucigem

Based at Macquarie University in Sydney, Lucigem produces a range of nanomaterials including fluorescent nanodiamonds and phosphorescent nanorubies. Nanoparticles developed by Lucigem's researchers exhibit excellent colloidal stability in aqueous solutions, without the need for coating or functional groups. Lucigem strives to generate nanoparticles with well-characterised physical and chemical properties, which ensure reproducible results.

Founded by Dr Louise Brown, 2016

www.lucigem.com.au

Science Bees Lab

Based in Singapore, Science Bees Lab aims to deliver engaging program that integrate art with science to school aged children.

1 FTE employees

Founded: Dr Sabrina Heng, 2018

www.sciencebeeslab.com

A Focus on Partnerships

At the CNBP we actively look to develop strong partnerships, building networks with major national and international research centres, as well as with industry to deliver exciting research, translation and commercial outcomes.

We firmly believe that our strength is significantly enhanced by engaging closely with our partners in an active and collaborative manner, with the end-benefit that our research is pushed in new and exciting directions that could not be achieved alone. Working with partners helps CNBP to strengthen research outcomes, drive development activity, achieve global competitiveness, provide exciting new collaboration opportunities for our researchers and communicate our research to the wider Australian community.



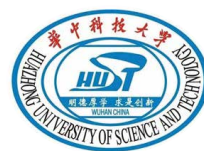
Collaborations in the vascular health domain continue between the heart health team and UHN with opportunities to access animal models for application and testing of new probes / devices.

**Partner Investigator:
Prof Gang Zheng**



Successful outcomes in 2018 include: Collaborative research exploring non-linear light generation in exposed core fibres [Warren Smith et al., Opt Letter, 2018]; and doped SAL glasses as prospective candidates for optical fibre dosimetry, passive sensors and fluorescent dosimeter devices [Shaw et al., J. Non-Cryst. Solids, 2018].

**Partner Investigator:
Prof Juergen Popp**



**HUST University is a
Top 10 Chinese University**

An exciting new publication outlining a multi-year CNBP-HUST project on intravital imaging of chronic constriction injury has been accepted for publication to be released in early 2019.

**Partner Investigator:
Prof Qingming Luo**

Our strength is significantly enhanced by engaging closely with our partners in an active and collaborative manner.

A Focus on Partnerships



Griffith University's Institute for Glycomics joins CNBP

This year the Institute for Glycomics at Griffith University became a node of the CNBP in recognition of their expertise in the emerging role that glycoscience is being found to have in all of the biologies being investigated in the CNBP. The Institute for Glycomics is a unique multi-disciplinary research institute with a particular focus in the area of glycoscience and is one of a few such institutes worldwide. It has an outstanding scientific staff profile of 200+ researchers that are world-leading in a variety of aspects in glycoscience, such as having developed the world largest glyco-array, the anti-influenza drug Relenza and novel immunisation strategies against diseases such as malaria. A recent multi-million-dollar investment allowed the establishment of a new, state-of-the-art mass spectrometry facility that is focussing on all aspects of glycosylation, from glyco-focused Mass Spectrometry Imaging (MSI) to the world's most sensitive glycomics analytical technology that allows for the reading of the glyco-language from as low as 1000 cells. These capabilities are now available to the CNBP enabling the targeting of cell surface sugars in research into pain, reproduction and cardiovascular disease.



CNBP launches the Griffith Node



CITY UNIVERSITY LONDON

CNBP PhD students Mr Kasun Dissanayake and Mr Rahul Kumar at CUL continue their CNBP project conducting synthesis of novel TLR4 active agents that are capable of modulating TLR4 function and sensing the consequences of its activation. Several new chemical entities have been derived which will aid in understanding the fundamental biology of innate immune signalling.

Partner Investigators:
Prof Tong Sun and
Prof Ken Grattan

Heraeus

Heraeus Quarzglas are global leaders in innovating quartz and fused silica solutions. CNBP's partnership with Heraeus continue to provide CNBP researchers with valuable expertise and support in the form of custom glass solutions for fibre fabrication and the development of novel fibre based sensing tools.

Key Industry Contact:
Mr Gerhard Schoetz

CNBP Partner Organisations



An invitation from Prof Gilberto Brambillo resulted in Prof Mark Hutchinson's presentation at the SOTON – UCL sponsored RANK prize: Optoelectronics workshop.

Partner Investigator:
Prof Gilberto Brambillo



As well as housing CNBPs heart health team, led by Prof Steve Nicholls and Dr Christina Bursill, SAHMRI hosted the CNBPs mid-year workshop focused on the challenges and realities of clinical engagement together with research translation.

Partner Investigator:
Prof Stephen Nicholls



**University of Colorado
Boulder**

Collaborative efforts were directed at overcoming technological challenges for identifying the key molecular and cellular substrates underlying emotion. In humans, exposure to both acute and chronic stressors is associated with the development of a number of psychiatric disorders. Converging lines of evidence implicate neuroimmune activity, in particular the increase of proinflammatory molecules, such as cytokines, as a critical driver of the cognitive and behavioral consequences of stress. Despite the strong association between cytokine signaling and disease, there is a paucity of tools for selective tracking and monitoring of neuroimmune cell function. Transdisciplinary projects to address this unmet need are progressing with researchers across several CNBP Nodes.

Partner Investigator:
Prof Steven Maier



Engagement with Peking University has slowed down in 2018 due to changes in personnel.

Partner Investigator(s):
Prof Peng Xi and Prof Yujie Sun



Engagement with CSIRO has been limited in 2018 due to changes in key personnel. However new collaborations have commenced with Adelaide PhD student Ms Aimee Horsfall utilising CSIRO facilities for high-throughput peptide synthesis.

CNBP Champion:
Dr Karolina Petkovic

CNBP Partner Organisations



National Institutes for Quantum and Radiological Science and Technology

The QST partnership was celebrated with a CNBP Partner launch in October followed by a successful joint workshop. Other successes include a successful QST- RMIT travel fellowship grant and publication [Ruan et al., Scientific Reports, 2018]. CNBP were delighted to welcome PI Dr Ohshima to CNBPs 2018 Annual Conference.

Partner Investigator:
Dr Takeshi Ohshima



Brant Gibson with Yoshiya Shimada at QST Partner Launch



中国科学院长春应用化学研究所
CHANGCHUN INSTITUTE OF APPLIED CHEMISTRY
CHINESE ACADEMY OF SCIENCES

CIAC

Joining the CNBP in June 2018, CIAC researchers actively collaborate with the CNBPs Pain team on projects related to innate immune targeted biosensors and novel pharmacology. CNBP publications include [Zhang et al., J. Chem. Inf. Model, 2018].

Partner Investigator:
Dr Xiaohui Wang

OLYMPUS®

FOCUS ON LIFE

As world leaders in delivering high quality equipment to the medical, endoscopy and industry markets, Olympus partners with CNB to engage at ground level R&D. Olympus support to CNBP includes regular lab visits, the loan of instruments, problem solving in regard to instrument applications and upgrades, as well as system service and training.

Key Industry Contact:
Dr Jian Shen



BIOPLATFOMRS
AUSTRALIA

Bioplatforms Australia enables Australian life science research by investing in state-of-the-art infrastructure and associated expertise in the specialist fields of genomics, proteomics, metabolomics and bioinformatics.

Bioplatforms Australia continue to support CNBP with annual cash support and access to Bioplatforms state-of-the-art facilities to generate 'omics data.

Key Industry Contact:
Dr Andrew Gilbert

Grants and Legacy Partners



**Government of
South Australia**

During 2018 CNBP maintained one active grant from the Premier's Research Infrastructure Fund (PRIF): \$1M PRIF Fellowship (2016- 2020) which supports Chair of BioPhotonics Prof Robert McLaughlin at the University of Adelaide.



**Trade &
Investment**

The CNBP was awarded a \$500K NSW Trade and Investment fund (2014 – 2017) to support industry relevant research at the CNBP. This funding played an important role in establishing capabilities at Macquarie University.



NCI

NATIONAL COMPUTATIONAL INFRASTRUCTURE

The CNBP has been awarded 800,000 core hours per annum of computing time, equating to \$32,000 annually since 2015. In 2017 Prof Andrew Greentree and team utilised the NCI collaboration to enable the running of complex theoretical state on the art super computer systems.



The CNBP is supported by the state of the art fabrication facilities of the Optofab Node of the ANFF. These enable CNBP researchers to make the optical fibre sensors that have continued to progress the Centre's research in 2018.

We actively look to develop strong partnerships, building networks with major national and international research centres, as well as with industry to deliver exciting research, translation and commercial outcomes.

Legacy Partners



Science and Technology Australia (STA) is Australia's peak body in science and technology - and represents about 70,000 Australian scientists and technologists working across all scientific disciplines.

STA membership helps CNBP to maintain strong relationships with the science community, politicians, business leaders and the wider community more generally.

Availer

Availer is a rapid commercialisation company based in Adelaide and New York, who won a \$2.4 million state government grant developed under the "South Australian Rapid Commercialisation Initiative" ("SARCI").



The American Australia Association (AAA) has a mission to broaden, strengthen and encourage ties across the Pacific through corporate, educational, economic, artistic and cultural activities and people- to-people exchange.

CNBP sponsor an annual CNBP-AAA Fellowship to bring a US-based scientist to the CNBP laboratories for an extended visit.



The Australian Science Media Centre is an independent, not-for-profit service for the news media, giving journalists direct access to evidence-based science and expertise

AusSMC membership connects CNBP scientists and press releases with active science journalists as well as providing a go-to location for media advice and training




Concordia College is a co-educational Early Learning Centre to Year 12 International Baccalaureate World School located in Adelaide's eastern suburbs.

CNBP have collaborated with staff at Concordia College (2015- 2018) to develop curriculum, facilities and outreach programs to inspire secondary school students to contemplate careers in STEM

Our strength is significantly enhanced by engaging closely with our partners in an active and collaborative manner.

Governance



A strong governance structure enables CNBP to implement its vision and pursue ambitious science goals with societal benefit.

CNBP core principles of **Academic Excellence, Nurturing Environment, Quality Communication and Commercial Impact** lie at the foundation of all Centre governance.

Governance Committees



Executive Management Committee

The CNBP Executive Management Committee (EMC) is Chaired by the Centre Director and consists of all CNBP Chief Investigators, the Chief Operations Officer (Secretary) and Representation from a student or ECR from each node.

2018 Membership was:

- Prof Mark Hutchinson (Chair)
- Prof Andrew Abell
- Mr Tony Crawshaw
- Prof Heike Ebendorff-Heidepriem
- Prof Andrew Greentree
- A/Prof Brant Gibson
- Prof Ewa Goldys
- Dr Martin Ploschner
- A/Prof Daniel Kolarich
- Prof Robert McLaughlin
- Dr Sanam Mustafa
- Dr Kathy Nicholson (Secretary)
- Dr Antony Orth
- Prof James Piper
- Prof Nicolle Packer
- Prof Jeremy Thompson
- Mrs Melodee Trebilcock



Advisory Board

The CNBP Advisory Board work to strengthen CNBP linkages with academic, industry and government by identifying strategic engagement opportunities. The board met three times in 2017 with two in person meetings and the later incorporating a joint session with the CNBP Executive Management Committee.

Advisory Board Membership:

- Ms Catriona Jackson (Chair), Deputy CEO Universities Australia
- Dr Melanie Bagg, Australian Academy of Sciences
- Prof Mike Brooks, DVCR, The University of Adelaide
- Prof Calum Drummond, DVCR RMIT University
- Dr Marguerite Galea-Evans, ATSE
- Dr Andrew Gooley, Trajan Scientific and Medical
- Prof Mark Hutchinson, Director CNBP
- Prof Peter Nelson, PVCR Macquarie University
- Dr Kathy Nicholson (Secretary), Chief Operating Officer, CNBP
- Prof Elaine Sadler, Director CAASTRO, University of Sydney
- Leonie Walsh, Consultant



International Science Committee

The CNBP International Science Committee (ISC) advises on the strategic direction of the scientific endeavours of the Centre and supports the Centre in increasing International visibility. ISC members act as mentors to CNBPs Senior Investigators, an invaluable program that is now in its third year.

In 2018 the ISC held 2 video conferences with 4 members attending the CNBP annual conference in December.

International Science Committee Membership:

- Prof Dennis Matthews (Chair), Director Centre of BioPhotonics, Science & Technology: UC Davis
- Professor Brian Wilson (Incoming Chair), University Health Network, Canada
- Prof Kishan Dholakia, University of St. Andrews, UK
- Prof Bob Grubbs, Nobel Laureate: Caltech
- Professor Mark Hutchinson, Director: CNBP
- A/Prof Kelly Nash, University of Texas San Antonio
- Prof Katarina Svanberg, Lund University
- Dr Kathy Nicholson (Secretary), Chief Operating Officer: CNBP

Governance Committees (cont'd)



Education and Outreach Committee

Chaired by Dr Melanie Bagg, the Education and Outreach committee guides CNBP researchers towards effective approaches to communicating the wonders of science to the broader community. During 2018 the committee met three times by video conference.

Education and Outreach Committee Membership:

- Dr Melanie Bagg, Director Communications and Outreach: Australian Academy of Science
- Mr Tony Crawshaw, CNBP Communications Officer
- Dr Rachel Dunlop, Medical Researcher and Skeptic
- Prof Mark Hutchinson, Director: CNBP
- A/Prof Rod Lamberts, Deputy Director, CPAS: ANU
- Mr Mike Seyfang, Private Consultant IT & Social Media
- Dr Kathy Nicholson (Secretary), Chief Operating Officer: CNBP



Nurturing Environment Committee

An evolution of the Gender Equity and Diversity Committee, the Nurturing Environment Committee (NEC) has evolved to continuously challenge the Centre to advance its policies and practices in gender equity and diversity; professional development, mentoring and other capacity building practices.

Nurturing Environment Committee Membership:

- Dr Kylie Dunning (Inaugural Chair), Mid-Career Researcher: The University of Adelaide - CNBP
- Dr Marguerite Evan-Galea (Incoming Chair), Executive Director of the Industry Mentoring Network in STEM: Australian Academy of Technology and Engineering
- Ms Sanchita Das, PhD Student: Macquarie University - CNBP
- Prof Andrew Greentree, Chief Investigator: RMIT University - CNBP
- Prof Mark Hutchinson, Director: The University of Adelaide - CNBP
- Dr Sanam Mustafa, Mid-Career Researcher: The University of Adelaide-CNBP
- Dr Kathy Nicholson (Secretary), Chief Operating Officer: CNBP
- Prof Nicolle Packer, Chief Investigator: Macquarie University - CNBP
- Dr Philipp Reineck, Mid-Career Researcher: RMIT University - CNBP
- Mrs Mel Trebilcock, Business Development Manager: CNBP



Centre Commercialisation Committee

Chaired by Dr Andrew Gooley, the Commercialisation Committee was formally established at the end of 2017 and commenced its first meetings in 2018, with the purpose of advising the strategic direction in the area of commercial impact and translation to the Centre.

Commercialisation Committee Membership:

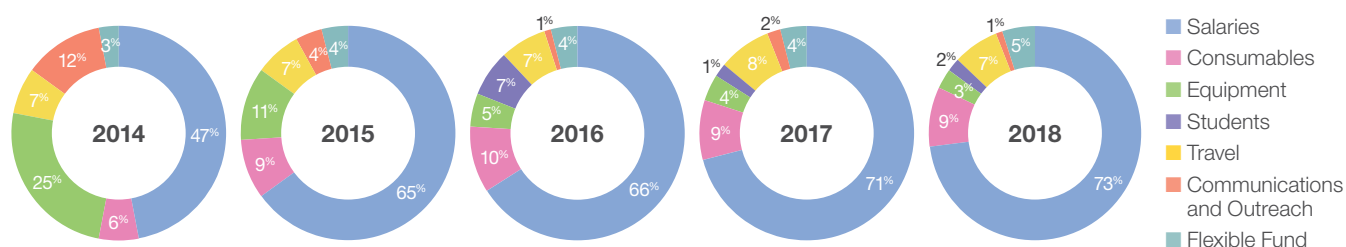
- Dr Andrew Gooley, Chief Scientific Officer: Trajan Scientific and Medical
- Mrs Melodee Trebilcock, (Secretary), CNBP Business Development & Events Manager: CNBP
- Prof Mark Hutchinson, Director: CNBP
- Dr Kathy Nicholson, Chief Operating Officer: CNBP
- Prof Andrew Abell, Node Director: The University of Adelaide & Commercialisation Champion: CNBP
- Prof Brant Gibson, Node Director: RMIT University - CNBP
- Prof Ewa Goldys, Node Director: University of NSW-CNBP
- Ms Anna Grocholsky, Director, Commercialisation & Innovation: Macquarie University
- Ms Kiera Bechta-Metti, Director, Adelaide Enterprise: The University of Adelaide
- Ms Amy Hunter, Associate Director, Intellectual Property & Research Commercialisation: RMIT University
- Ms Eloise O'Keefe, Business Manager, Institute for Glycomics: Griffiths University
- Mr Ben Pullen, CNBP Entrepreneur Network representative: CNBP

Financials

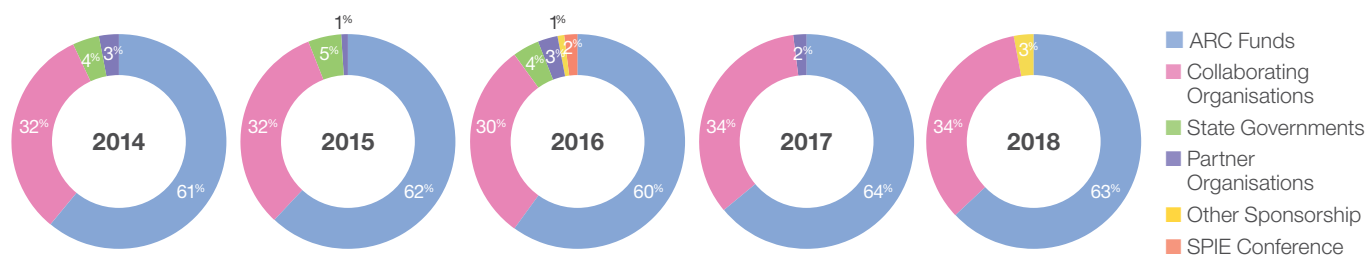
EXPENDITURE	2014 ACTUALS	2015 ACTUALS	2016 ACTUALS	2017 ACTUALS	2018 ACTUALS	2019 PROJECTIONS
Salaries	\$ 784,194	\$ 3,789,521	\$ 4,213,276	\$ 4,150,971	\$ 3,798,887	\$ 4,139,199
Consumables	\$ 107,403	\$ 525,034	\$ 620,525	\$ 556,083	\$ 475,733	\$ 580,467
Equipment	\$ 414,627	\$ 646,603	\$ 296,793	\$ 241,777	\$ 138,466	\$ 185,000
Students	\$ -	\$ 21,326	\$ 420,765	\$ 62,068	\$ 81,355	\$ 100,000
Travel	\$ 125,710	\$ 393,599	\$ 428,289	\$ 486,925	\$ 402,138	\$ 349,960
Communications & Outreach	\$ 193,176	\$ 222,484	\$ 87,219	\$ 119,702	\$ 23,251	\$ 99,000
Flexible Fund	\$ 51,411	\$ 204,558	\$ 280,004	\$ 244,882	\$ 246,009	\$ 295,000
Total	\$ 1,676,521	\$ 5,803,125	\$ 6,346,871	\$ 5,862,408	\$ 5,165,839	\$ 5,748,626

INCOME	2014	2015	2016	2017	2018
ARC Funds	\$ 3,385,012	\$ 3,445,635	\$ 3,504,212	\$ 3,556,775	\$ 3,610,126
Collaborating Organisations	\$ 1,781,724	\$ 1,791,815	\$ 1,782,478	\$ 1,914,459	\$ 1,929,263
State Governments	\$ 216,667	\$ 261,000	\$ 266,500	\$ 50,000	\$ -
Partner Organisations	\$ 140,000	\$ 90,000	\$ 190,000	\$ 90,000	\$ 190,000
Other Sponsorship	\$ 909	\$ -	\$ 4,545	\$ 36,512	\$ 13,333
SPIE Conference	\$ -	\$ -	\$ 131,906	\$ -	\$ -
Total	\$ 5,524,312	\$ 5,588,451	\$ 5,879,641	\$ 5,561,234	\$ 5,742,722

2014 - 2018 EXPENDITURE



2014 - 2018 INCOME



CNBP KPIs

CNBP ~ 2018 KEY PERFORMANCE MEASURES	TARGET	OUTCOME
	2018	2018
Number of Research Outputs		
Journal articles	100	118
Book chapters	2	1
Patents	2	3
Other - unique posts to social media	50	106
Quality of Research Outputs		
% of journal publications in > 3.5 impact factor journals	60%	70%
% of publications reporting interdisciplinary research 106	45%	56%
Citation data for print publications (each on average for 2014-15 papers)	10	27
Research awards (student prizes, researcher awards, etc)	40	54
# Media stories from Centre activities	40	216
# website hits ('000) - (defined as page views)	20	58.6
Publications in top 5% of alt metrics	4	10
Number of Training Courses Held / Offered by the Centre		
# PD courses for staff and postgraduate students	2	8
% CNBP personnel participating in one or more CNBP PD activity	80%	93%
Number of Workshops / Conferences Held / Offered by the Centre		
# Workshop / conferences for staff and postgraduate students	2	3
% CNBP personnel participating in one or more CNBP workshop / conference	80%	74%
Number of Additional Researchers Working on Centre Research		
Postdoctoral researchers	20	34
Honours students	5	5
PhD students	40	65
Masters by research students	5	11
Associate investigators	20	62

CNBP KPIs

CNBP ~ 2018 KEY PERFORMANCE MEASURES	TARGET	OUTCOME
	2018	2018
Number of Postgraduate Completions		
Honours student	5	5
Master student	5	6
PhD student	10	9
Number of Mentoring Programs offered by the Centre		
Mentoring programs	4	6
Number of Presentations / Briefings		
To the public (including schools)	15	27
To government (parliamentarians and departments / agencies at both state and Federal levels)	20	25
To industry / business / end-users	15	21
To professional organisations and bodies	15	22
Number of New Organisations Collaborating with, or Involved in, the Centre		
Organisations	1	3

CNBP SPECIFIC MEASURES	TARGET	OUTCOME
	2018	2018
Internships with industry	3	3
Publications with international collaborations	20	61
International funding applications with international collaborators	4	4
Tech transfer / spin-out / start-up companies	4	4
Joint funded projects with industry (e.g. ARC linkage projects)	3	3
Dependent and / or carer travel scholarships available for Centre members	\$ 5,000	\$ 5,000
Nurturing Environment committee to review and update GED policy annually	yes	yes

Appendix



Appendix 1: 2018 Centre Publications

- Ashwood, C.**, C. H. Lin, M. Thaysen-Andersen and **N. H. Packer** (2018). "Discrimination of Isomers of Released N- and O-Glycans Using Diagnostic Product Ions in Negative Ion PGC-LC-ESI-MS/MS." *J Am Soc Mass Spectrom* 29(6): 1194-1209.
- Atakaramians, S., I. V. Shadrivov, A. E. Miroshnichenko, A. Stefani, **H. Ebendorff-Heidepriem**, **T. M. Monro** and **S. Afshar V** (2018). "Enhanced terahertz magnetic dipole response by subwavelength fiber." *APL Photonics* 3(5).
- Bajic, J. E., I. N. Johnston, G. S. Howarth and **M. R. Hutchinson** (2018). "From the Bottom-Up: Chemotherapy and Gut-Brain Axis Dysregulation." *Frontiers in Behavioral Neuroscience* 12.
- Beckett, E. A. H., **V. Staikopoulos** and **M. R. Hutchinson** (2018). "Differential effect of morphine on gastrointestinal transit, colonic contractions and nerve-evoked relaxations in Toll-Like Receptor deficient mice." *Sci Rep* 8(1): 5923.
- Bradac, C., I. D. Rastogi, **N. M. Cordina**, **A. Garcia-Bennett** and **L. J. Brown** (2018). "Influence of surface composition on the colloidal stability of ultra-small detonation nanodiamonds in biological media." *Diamond and Related Materials* 83: 38-45.
- Briggs, M. T.**, **M. R. Condina**, M. Klingler-Hoffmann, G. Arentz, **A. V. Everest-Dass**, G. Kaur, M. K. Oehler, **N. H. Packer** and **P. Hoffmann** (2018). "Translating N-Glycan Analytical Applications into Clinical Strategies for Ovarian Cancer." *Proteomics Clin Appl*: e1800099.
- Brown, H. M.**, E. S. Green, T. C. Y. Tan, M. B. Gonzalez, A. R. Rumbold, M. L. Hull, R. J. Norman, **N. H. Packer**, S. A. Robertson and **J. G. Thompson** (2018). "Periconception onset diabetes is associated with embryopathy and fetal growth retardation, reproductive tract hyperglycosylation and impaired immune adaptation to pregnancy." *Scientific Reports* 8(1).
- Campbell, J. M.**, M. D. Stephenson, B. de Courten, I. Chapman, S. M. Bellman and E. Aromataris (2018). "Metformin Use Associated with Reduced Risk of Dementia in Patients with Diabetes: A Systematic Review and Meta-Analysis." *Journal of Alzheimers Disease* 65(4): 1225-1236.
- Cao, C., R. Jin, H. Wei, W. Yang, **E. M. Goldys**, **M. R. Hutchinson**, S. Liu, X. Chen, G. Yang and **G. Liu** (2018). "Graphene Oxide Based Recyclable *in Vivo* Device for Amperometric Monitoring of Interferon-gamma in Inflammatory Mice." *ACS Appl Mater Interfaces* 10(39): 33078-33087.
- Cao, C., **F. Zhang**, **E. M. Goldys**, F. Gao and **G. Liu** (2018). "Advances in structure-switching aptasensing towards real time detection of cytokines." *TrAC Trends in Analytical Chemistry* 102: 379-396.
- Chen, H., Y. L. Chan, C. Linnane, Y. L. Mao, **A. G. Anwer**, A. Sapkota, T. F. Annissa, G. Herok, B. Vissel, B. G. Oliver, S. Saad and C. A. Gorrie (2018). "L-Carnitine and extendin-4 improve outcomes following moderate brain contusion injury." *Scientific Reports* 8.
- Chen, W.**, **W. Deng**, X. Xu, **X. Zhao**, J. N. Vo, **A. G. Anwer**, T. C. Williams, H. Cui and **E. M. Goldys** (2018). "Photoresponsive endosomal escape enhances gene delivery using liposome-polycation-DNA (LPD) nanovectors." *Journal of Materials Chemistry B* 6(32): 5269-5281.
- Church, T. L., D. Bernin, **A. E. Garcia-Bennett** and N. Hedin (2018). "Dispersed Uniform Nanoparticles from a Macroscopic Organosilica Powder." *Langmuir* 34(6): 2274-2281.
- Clement, S.**, **W. Chen**, **W. Deng** and **E. M. Goldys** (2018). "X-ray radiation-induced and targeted photodynamic therapy with folic acid-conjugated biodegradable nanoconstructs." *Int J Nanomedicine* 13: 3553-3570.
- Cordina, N. M.**, **N. Sayyadi**, **L. M. Parker**, **A. Everest-Dass**, **L. J. Brown** and **N. H. Packer** (2018). "Reduced background autofluorescence for cell imaging using nanodiamonds and lanthanide chelates." *Sci Rep* 8(1): 4521.
- Deng, W.**, **W. Chen**, **S. Clement**, **A. Guller**, **Z. Zhao**, A. Engel and **E. M. Goldys** (2018). "Controlled gene and drug release from a liposomal delivery platform triggered by X-ray radiation." *Nat Commun* 9(1): 2713.
- Diaz, D., **A. Care** and **A. Sunna** (2018). "Bioengineering Strategies for Protein-Based Nanoparticles." *Genes (Basel)* 9(7).
- Ding, L., **Y. Ruan**, **T. Li**, **J. Huang**, **S. C. Warren-Smith**, **H. Ebendorff-Heidepriem** and **T. M. Monro** (2018). "Nitric oxide optical fiber sensor based on exposed core fibers and CdTe/CdS quantum dots." *Sensors and Actuators B: Chemical* 273: 9-17.
- Du, X., W. Li, **B. Shi**, L. Su, X. Li, H. Huang, Y. Wen and X. Zhang (2018). "Facile synthesis of mesoporous organosilica nanobowls with bridged silsesquioxane framework by one-pot growth and dissolution mechanism." *J Colloid Interface Sci* 528: 379-388.
- Duan, C., L. Liang, L. Li, **R. Zhang** and Z. P. Xu (2018). "Recent progress in upconversion luminescence nanomaterials for biomedical applications." *Journal of Materials Chemistry B* 6(2): 192-209.
- Everest-Dass, A. V.**, **E. S. X. Moh**, **C. Ashwood**, **A. M. M. Shathili** and **N. H. Packer** (2018). "Human disease glycomics: technology advances enabling protein glycosylation analysis - part 1." *Expert Rev Proteomics* 15(2): 165-182.
- Everest-Dass, A. V.**, **E. S. X. Moh**, **C. Ashwood**, **A. M. M. Shathili** and **N. H. Packer** (2018). "Human disease glycomics: technology advances enabling protein glycosylation analysis - part 2." *Expert Rev Proteomics* 15(4): 341-352.
- Fan, Y.**, **P. Wang**, **Y. Lu**, **R. Wang**, **L. Zhou**, **X. Zheng**, **X. Li**, **J. A. Piper** and **F. Zhang** (2018). "Lifetime-engineered NIR-II nanoparticles unlock multiplexed *in vivo* imaging." *Nat Nanotechnol* 13(10): 941-946.
- Gao, F., **Y. Wang**, L. Xu, Z. Feng, Q. Wu, B. Zhang, J. Liu, J. Tang, M. Tang, H. Liu, S. Fu, **Y. Ruan**, **H. Ebendorff-Heidepriem** and D. Liu (2018). "Light-controllable fiber interferometer utilizing photoexcitation dynamics in colloidal quantum dot." *Opt Express* 26(4): 3903-3914.

Appendix 1: 2018 Centre Publications (cont'd)

- Garcia-Bennett**, A. E., M. Lau and N. Bedford (2018). "Probing the Amorphous State of Pharmaceutical Compounds Within Mesoporous Material Using Pair Distribution Function Analysis." *J Pharm Sci* 107(8): 2216-2224.
- Gissibl, A., **A. Care**, **L. M. Parker**, **S. Iqbal**, G. Hobba, H. Nevalainen and **A. Sunna** (2018). "Microwave pretreatment of paramylon enhances the enzymatic production of soluble beta-1,3-glucans with immunostimulatory activity." *Carbohydr Polym* 196: 339-347.
- Gomes, A. D., B. Silveira, **S. C. Warren-Smith**, M. Becker, M. Rothhardt and O. Frazão (2018). "Temperature independent refractive index measurement using a fiber Bragg grating on abrupt tapered tip." *Optics & Laser Technology* 101: 227-231.
- Gosnell, M. E.**, D. M. Polikarpov, **E. M. Goldys**, **A. V. Zvyagin** and D. A. Gillatt (2018). "Computer-assisted cystoscopy diagnosis of bladder cancer." *Urol Oncol* 36(1): 8 e9-8 e15.
- Guller, A. E.**, **A. Nadort**, A. N. Generalova, E. V. Khaydukov, A. V. Nechaev, I. A. Kornienko, E. V. Petersen, L. Liang, A. B. Shekhter, Y. Qian, **E. M. Goldys** and **A. V. Zvyagin** (2018). "Rational Surface Design of Upconversion Nanoparticles with Polyethylenimine Coating for Biomedical Applications: Better Safe than Brighter?" *ACS Biomaterials Science & Engineering* 4(9): 3143-3153.
- Guryev, E. L., N. O. Volodina, N. Y. Shilyagina, S. V. Gudkov, I. V. Balalaeva, A. B. Volovetskiy, A. V. Lyubeshkin, A. V. Sen, S. A. Ermilov, V. A. Vodeneev, R. V. Petrov, **A. V. Zvyagin**, Z. I. Alferov and S. M. Deyev (2018). "Radioactive (Y-90) upconversion nanoparticles conjugated with recombinant targeted toxin for synergistic nanotheranostics of cancer." *Proceedings of the National Academy of Sciences of the United States of America* 115(39): 9690-9695.
- Havlik, J., V. Petrakova, J. Kucka, H. Raabova, D. Panek, V. Stepan, Z. Zlamalova Cilova, **P. Reineck**, J. Stursa, J. Kucera, M. Hruby and P. Cigler (2018). "Extremely rapid isotropic irradiation of nanoparticles with ions generated *in situ* by a nuclear reaction." *Nat Commun* 9(1): 4467.
- He, X., J. Fang, **Y. Ruan**, X. Wang, Y. Sun, N. Wu, Z. Zhao, Y. Chang, N. Ning, H. Guo and L. Huang (2018). "Structures, bioactivities and future prospective of polysaccharides from *Morus alba* (white mulberry): A review." *Food Chem* 245: 899-910.
- Horsley, J. R.**, **J. Yu**, K. L. Wegener, C. Hoppmann, K. Ruck-Braun and **A. D. Abell** (2018). "Photoswitchable peptide-based 'on-off' biosensor for electrochemical detection and control of protein-protein interactions." *Biosens Bioelectron* 118: 188-194.
- Howard, S. R., A. Avargues-Weber, J. E. Garcia, **A. D. Greentree** and A. G. Dyer (2018). "Numerical ordering of zero in honey bees." *Science* 360(6393): 1124-1126.
- Hutchinson, M. R.** (2018). "'Convergence' created psychoneuroimmunology, and is needed again to secure the future of the field." *Brain Behav Immun* 71: 1-2.
- Hutchinson, M. R.** (2018). "Glial ties to persistent pain : Immune-like cells in the central nervous system are now recognized as key participants in the creation and maintenance of persistent pain." *Scientist* 32(1).
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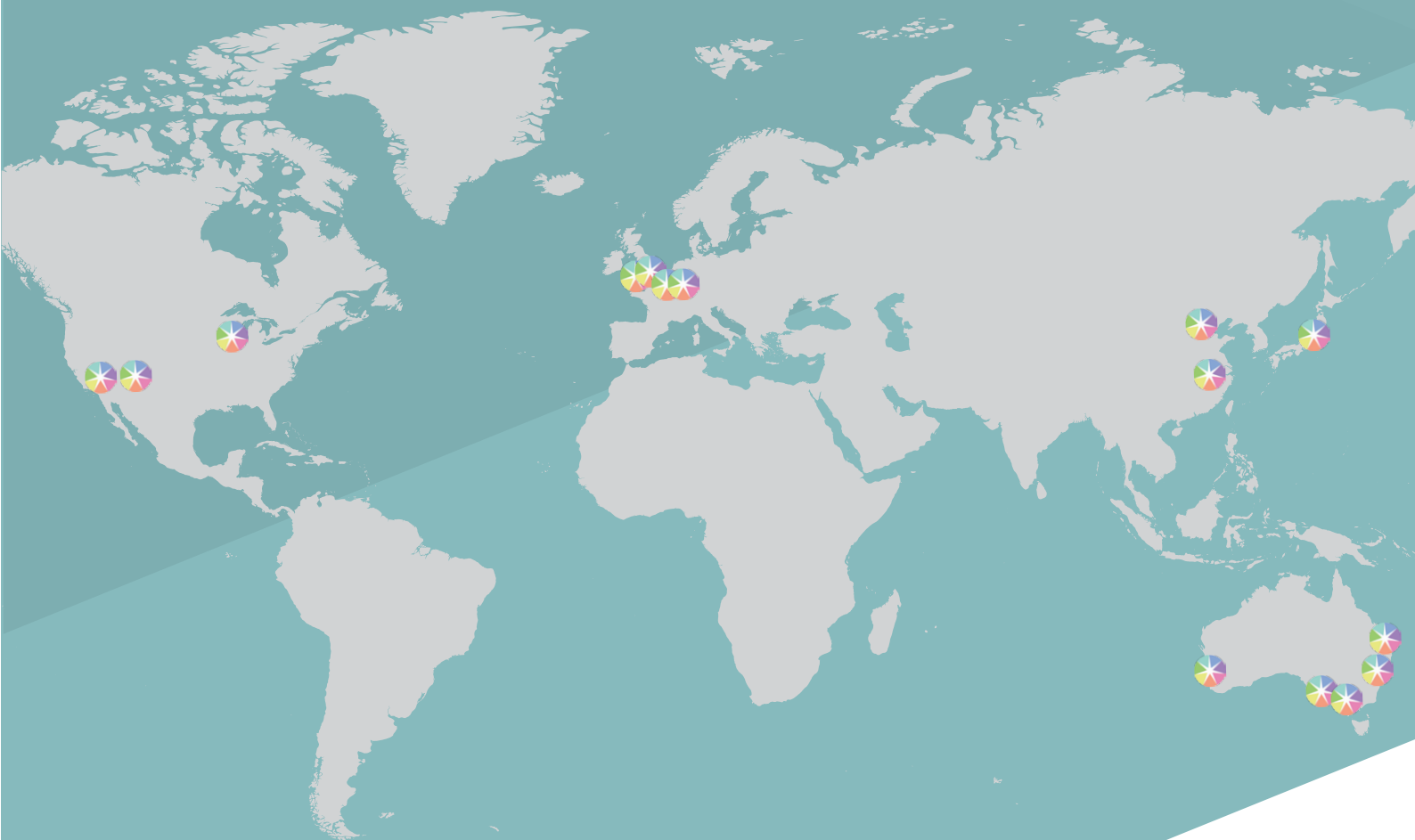
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Notes

CNBP links Australia's key nanophotonics groups and builds on Global Collaborations with a focus on doing the science required to advance biology.





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