

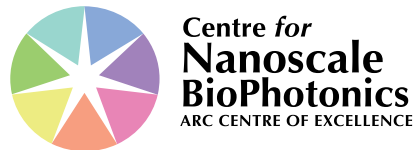


Centre for
**Nanoscale
BioPhotonics**
ARC CENTRE OF EXCELLENCE



Annual Report 2014

Creating Windows Into The Body



Australian Government
Australian Research Council



MACQUARIE
University
SYDNEY - AUSTRALIA



The Centre for Nanoscale Biophotonics links Australia's key nanophotonics groups and builds on Global Collaborations with a focus on doing the science required to advance biology.



Heraeus

UNIVERSITY OF
Southampton



Contents

As ambitious as man's flight to the moon, our journey is to an inward Universe — inside the human body — at the Nano scale — with the power of light. This is a journey that will be truly transformational.

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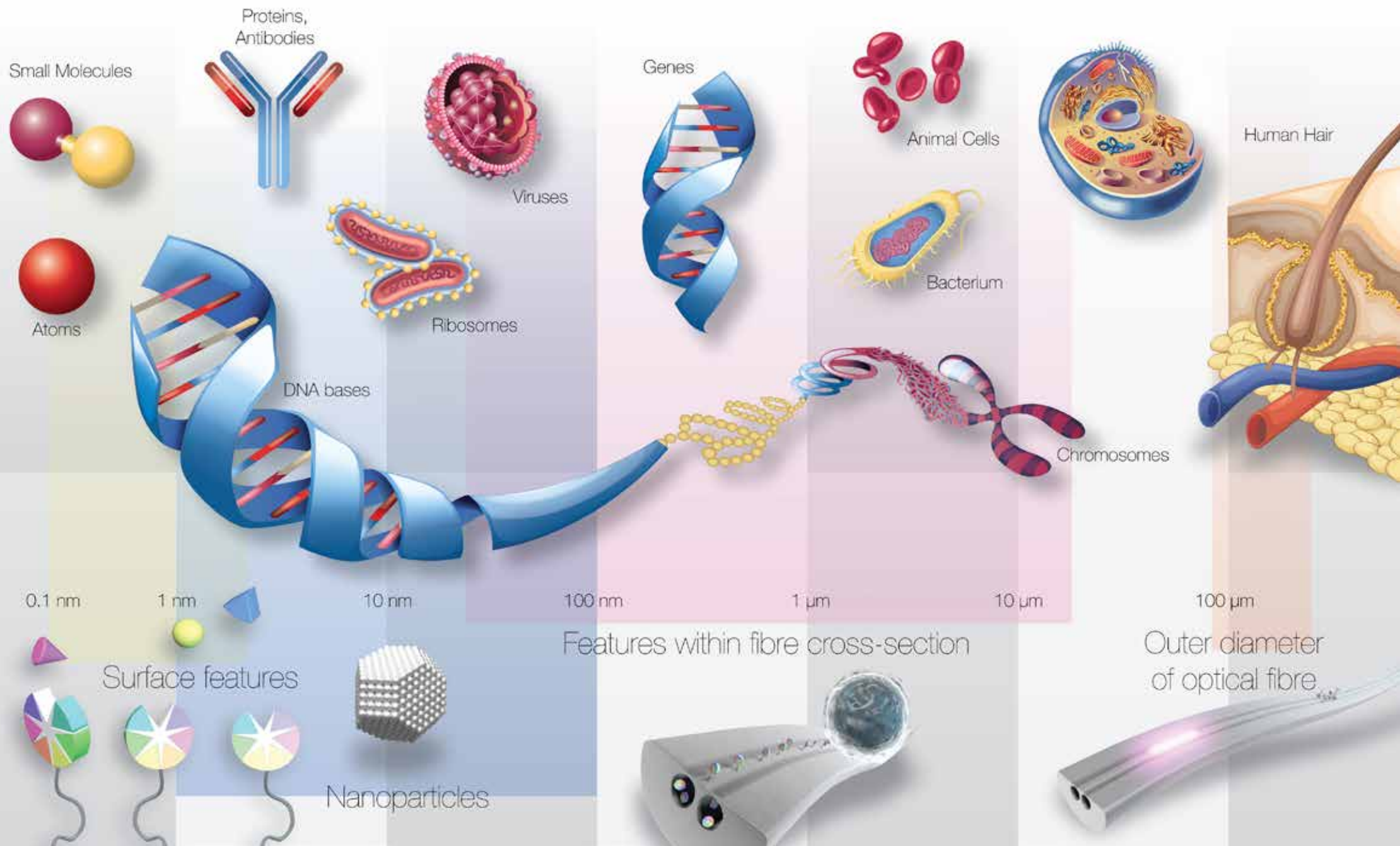
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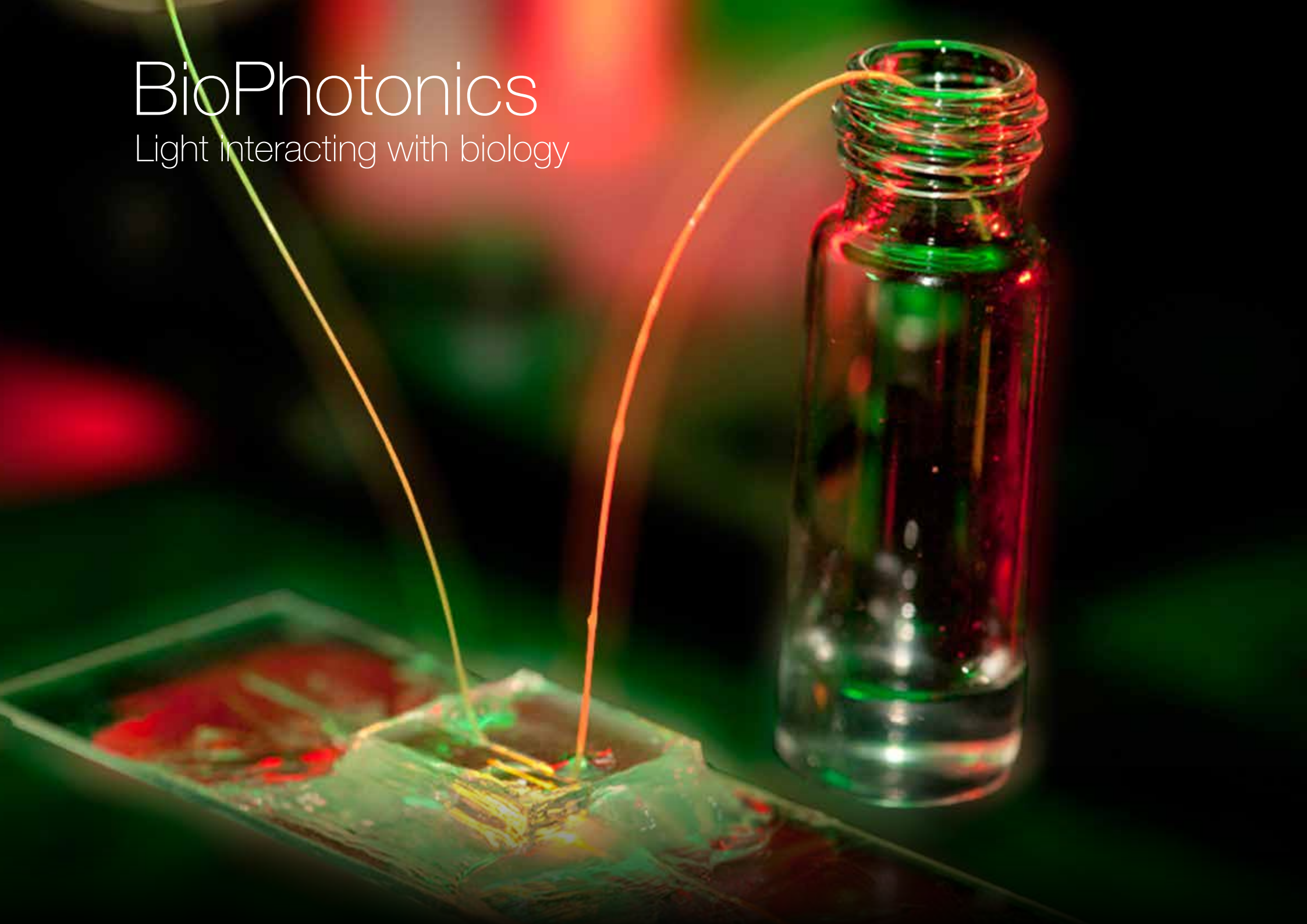
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Nanoscale = 100x Smaller Than the Width of a Human Hair



BioPhotonics

Light interacting with biology



Director's Report

We will be conducting amazing science — the way that we do this science will be engendering creative, adventurous, innovative, open and ethical practices in our scientists.



Prof. Mark Hutchinson, Director, CNBP

Welcome to the inaugural annual report of the Australian Research Council Centre of Excellence for Nanoscale BioPhotonics (CNBP), and the beginning of our exciting scientific journey. 2014 has been a year of amazing firsts for our Centre as we have initiated our formal Centre activities.

Within the CNBP we are asking the questions that are fundamental to understanding how human life begins. We are questioning what the other 90% of our brain and

spinal cord does when we are in pain. And we are asking why some plaques in blood vessels clot and lead to cardiac disease making the heart fail.

Within the CNBP we want to ask questions at the nanoscale. For 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. It is at the nanoscale that we can observe life begin, watch the triggers of pain be activated, and heart disease evolve. I am very excited about the work conducted in our Centre in 2014 and what we have in store for the coming years.

As we grow and develop the Centre four key principles will be instilled in, and emanate from, all our activities. These are Academic Excellence, Commercial Impact, Quality Communication and a Nurturing Environment. This means we will be conducting amazing science. But it also means that the way that we do this science will be engendering creative, adventurous, innovative, open and ethical practices in our scientists. Importantly, the scientific discoveries are only the beginning of the journey. We are actively seeking to work with our current and future commercial partners to create disruptive technologies. These technologies and services will service multiple markets from outback farms in animal production through to the rural doctor treating their patients. We have a vision to create economic and social value for all our communities. Our high impact

science publications will only be part of our outcomes. Our Centre researchers will be out in the community educating and exciting others about our science. We will be engaging and encouraging communities to have enquiring minds. We will be educating the next generation of researchers to begin to ask their research questions now, so that they can have careers of life-long learning. Finally, our Centre is one in which our scientists can openly share and test new, raw and cutting edge hypotheses. We are a Centre that is mentoring and building the next generation of science leaders. We are a Centre that will provide opportunities to practice and to sometimes fail, so that when the once in a lifetime opportunities come around our researchers are already equipped with the necessary skills.

A 2014 highlight was the official Centre launch on November 21st. Senator Bridget McKenzie MP, Prof. Aiden Byrne ARC, and Vice Chancellor Warren Bebbington officially launched the Centre at “The Braggs”, University of Adelaide. This event signified the first official public Centre activity and recognised the collaborative efforts and financial generosity of many, including the Australian Research Council; our host Universities; the South Australian and New South Wales Governments; and the diversity of skills and wisdom from our Nodes: the University of Adelaide, Macquarie University and RMIT University; Partner organisations:

Director's Report

I would like to congratulate all of the Centre's personnel for a highly successful and productive year.

South Australian Health and Medical Research Institute, CSIRO, Bioplatforms Australia, Olympus Australia, Heraeus Quarzglas in Germany, Leibniz Institute of Photonic Technology, The City University London, Huazhong University of Science and Technology, University of Southampton, Peking University, and University Health Network Toronto and associate investigators from around Australia. The Centre launch was an amazing event with over 200 attendees, including representatives of the State Government, industry, members of the University communities and the general public. We were also delighted to see strong media engagement on our launch allowing us to introduce ourselves to thousands of Australians via National 10 News, ABC radio and several print mediums.

As a new highly transdisciplinary Centre of Excellence with members spread across multiple scientific disciplines and geographical locations, we identified internal relationship building as a key focal area for 2014. As a result we hosted three Centre-wide workshops: the first in January to celebrate our successful bid, the second in July to bed down conversations between the Nodes; and the third our Inaugural scientific Retreat in November. Hosted in Port Lincoln, the inaugural Centre scientific retreat was a resounding success with over 80 Centre staff and Associate and Partner Investigators in attendance for the three-day event. The first retreat

consisted of a blend of master classes, speed dating, in-depth scientific discussions and professional development, culminating in foundational Centre team formation. Special thanks to Mel Trebilcock for coordinating the event.

This year has also seen the formation and first gatherings of our Centre support committees such as our Advisory Board chaired by Prof. Ian Frazer, and attended by Profs. Brooks, Drummond & Nelson, Ms. Catriona Jackson, Prof. Goran Roos (Chair of Commercialization and Industry committee), and Dr. Paul Willis (Chair Education and Outreach committee). Our first International Science Committee discussions occurred in 2014 Chaired by Prof. Dennis Matthews and attended by Profs. Katorina Svanberg, Yafeng Guang, Francesco Pavone, Paul French and Nobel Laureate Bob Grubbs.

We look forward to sharing our success stories with the wider community. In 2014 we have talked to many different audiences including year 8-9 students at Port Lincoln high school; the general public at science in the pub events; Federal Parliamentary Members at Science Technology Australia Science Meets Friends of Parliament; clinicians at cardiology, pain and reproductive medicine meetings; and our scientific peers through publications and conferences.

The Centre staff recruitment process attracted over 1400 applications for the 21 research appointments. These positions have been taken up across the University of Adelaide, Macquarie University, and RMIT University Nodes. It is very exciting to see the calibre of the applicants and the substantial interest in our research. In 2014 we saw some of our new postdocs join the team, with the remainder commencing employment in early 2015.

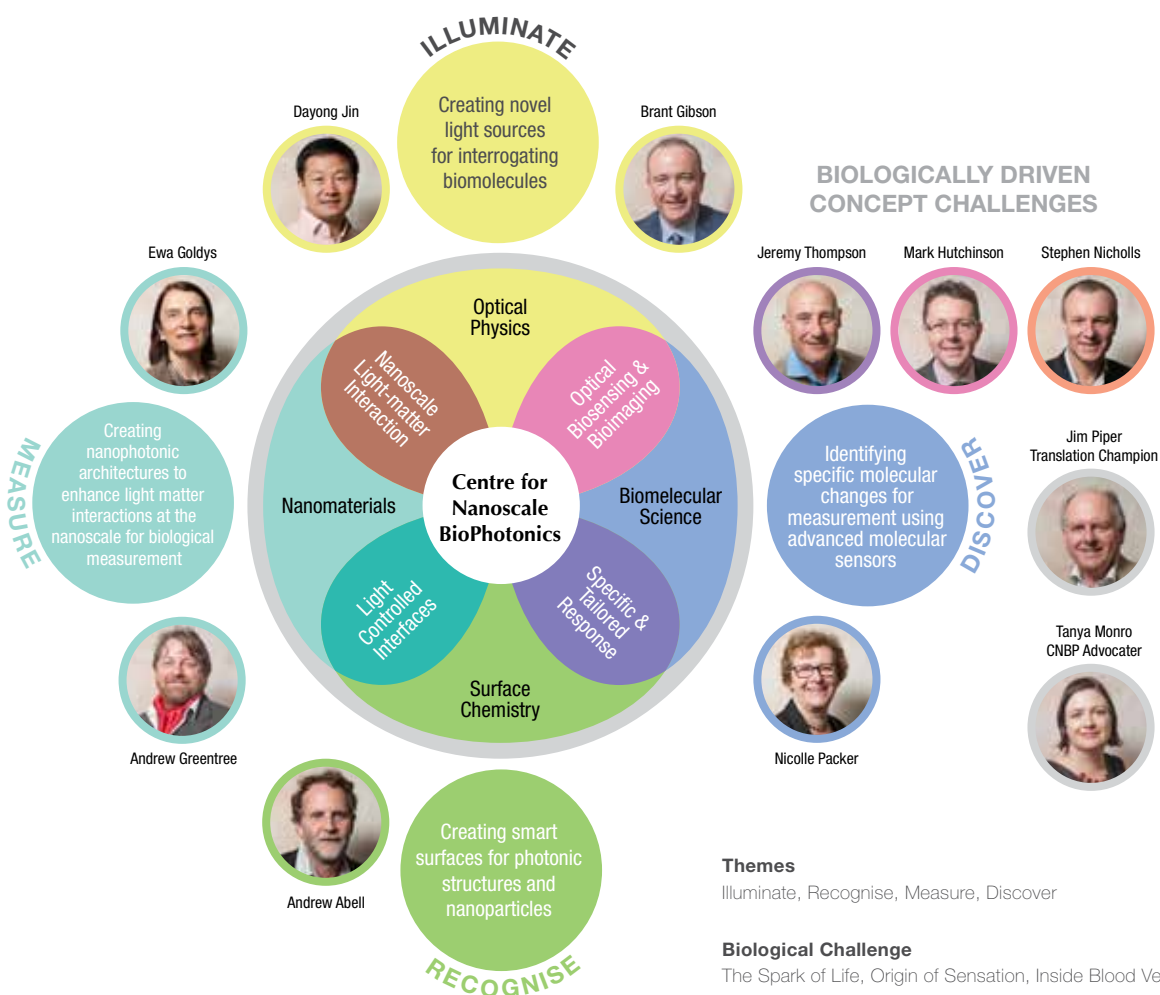
I would like to congratulate all of the Centre's personnel for a highly successful and productive year. In particular, I am grateful to my co-chief Investigators, and the Centre's Chief Operations Officer, Dr. Kathy Nicholson for their efforts in establishing our unique and exciting Centre.



Prof. Mark Hutchinson
Director, CNBP

About Us

This vision will be delivered within four cross-connected science themes and three biologically driven challenges at the forefront of current research



Overview

CNBP researchers are driving the development of new devices to measure and sense at a nanoscale level — providing powerful new ways of understanding cellular processes within the human body.

The Broad Objectives of the CNBP

1. Lead international research in nanobiophotonics – creating tools for understanding complex biological systems
2. Empower and integrate fields of leading researchers across physics, chemistry and biology
3. Pioneer approaches to transdisciplinary research training and nurturing entrepreneurship in emerging scientists
4. Inspire children through to young adults to aspire to careers in science as a pathway to making a difference
5. Engage with leading international centres and researchers to strengthen outcomes and raise the profile of Australian Research and
6. Seed industries by creating disruptive technology platforms and partnering with industry.

The Scientific Aims of the CNBP

1. Reach the limits of light-based measurement within complex and dynamic biological environments
2. Exploit physics and multiple scales — nanoscale to macro — using photons to bridge from nanomaterial to devices
3. Create smart, tailored interfaces between these nanoscale systems and the biochemical environment
4. Develop new ways to control molecular function in solution and on surfaces
5. Establish new forms of assay measurement that can operate within living organisms
6. Use these assays to study key problems associated with embryological development, and brain and blood vessels function and
7. Understand the molecular mechanisms, processes and functionalities in these biological systems.

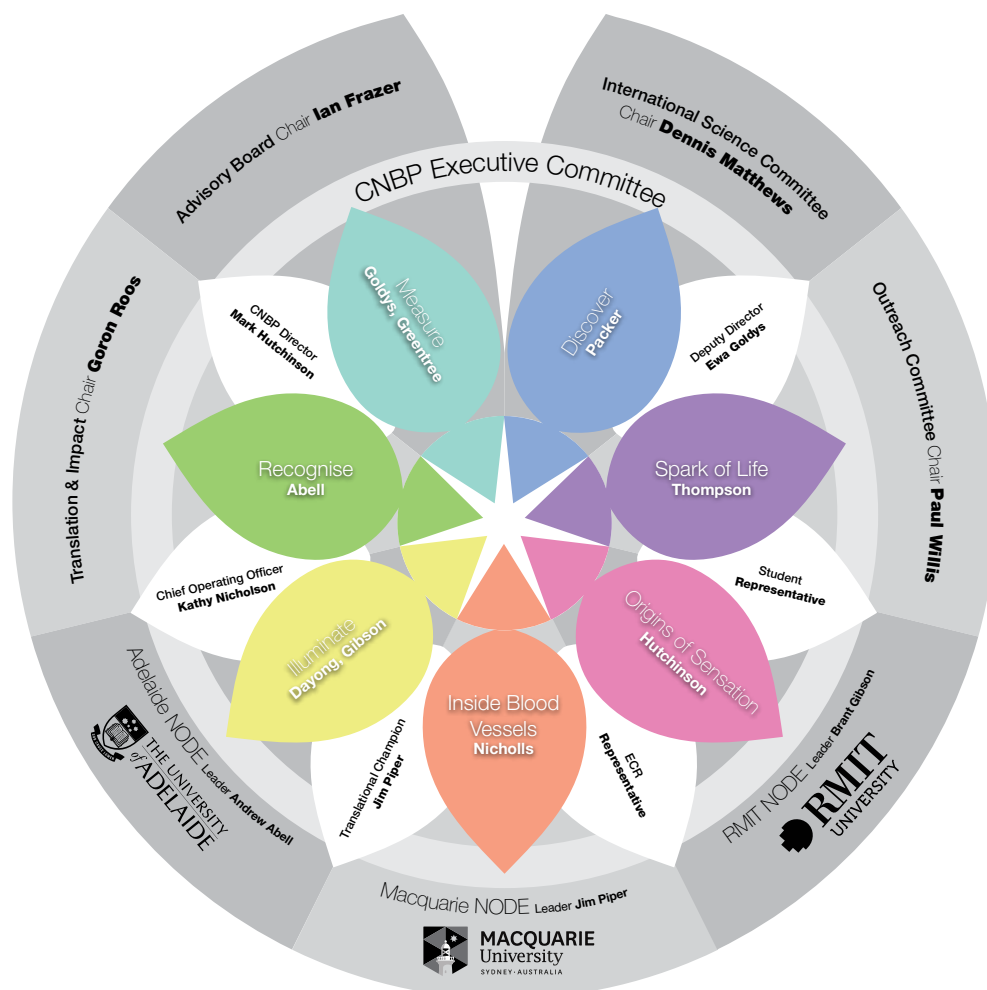
CNBP Values underpin all aspects of our work

- Academic Excellence
- Commercial Impact
- Quality Communication and
- A Nurturing Environment.



Structure and Governance

The CNBP is a collaborative program with research focused within Nodes at the University of Adelaide, Macquarie University and RMIT University.



The CNBP links into the broader Australian community through a selected web of Associate Investigators (AIs) from University of Adelaide, Macquarie University, RMIT University, Melbourne University, Monash University, University of Technology Sydney, University of New South Wales and University of Western Australia.

The reach and capacity of the Centre will be enhanced by active links with Partner Organisations, providing Centre researchers with rich opportunities to work within leading international groups in areas that complement and extend the core capabilities in the Centre, both within Australia (CSIRO, SAHMRI) and overseas (Leibniz Institute of Photonic Technology, Peking University, Huazhong University of Science and Technology, University Health Network Toronto, Southampton University and City University London). Our corporate partners (Olympus Australia, Heraeus Quarzglas and Bioplatfroms Australia) will help drive commercial outcomes from CNBP research.

A strong governance structure will enable us to marshal the enthusiasm and commitment of this team to the vision of the CNBP to pursue ambitious science goals.

Executive Management Committee

Centre Boards and Committees are structured to provide high level advice and support to the Executive Management Committee.

The purpose of the Executive Management Committee (EMC) is to oversee all aspects of Centre activities.

In 2014 the Executive Management hosted 21 meetings on a fortnightly basis. Four of these meetings were half-day in-person workshops rotating across the Nodes. Video conference was used for the other meetings.

In 2015 two additional positions will be added to the committee to represent the Early Career Researchers and PhD communities within the Centre. The committee will continue to meet every 2 weeks via video-conference with regular face-to-face meetings rotating across the Nodes.



CNBP 2014 Executive Management Committee (from left to right)
Front row: Dr. Kathy Nicholson, Prof. Ewa Goldys, Prof. Tanya Monro, A/Prof. Dayong Jin, Prof. Nicolle Packer, A/Prof. Brant Gibson
Back row: Andrew Greentree, Prof. Mark Hutchinson, Emeritus Prof. Jim Piper AM, Prof. Steve Nicholls, Prof. Andrew Abell, A/Prof. Jeremy Thompson

Prof. Mark Hutchinson (Chair)

Director, Origin of Sensation Leader
The University of Adelaide

Prof. Ewa Goldys

Deputy Director, Measure Co-Leader
Macquarie University

Dr. Kathy Nicholson (Secretary)

Chief Operating Officer, The University of Adelaide

Prof. Andrew Abell

UA Node Leader; Recognise Leader
The University of Adelaide

Emeritus Prof. Jim Piper, AM

MQ Node Leader, Macquaries University

A/Prof. Brant Gibson

RMIT Node Leader; Illuminate Co-leader
RMIT University

A/Prof. Jeremy Thompson

Spark of Life Leader, The University of Adelaide

Prof. Tanya Monro

CNBP Advocate, The University of Adelaide
University of South Australia

Prof. Stephen Nicholls

Inside Blood Vessels Leader, SAHMRI

Prof. Andrew Greentree

Measure Co-leader, RMIT University

Prof. Nicolle Packer

Discover Leader, Macquarie University

A/Prof. Dayong Jin

Illuminate Co-leader, Macquarie University

Advisory Board

“The technologies developed through the CNBP are likely to be paradigm shifting in the development of the healthcare tools of the future and I want to be involved in that process.”

—Professor Ian Frazer, Chair of the CNBP Advisory Board

Prof. Ian Frazer (Chair)

Director, Translational Research Institute,
University of Queensland

Prof. Mark Hutchinson

Director, CNBP

Prof. Michael Brooks

DVCR, The University of Adelaide

Prof. Calum Drummond

DVCR, RMIT University

Prof. Peter Nelson

PVCR, Macquaries University

Ms. Catriona Jackson

CEO, Science Technology Australia

Dr. Paul Willis

Director, RiAus

Prof. Goran Roos

Advanced Manufacturing Board of SA

Mr. Mick Reid

Private Consultant

Dr. Kathy Nicholson (Secretary)

Chief Operating Officer, CNBP

The purpose of the CNBP Advisory Board is to advise on the strategic directions for the Centre and monitor delivery of Centre outcomes. The Advisory Board will also strive to strengthen the Centres' linkages with academia, industry and government, identifying strategic engagement opportunities.

The first meeting of the Advisory Board was hosted in Adelaide on November 14 2014. In 2015 the Board will meet a minimum of 3 times using video/teleconference facilities.



CNBP 2014 Advisory Board (from left to right):
Dr. Paul Willis, Prof. Ian Frazer, Ms. Catriona Jackson, Prof. Mark Hutchinson, Prof. Mike Brooks,
Dr. Kathy Nicholson, Prof. Peter Nelson, Prof. Calum Drummond, and Prof. Goran Roos.

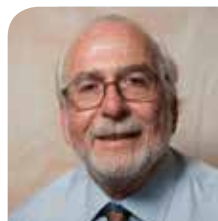
International Science Committee

We are committed to ensuring that the CNBP engages in the very highest levels of scientific discovery and knowledge creation.

The purpose of the CNBP International Science Committee (ISC) is to advise on the strategic directions of the scientific endeavours of the Centre and support delivery of other Centre outcomes.

The first meeting of the ISC was hosted at the conclusion of the CNBP Annual Retreat on November 24th. Four members attended in person and three via video-conference.

2015 meetings are planned to coincide with a major international conference in the US and the 2nd Annual CNBP Retreat in Australia.



Prof. Dennis Matthews (Chair)

Director, Centre of Biophotonics,
Science & Technology
UC Davis



Prof. Mark Hutchinson

Director
CNBP



Prof. Katarina Svanberg

Professor
Lund University



Prof. Paul French

Professor
Imperial College London



Prof. Bob Grubbs

Professor and Nobel Laureate
Caltech



Prof. Yafeng Guan

Professor
Chinese Academy of Sciences



Prof. Francesco Pavone

European Laboratory for
Nonlinear Spectroscopy

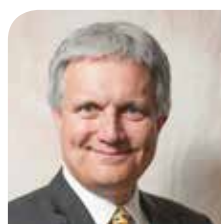


Dr. Kathy Nicholson (Secretary)

Chief Operating Officer
CNBP

Education and Outreach Committee

We are passionate about nanotechnology and biophotonics and we wish to bring the wonders of science to the public with energy and enthusiasm.



Dr. Paul Willis (Chair)

Director
RiAus



Prof. Mark Hutchinson

Director
CNBP



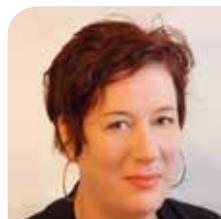
Mr. Mike Seyfang

Private Consultant
IT & Social Media



Mr. Nick Besley

Senior Manager, Engagement
RMIT University



Dr. Rachel Dunlop

Medical Researcher
and Sceptic



A/Prof. Rod Lamberts

Associate Director
CPAS, ANU



Mr. Tony Crawshaw

Incoming Outreach and
Education Coordinator
CNBP



Dr. Kathy Nicholson (Secretary)

Chief Operating Officer
CNBP

Education and Outreach Committee

Chaired by Dr. Paul Willis, our Education and Outreach Committee will guide CNBP researchers towards effective approaches to communicating the wonders of science to the broader community.

The first meeting of the Education and Outreach Committee is scheduled for February 2015.

Translation and Impact Committee

We will bring translational thinking and strategy into everything we do.

Translation and Impact Committee

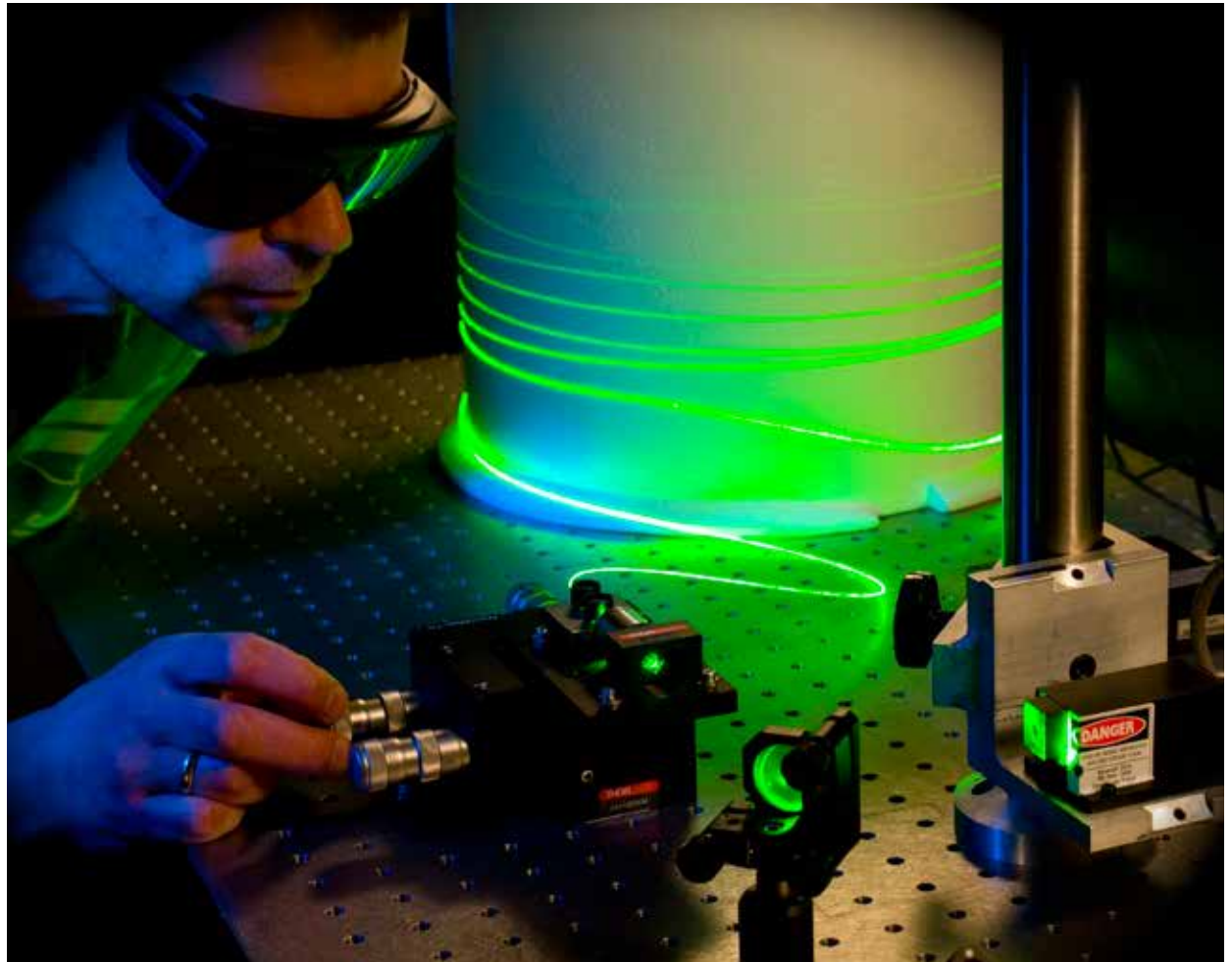
CNBP Researchers are focused on using the Centre to pioneer the fundamental science required to facilitate translational outcomes. This cannot be done as an afterthought of research. The Translation and Impact committees will support CNBP researchers in building translational thinking, and strategy into everything we do. This will help to create an outcome-based culture – that celebrates and nurtures innovation. In this way we will drive the science in directions that will create opportunities for economic and societal benefits as well as attracting to the Centre researchers seeking to make a difference.

Chaired by Professor Goran Roos, this committee will be formed and commence meetings in 2015.



Prof. Goran Roos

Advanced Manufacturing Board
of South Australia



Centre Personnel

	Theme Leader	Researchers (2014)	Students (2014)	Researchers (2015†)	Students (2015†)
A	A/Prof. Dayong Jin (MQ)	A/Prof. Heike Ebendorff Heidepriem* (UA)	Yuijia Lie (MQ & Peking University)	Dr. Fan Wang (MQ)	Nafisa Zohonra (RMIT)
	A/Prof. Brant Gibson (RMIT)	Prof. Yong Liu (MQ)		Dr. Xue Bai (MQ)	Ashleigh Heffernan (RMIT)
		Dr. Xiaoxue (helen) Xu (MQ)		Dr. Alfonso Garcia Bennette (MQ)	Elizabeth Camillieri (RMIT)
		Dr. Philipp Reineck (RMIT)		Dr. Anthony Orth (RMIT)	Zhihuang Zhou (MQ)
		Roman Kostecki* (UA)		Dr. Peipei Jia (UA)	Xuanzhao Panpan (UA)
B	Prof. Andrew Abell (UA)	Dr. Sabrina Heng (UA)	Malcolm Purdy (UA)	Dr. Jenny Butler (UA)	
		Dr. Jingxian Yu (UA)	Georgina Sylvia (UA)	Dr. John Horsley (UA)	
				Dr. Xiaozhou (Michelle) Zhang (UA)	
C	Prof. Ewa Goldys (MQ)	Prof. Tanya Monro (UA and UniSA)	Anna Guller (MQ)	Dr. Ivan Maksymov (RMIT)	
	Prof. Andrew Greentree (RMIT)	A/Prof. Heike Ebendorff Heidepriem* (UA)	Saabah Mahbub (MQ)	Dr. Erik Schartner (UA)	
		Dr. Georgios Tsiminis (UA)	Aziz Rehman (MQ)		
		Dr. Biju Citus (MQ)	Tess Sody (UA)		
		Dr. Daniel Drumm (RMIT)	Jonathan Hall (UA)		
		Roman Kostecki* (UA)	Hong Ji (UA)		
		Dr. Piotr Wargocki (MQ Visiting fellow)			
		Martin Gosnell (MQ)			
D	Prof. Nicolle Packer (MQ)	Dr. Nima Sayyadi (MQ)		Dr. Arun Dass (MQ)	Yu (Rain) Shi (MQ)
		Dr. Niocle Cordina (MQ)		De Andrew Care (MQ)	Chris Ashwood (MQ)
				Dr. Lindsay Parker (MQ)	
				Dr. Adidali Mohamedali (MQ)	
E	A/Prof. Jeremy Thompson (UA)	Dr. Melanie McDowall (UA)			
		Dr. Hannah Brown (UA)			
		Leslie Ritter (UA)			
F	Prof. Mark Hutchinson (UA)	Dr. Sanam Mustafa (UA)	Stefan Musolino (UA)		
		Vasiliki (Vicky) Staikopoulos (UA)			Jonathan Jacobsen (UA)
G	Prof. Stephen Nicholls (SAHMRI)	Dr. Achini Vidnaphthirana (UA)			
		Dr. Nisha Schwarz (UA)			
		Benjamin Pullen (UA)			

*Members of more than one research theme

†Joining the team in 2015

A. Illuminate Team
B. Recognise Team
C. Measure Team
D. Discover Team

E. Spark of Life Team
F. Origin of Sensation Team
G. Inside Blood Vessels Team

Centre Personnel

CENTRE EXECUTIVE TEAM

Prof. Mark Hutchinson	Centre Director
Prof. Ewa Goldys	Centre Deputy Director
Dr. Kathy Nicholson	Chief Operations Officer
Prof. Andrew Abell	Node Leader, The University of Adelaide
Emeritus Prof. Jim Piper AM	Node Leader, Macquarie University
A/Prof. Brant Gibson	Node Leader, RMIT University
Mrs. Melodee Trebilcock	Annual Retreat Coordinator
Mr. Joshua Burton	Visual Identify and Graphic Design
Mrs. Sara Leggatt	EA To the Director and Node Support, The University of Adelaide
Mrs. Jan Morgans	Node Support, Macquarie University
Mrs. Michelle Keeling	Node Support, Macquarie University

PARTNER INVESTIGATORS

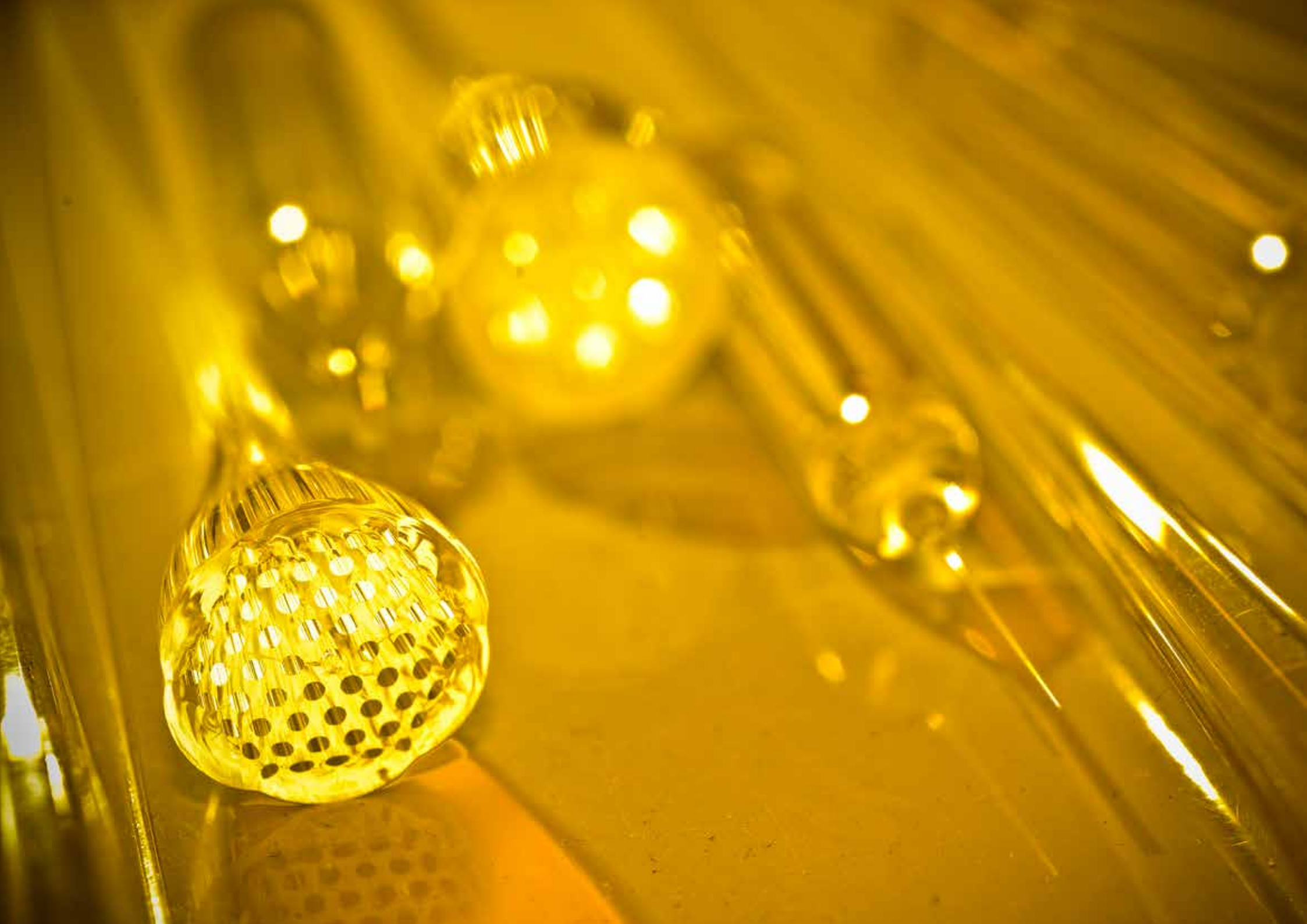
Prof. Steve Nicholls	Inside Blood Vessels Theme Leader, SAHMRI
Prof. Juergen Popp	Institute of Photonic Technology (IPHT) Jena
Prof. Sun Tong	City University London
Prof. Qingming Luo	Huazhong University of Science and Technology
A/Prof. Peng Xi	Peking University
A/Prof. Gilberto Brambilla	University of Southampton
Dr. Yonggang Zhu	CSIRO
A/Prof. Yujie Sun	Peking University, Beijing
Prof. Brian Wilson	University of Toronto
Prof. Steven Maier	The University of Colorado, Boulder

ASSOCIATE INVESTIGATORS

Dr. Jonathon George	The University of Adelaide
Prof. Bruce Hammock	UC Davis
A/Prof. Kevin Pflieger	University of Western Australia
A/Prof. Shahraam Afshar Vahid	The University of Adelaide
Dr. Alexandre Francois	The University of Adelaide
Prof. Dougal McCulloch	RMIT University
Dr. Igor Aharanovich	University of Technology, Sydney
Dr. Louise Brown	Macquarie University
Prof. Marc Wilkins	University of NSW
Prof. Paul Mulvaney	University of Melbourne
Dr. Mark Prescott	Monash University
Dr. Run Zhang	Macquarie University
A/Prof. Andrei Zvyagin	Macquarie University

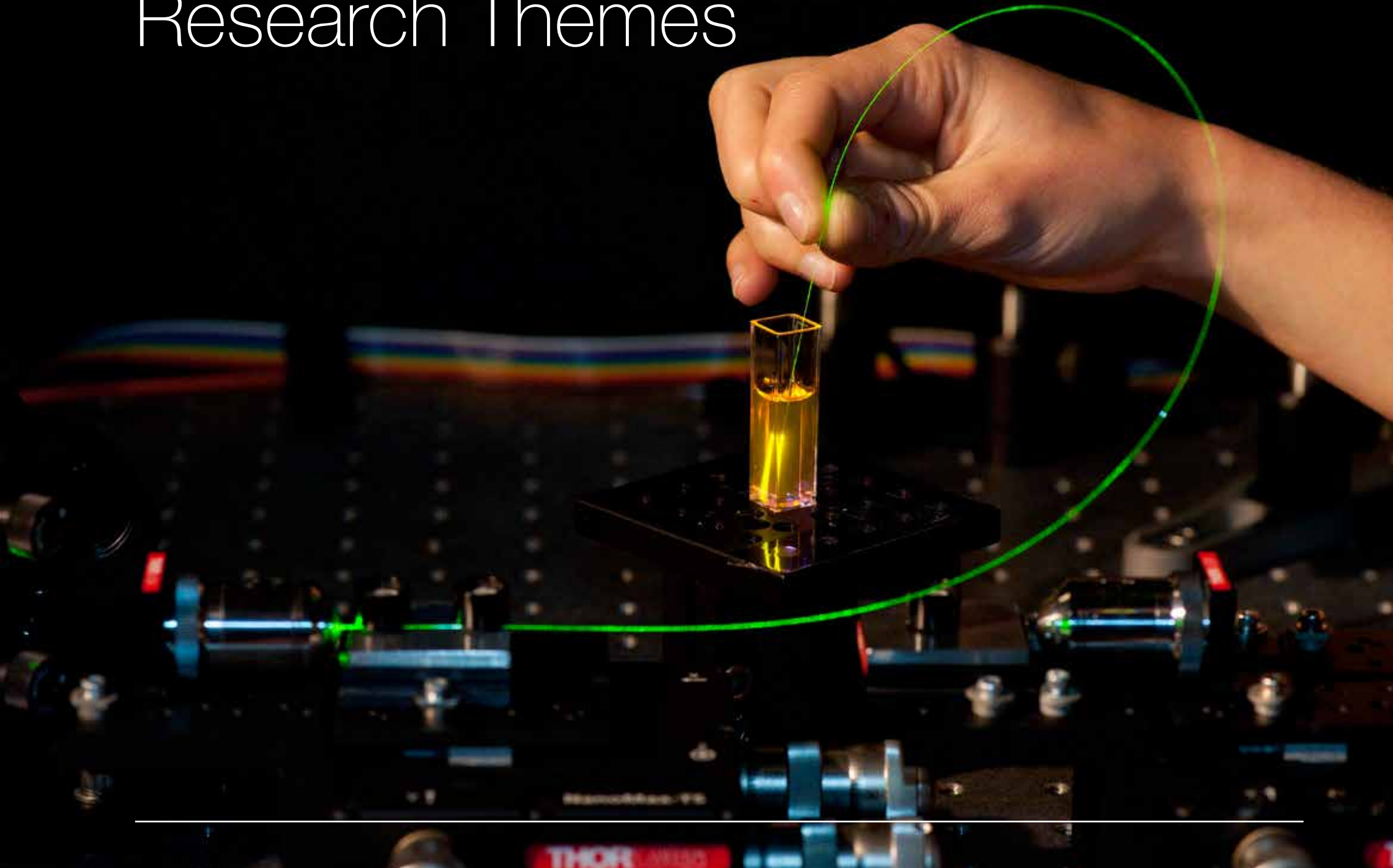


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Section 2

Research Themes

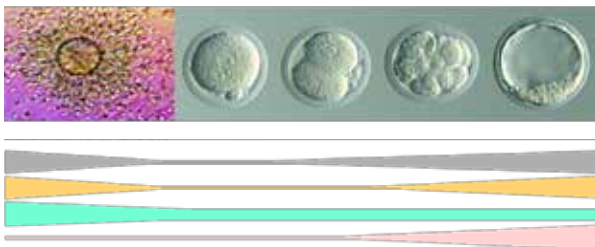


Biological Challenge 1: Spark of Life

Challenge Leader: A/Prof. Jeremy Thompson



Spark of Life Biological Challenge Leader A/Prof. Jeremy Thompson



We will explore the effect of maternal environment on the embryo

We will work towards understanding the dynamic processes at the beginning of life.

Nanoscale BioPhotonics offers approaches to measuring ions and metabolites, DNA, RNA and histone structures. This will reveal the causal pathways between maternal microenvironment and pre-conception programming.

Summary

For most animals, life begins with an egg and sperm meeting within the female reproductive tract. Each egg and sperm contains the genes that will shape much of the size, shape, appearance and health of a new life. Genes are therefore fundamental to the determination of the identity of a new individual, as the genetic code is a recipe for the developing life to form to follow.

However, in many ways the environment in which a developing new life encounters has a profound influence on determining the identity of the individual. In particular, we know that the environment within the mother's reproductive tract tinkers with the recipe, not by changing the code of genes, but by subtly adjusting when genes are turned off and on. We call this 'epigenetics' and it involves several different mechanisms that directly impinge on when genes are active and inactive. This is especially so immediately after fertilization, which represents a time when significant epigenetic

mechanisms are highly active – the purpose of which is to inform the new life what kind of environment awaits for it after its born, so that it can adapt to that environment beyond what destiny lies within the genetic code.

Think of the maternal environment like a cook reading a recipe for a cake: what if an ingredient is missing? Or an accidental mistake in combining ingredients occurs, which leads more or less ingredient(s) added than proposed by the recipe. Like the cook, epigenetic mechanisms work to alter the recipe to shape the cake differently from what it was designed to be, as a response to what is available. And like the cake, some of this adaption may lead to benefits in some aspects of the new life, but may also lead to undesirable consequences as well.

A mother's metabolic health is a significant driving force in mediating epigenetic mechanisms within the reproductive tract and causing epigenetic change within eggs and embryos. Metabolic diseases, such as obesity and diabetes, as well as inflammation, negatively impact egg and embryo health, as the reproductive tract environment mirrors that of her systemic health.

Currently our tools to measure egg and embryo health are poor. We view how dynamic embryo development is from a distance, through measuring the products of gene expression and metabolism from embryos

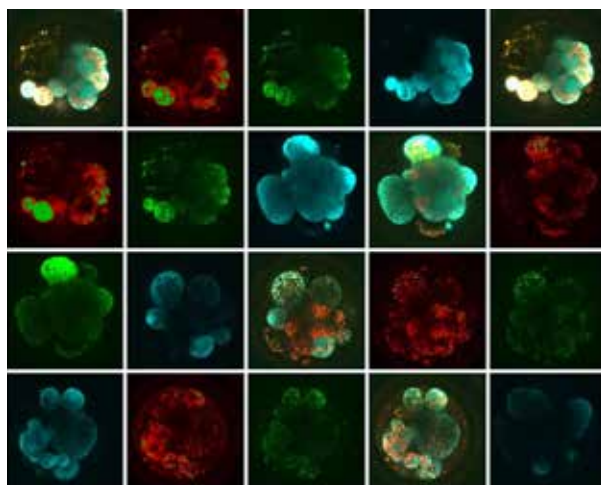
Spark of Life

To understand the dynamic processes at the beginning of life.



Biological Challenge 1: Spark of Life

What happens the moments following conception?



Triple stained bovine embryos



Dr. Mel McDowall and Ms. Leslie Ritter reviewing triple stained bovine embryos

collected from the reproductive tract and examined in isolation, away from its natural environment. Measuring the precise epigenetic changes that occur at the single embryo level is not feasible, and none of these can be measured within the reproductive tract, which in itself provides a dynamically changing, yet largely uncharacterized environment.

Our research has hit a road-block. We can't measure how embryo metabolism links into epigenetic change, especially on a single embryo basis.

We want to know what are the metabolic adaptations and epigenetic consequences that occur in embryos when they encounter an adverse maternal environment (such as diabetes and obesity) even though they keep growing but result in an unhealthy offspring.

By engaging with the four themes, we will progressively measure these parameters on a single embryo scale, as non-invasively as we can, ultimately aiming to do so within the reproductive tract.

We have begun by looking at novel fluorescence assays for ions and products of metabolism, using both auto-fluorescence and specific probes that reveal changes in metabolism in real-time during development on a single embryo basis.

2014 Progress Report and Plans for 2015

2014 Achievements

Selecting the 'best' embryo for transfer from an IVF cycle is critical in both animal breeding and clinical infertility treatment. However, microscopic morphology is a poor predictor, even by an experienced embryologist. Several new techniques have been developed; in particular time-lapse microscopy improves outcomes, but has major cost limitations. We believe that non-invasive measures of embryo blastomere health are the only option. Led by Dr. Melanie McDowall who is collaborating with the Macquarie node and others in the Adelaide node, we are evaluating the auto-fluorescence of naturally occurring metabolic fluorophores to assess embryo health.

We recently published that haemoglobin is present in the ovary, particularly granulosa and cumulus cells, as well as the oocyte, especially at the time of ovulation. Led by Dr. Hannah Brown, we are now asking why this gas-binding protein is in these cells; could it play a role in ovulation, binding either O_2 or NO in the ovary at this critical time? And are there parallels for a role of haemoglobin in some neuronal cells and blood vessel endothelial cells, both known to express this protein as well? CNBP research development of novel NO probes at both the Adelaide and Macquarie nodes, and collaborations with our Partner Investigators in Beijing

Biological Challenge 1: Spark of Life

and Wuhan, China on photoacoustic microscopy that can measure haemoglobin -O_2 in cells, will enable us to answer these questions.

Plans for 2015

We will expand our capabilities for the application of functionalized structured fibers, adapt new imaging capabilities and assess the capacity of nanoparticles to solving deficiencies in our current capacity to measure biological events within oocyte, embryos and the reproductive tract:

The application of advanced, non-invasive fluorescence imaging, such as 'hyperspectral analysis' using multiple excitation wavelengths, and novel fluorophores for specific ions, to explore the metabolic and signaling of oocytes and early embryos, especially at the time of fertilization, and relate this to the surrounding maternal environment within the reproductive tract, such as that which occurs in diabetes and obesity.

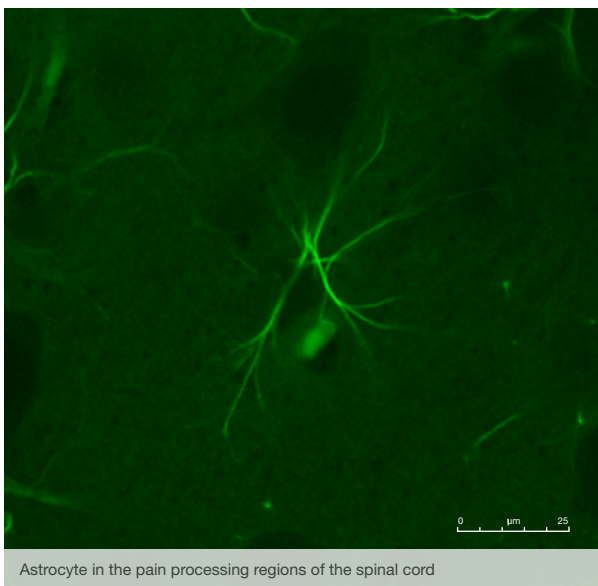
With other themes, development of microfiber probes for analysis of gases such as oxygen and nitric oxide within the female reproductive tract, leading to determining the role for non-vascular cellular haemoglobin.

Explore the concept of a 'prosthetic' oocyte and embryo, where the cytoplasm has been removed and replaced with a gel that slowly releases specific growth factors and/or cytokines, plus incorporates nanoparticles with sensing capacities, to be placed in the reproductive tract to report how embryos interact with the reproductive tract.

We are working with our colleagues in the Illuminate, Recognise, Measure & Discover themes to customise solutions so we can find out what is happening moments following conception.

Biological Challenge 2: Origin of Sensation

Challenge Leader: Prof. Mark Hutchinson



We will identify the origin, actions and behavioural consequences of central nervous system (CNS) immune signals.

Nanoscale BioPhotonics with functionalisation of the optical fibre tip has the power to go to places in the brain and monitor small molecules and proteins in localised volumes of cerebrospinal fluid that could never be assessed before.

Summary

This Concept Challenge will take the sensing technologies developed in the Centre and will use them to discover the immune-like signals that contribute to pain.

Over the past 30 years the evidence for glial immune-like signals in pain has grown from a trickle to a torrent. It is thought that immune signals, such as proinflammatory proteins, called cytokines, are critical for normal pain and the development of chronic pain states. Importantly, we are pioneering research examining sex differences in pain signalling, and demonstrating that females have a significantly heightened glial involvement in pain processing.

However, the exciting opportunities that this research affords, remains blocked by the limitations of existing sensing tools for immune signals in the brain and spinal cord.

To advance our understanding of glial involvement in touch and pain processing we need a new type of sensing technology that allows for precise and sensitive, temporal and spatial resolution of classic immune signals. These tools must be able to sense their targets, at low concentrations, in small volumes, in discrete locations, and do this repeatedly over time. These lofty goals set by this Concept Challenge for development by Themes 1 to 4 will address the needs of basic scientists whilst simultaneously addressing the ethical considerations of the '3Rs': Replacement, Refinement and Reduction of animals in research.

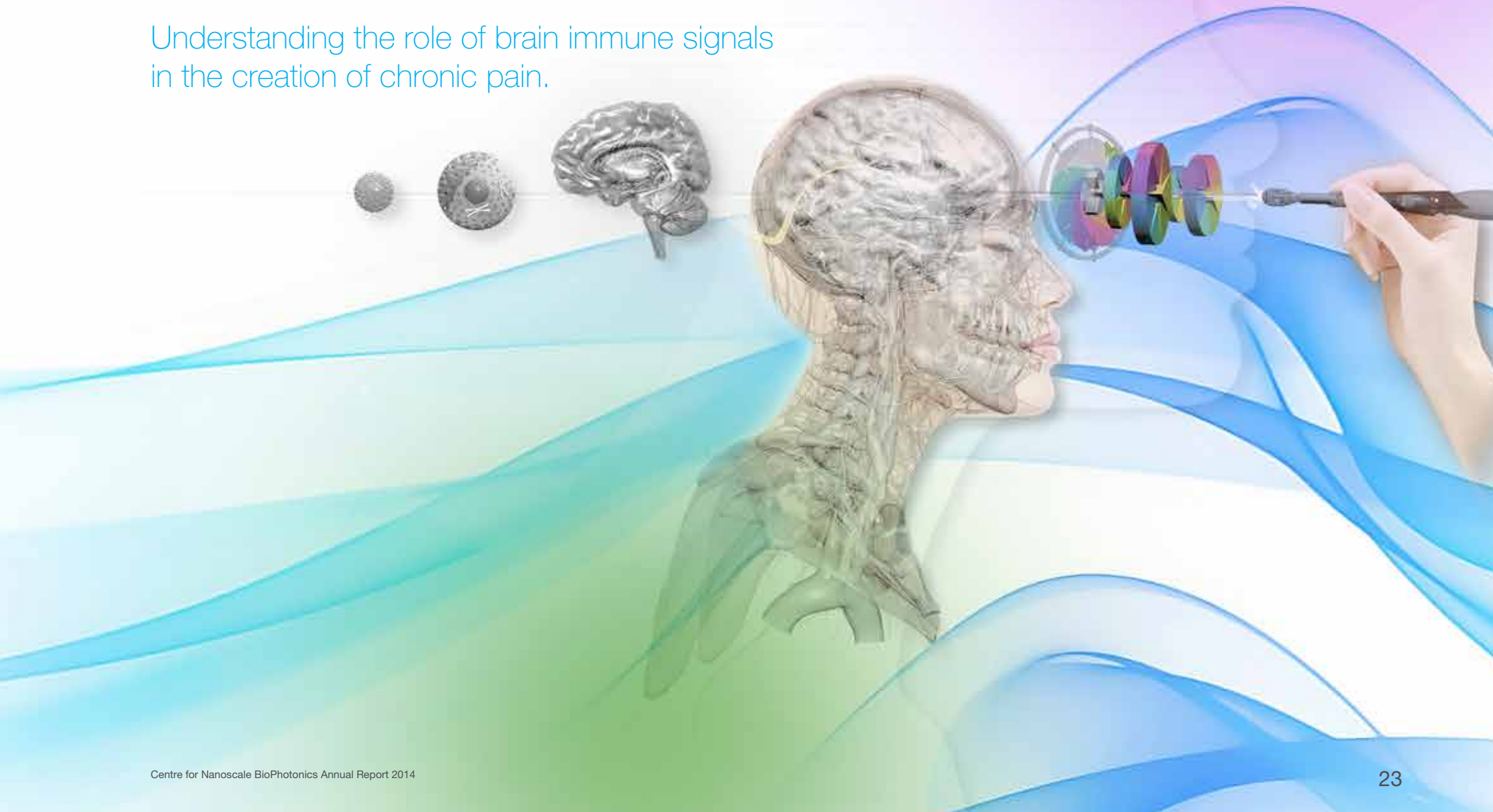
This concept challenge will produce the information validating the use of these new sensing technologies. Prof. Mark Hutchinson will lead a team of medical scientists and PhD students through the stages of concept development, testing, rollout and release.

Concept development: Through existing and new collaborations we will work alongside the Centre scientists as they develop their technologies from conceptual frameworks to tangible devices.

Concept testing: Upon handover of the new sensing technologies developed in the Centre, we will explore application of the technologies to validate them against existing methods.

Origin of Sensation

Understanding the role of brain immune signals in the creation of chronic pain.

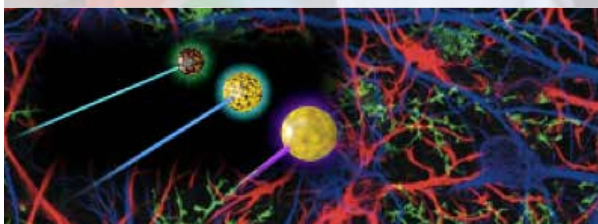


Biological Challenge 2: Origin of Sensation

Studying glial cells — the other 90% of the brain.



Dr. Sanam Mustafa and Prof. Mark Hutchinson



We will obtain real time analytics of the Central Nervous System

Concept rollout: Upon finalisation of a new sensing technology, new basic science projects will be initiated. These experiments will test new scientific questions, never before possible due to limitations of existing methods.

Concept release: We will pioneer the testing of the new sensing technologies in a broad range of applications in both the brain and spinal cord. My aim is to provide researchers skilled in the science of neuroimmunology with access emerging Centre-based sensing technologies.

2014 Progress Report and Plans for 2015

The origins of sensation concept challenge has approached the scientific and communication challenges set forth by the CNBP funding at either end of several spectrums. The goal is to meet in the middle.

Scientific Activities

Science at the Nanoscale and cellular scale: Our Centre research staff Dr. Sanam Mustafa and Vicky Staikopolous have initiated collaborative research projects with members of the Illuminate, Discover and Measure themes to develop specialised zero background histological visualisation tools using the Centre's range of nanolamp technologies. Importantly, this is coupled with the innovative tissue clearing techniques to create transparent brains for improved visualisation of the three

dimensional tripartite and tetrapartite neuroimmune junction box of the brain and spinal cord. The focus of the development of these visualisation tools is to target rare and currently poorly defined immune related brain proteins, and very short lived reactive species. Additionally, novel label free imaging techniques are also being explored in cellular and histological tissue preparations. The creation of novel cell based sensors. This research activity has seen a burgeoning of internodal and inter-disciplinary collaboration and knowledge sharing. Early data promise big discoveries for this research in 2015.

Nanoscience at the macroscale: In order to create nanoscale biophotonic tools that can be employed in preclinical behavioural models, the surgical approaches, architecture of the fibres and laser sources need to be made biocompatible, behavioural compatible and laboratory compatible. At this end of the scale spectrum our Centre PhD student Stefan Musolino has worked extensively with the 'Illuminate' theme to construct and test an indwelling brain biophotonic sensor. In this development phase this sensor is equipped to measure brain micronuclei temperatures, realtime in the behaving rat.

Biological Challenge 2: Origin of Sensation

Communication activities

"Nanoscale BioPhotonics? – what is that?" In the early days this is the response we received from the majority of the medical scientists we have interacted with. To actively educate the scientific and clinical communities about our excitement for this novel research we have taken Nanoscale BioPhotonics on the road. Prof. Hutchinson has introduced the Centre and its core activities to the annual scientific meeting of the Australasian Society for Pharmacologists and Toxicologists, and Molecular Pharmacology of G Protein-Coupled Receptors meeting. Additionally, education and training events with clinical Colleges of Palliative Medicine, Occupational Medicine, Rehabilitation Medicine and Faculty of Pain Medicine have also occurred.

Origins of sensation in 2015

The new scientific year will see the conversion of multiple promising scientific stories at the nano- to macroscales, into outcomes that have both scientific and commercial impact.

The team is also excited to grow with the addition of a new PhD student, Azim Arman, who will bring his wealth of veterinary skills to applying biophotonic sensors to understand sex differences in pain processing. Additionally we have a visiting researcher Dr. Yi Li sponsored by a Chinese Government Scholarship who will be conducting development and validation of biophotonic tools in cell culture to sense acute neuroimmune responses related to pain processing.

We are working with our colleagues in the Illuminate, Recognise, Measure & Discover themes to build new tools so we can find out what the other 90% of the brain is doing.

Biological Challenge 3: Inside Blood Vessels

Challenge Leader: Prof. Stephen Nicholls



Biological Challenge Inside Blood Vessels Leader Prof. Stephen Nicholls

We will dynamically quantify proteins and molecules within the endothelium.

Nanoscale BioPhotonics has the power to reveal the underpinning mechanisms associated with high blood pressure, cell adhesion and blood flow.

Summary

The blood vessels play an important role in regulating human health by virtue of their critical role in delivering oxygen and nutrients to organs, removing metabolic waste products and by directing inflammatory and immune responses to microbes and foreign bodies. The vasculature also plays an important role as the site of formation of atherosclerotic plaque, the underlying cause of heart attacks and strokes. While our understanding of the factors involved in the physiological function of blood vessels and their progression to a range of disease states has been increasingly established, our ability to sense these activities in cellular and organ settings remain limited. Evaluation of blood vessels are largely limited to characterising the anatomical burden and histological composition of the artery wall contents, yet the ability to accurately visualise the molecular events within have remained largely elusive.

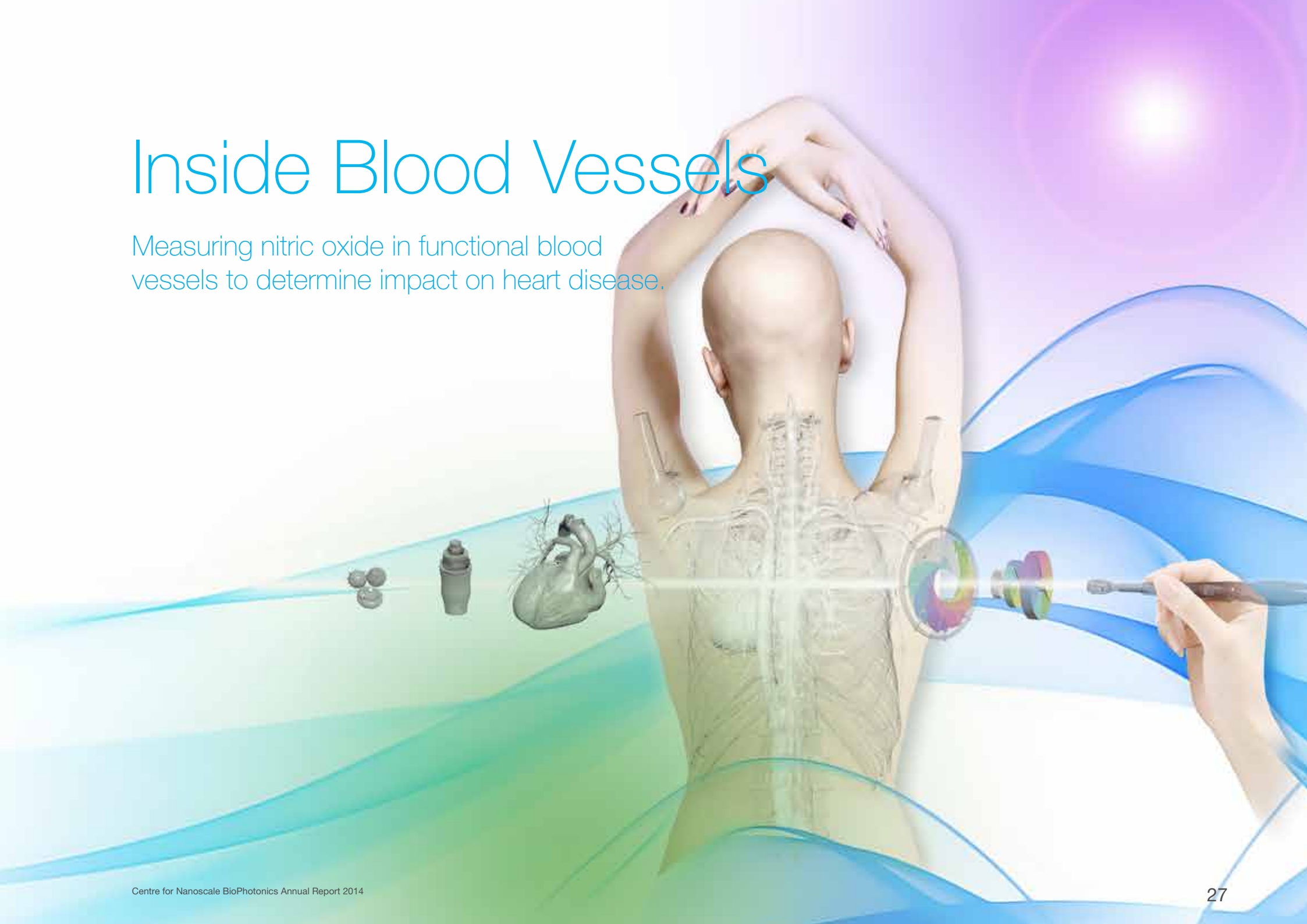
Involvement in the CNBP provides a unique opportunity for investigators focusing on vascular biology to collaborate with physicists and chemists to develop

novel sensing approaches to detecting molecular pathways involved in vascular health. The Inside Blood Vessels biological challenge has been established with these collaborations in mind and will focus on a number of key areas including:

- Developing accurate methods to detect nitric oxide in biological systems. Nitric oxide has been identified as the key factor involved in the maintenance of vascular homeostasis. While considerable research efforts have been undertaken to understand the factors that influence nitric oxide and its role in vascular health and disease, the ability to accurately detect nitric oxide is limited by its short half life. As a result, vascular studies of nitric oxide are typically limited to surrogate measures. The CNBP is dedicated to a multidisciplinary approach to developing effective approaches to the detection and measurement of nitric oxide in biological systems.
- Developing effective approaches to monitoring inflammatory pathways. The blood vessels play an important role in the regulation of inflammatory cells to tissues in order to fight invading microbes and foreign bodies. In the setting of disease states, inflammatory events have been demonstrated to play an important role in the promotion of all stages of vascular disease. As a result, the ability to accurately detect inflammatory vascular events in biological systems represents a major objective of the challenges' objectives.

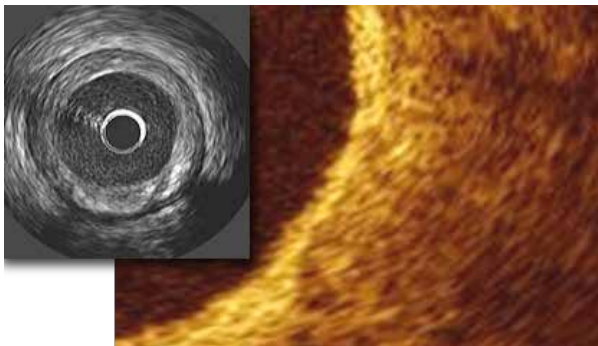
Inside Blood Vessels

Measuring nitric oxide in functional blood vessels to determine impact on heart disease.

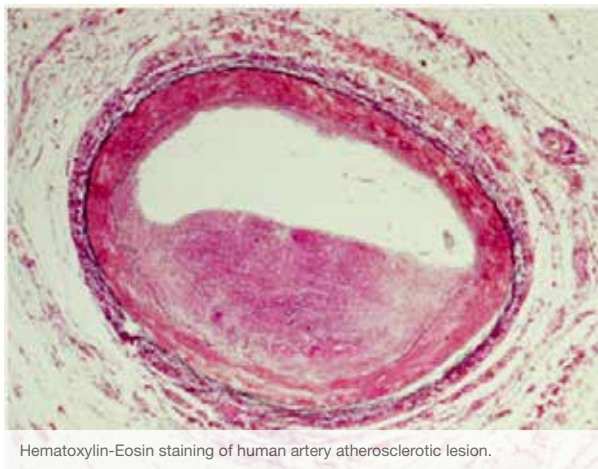


Biological Challenge 3: Inside Blood Vessels

What causes high blood pressure?



In vivo modalities to image human arteries: Intravascular Ultrasound (IVUS) and Optical Coherence Tomography (OCT)



Hematoxylin-Eosin staining of human artery atherosclerotic lesion.

- The endothelial cell represents the single cell layer lining the lumen of blood vessels. They play the critical role in all aspects of regulating vascular health, are rendered dysfunctional in the earliest stages of vascular disease and apoptosis (or programmed cell death) of this layer has been increasingly recognised as an inciting event in many heart attacks and strokes. Yet there is currently no effective approach to be able to monitor endothelial cell function and viability in the *in vivo* setting. Efforts within this challenge will aim to more effectively monitor endothelial cell activity in biological systems.
- The growth of new vessels (or angiogenesis) represents a critical feature during human development and a range of states including vascular disease, cancer and transplantation. While the molecular events implicated in physiological and pathological angiogenesis have been elucidated in cellular systems, there is currently no effective approach to imaging angiogenesis *in vivo*. The centre is dedicated to developing such novel techniques.

These collaborative projects have the potential to be transformative, to equip vascular scientists with novel approaches to studying the cellular biology underlying vascular health, while at the same time providing clinicians with better tools to developing more effective approaches to the detection, prevention and treatment of vascular disease.

2014 Progress Report and Plans for 2015

The inside blood vessels concept challenge has approached the scientific and communication challenges set forth by the Centre for Nanoscale BioPhotonics funding via the development of collaborations with each of the major themes in order to develop more effective biological sensors of the vascular system.

Scientific Activities

Science at the Nanoscale and cellular scale: Our Centre research staff Dr. Achini Vidanapathirana and Benjamin Pullen have initiated collaborative research projects with members of the Recognise, Illuminate and Discover themes to develop novel tools to detect and quantify nitric oxide, inflammation and oxidative stress at a cellular level. Nitric oxide is a vital factor regulating vascular health, yet the ability to currently sense and measure it in cellular models, tissues and in the *in vivo* state have presented a considerable challenge. The ability to develop effective tools to sense nitric oxide in biological systems will enable further studies of the factors that influence vascular health. Inflammation and oxidative stress have been demonstrated to play an important role in the regulation of normal vascular function and have important effects that promote a range of vascular diseases. The ability to sense the complex intersection of a range of inflammatory and oxidative events would

Biological Challenge 3: Inside Blood Vessels

provide an important step to comprehensively investigate the biological systems influencing blood vessel function. Our investigators have initiated enthusiastic and transdisciplinary collaborations with other members of the CNBP to commence work in this area.

Nanoscience at the macroscale: In order to create nanoscale biophotonic tools that can be employed in preclinical vascular models, we require the development of novel sensing tools to be delivered within vessels in a manner which is useful for the researcher and potentially clinical practice. Dr. Nisha Schwarz is working with collaborators in the photonic section to employ novel spectroscopic approaches to imaging the artery wall.

Communication activities

During the first year of the centre, we have actively communicated the major objectives of our challenge to the broader cardiovascular research community at the Cardiac Society of Australia and New Zealand and the Australian Atherosclerosis Society in order to engage more widespread interest in the potential applications and collaborations that can be generated by the centre.

Inside Blood Vessels 2015

Early in this new scientific year we will welcome Dr. Peter Psaltis and Dr. MyNgan Duong to our challenge in their capacities as senior researchers within our group. Dr. Psaltis is an interventional cardiologist with a well-established interest in the cellular biology involving the adventitia, the outer layer of the vessel wall. His interests will intersect well with the primary objectives to develop novel sensors of nitric oxide, inflammation and oxidative stress. Dr. Duong has well established experience in the metabolism and biological properties of plasma lipoproteins. The ability to develop more effective approaches to sense and detect the interaction between lipoproteins and cellular/tissue systems would produce a major advance in the field.

We are working with our colleagues in the Illuminate, Recognise, Measure & Discover themes to build new tools so we can discover what causes high blood pressure.

Research Theme 1: Illuminate

Theme Leaders: A/Prof. Jin Dayong, A/Prof. Brant Gibson



Illuminate Theme Leaders A/Prof. Jin Dayong and A/Prof. Brant Gibson



Non-invasively probing individual interacting biomolecules by using nanoparticle based 'lamps'

The science theme of Illuminate explores advanced optical materials that efficiently deliver and collect light to and from cells and molecules locally. This allows us to non-invasively probe individual interacting biomolecules by using nanoparticle-based 'lamps'.

The Illuminate theme pursues bio-compatible fluorescent nanoparticles, next generation optical fibres and nanoparticle enriched hybrid materials.

We will create:

- excitation photons designed to probe molecular-level systems
- novel nanoprobe with tailored emission characteristics
- advanced optical fibres for delivering light to/from nano environments
- nanoparticles enriched materials and structures

Summary

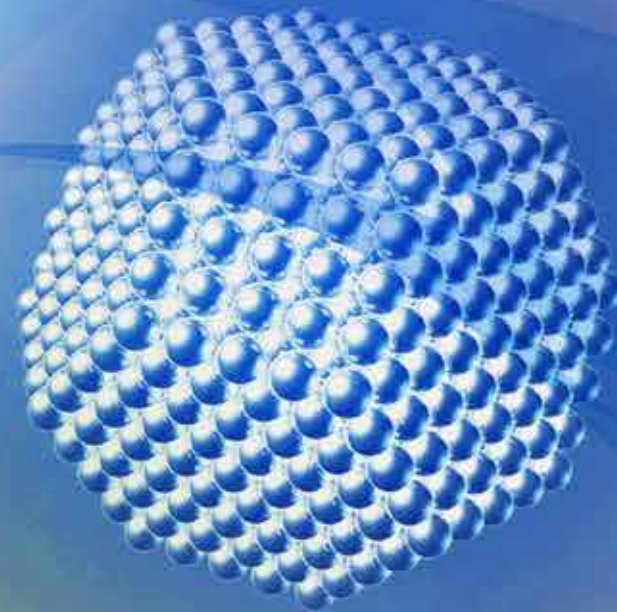
Novel nanoscale 'lamps'

The Illuminate team will produce super-bright molecular probes for the rapid interrogation of target molecules down to the single molecule level. We will create and assess a versatile library of novel nanomaterials for probing biological systems – nanoscale light sources with unprecedented spatial and temporal resolution. We will work with the Theme 2 'Recognize' team to functionalise these probes and design photon-switchable sensors. These functionalized nanoparticles will enable the nanophotonic architectures developed in Theme 3 'Measure' to obtain super-resolution multiplexed information for the long-term monitoring of physiological cellular and molecular responses.

We are building and evaluating to tailor a material library of nanoparticles with a range of absorption/emission wavelengths, size, brightness (single and ensemble emitters) and functionality. Our long-term aim is to create biocompatible sub-10 nm nanoparticles with ultra-high brightness ($> 10^8$ photons/s). While cross-disciplinary collaborations are essential, this theme focuses on building our expertise in nanoscale optical characterizations of luminescent nanoparticles and controlled growth of nanocrystals and hybrid-multifunctional nanomaterials.

Illuminate

Creating new light sources such as nanoscale 'lamps', advanced optical fibres and novel nanoprobe that deliver and collect light, targeting cells and molecules in the body.



Research Theme 1: Illuminate

Creating light when and where we need it.



The team will produce high-efficient upconverting SuperDots, through advanced design, materials engineering and integration of nanophotonic tools to enrich thousands of emitters within a single nanoparticle. Background-free operation will be achieved by utilising either time-resolved gating to remove background signals or upconversion scheme – delivering near-infrared light to the biological environment will avoid biological autofluorescence. Equally critical for our Centre will be to engineer and characterize fluorescent nanoparticles as sources of single photons for single molecule sensing. This is built on our expertise with materials such as luminescent nanodiamond and metal oxides.

Advanced optical fibres for delivering light to and from biological nanoenvironments.

One of our goals is to improve the UV transmission of optical fibres by fabricating fibres suitable for light delivery and sensing from glasses that offer greater UV performance. By extending the reach of these fibres into the UV using cross-sectional structuring, low power UV light will be delivered to the cellular environment for probing cellular autofluorescence, particularly from (270–350nm).

We will investigate the impact of fluorine doping, hydroxyl group content, fibre fabrication conditions, laser power and wavelength on UV transmission and fluorescence to

identify the composition best suited for the development of fibres capable of delivering UV light from cells. Structuring concepts such as Kagome lattices enable the guidance of light within hollow core fibre. These structures can decrease the fraction of the light guided in the glass, and have been used to shift the infrared edge of silica fibres from 2 μ m to 4 μ m. Translating this concept, and utilising a range of low loss UV materials, Kagome fibre concepts will allow the transmission of light to extend further into the UV.

Nanoparticle enriched hybrid materials.

We are also focusing on integrating the nanoscale ‘lamp’ sensing elements of nanoparticles and fibres, with the macroscopic read-out of the sensing architecture to be developed in Science Theme 3 ‘Measure’. Nanoparticle-enriched active materials will serve as a bridge between nanoparticles and bulk materials while conserving and enhancing nanoprobe functionality. We are currently exploring the physical and chemical interactions between the nanoparticles and the materials they are embedded in or attached to with the ultimate aim of controlling the nanoparticles’ properties and sensing performance via embedding. This area of research is being performed in the context of fluorescence sensing developed internally within CNBP as well as Raman sensing strongly supporting Theme 4 ‘Discover’.

Research Theme 1: Illuminate

2014 Progress Report and Plans for 2015

For 2015, Illuminate projects will fall into the following capability areas: Optical Fibres, Nanoparticles and Probes for nanoscopy/microscopy. With progress and plans outlines below.

Optical Fibres:

- We have demonstrated a platform for nanoparticle enriched materials, which will be exploited in 2015 in the CNBP to create new nano particle-doped fibres and cavities
- In 2015 we will also focus on exploring performance of UV transmitting silica fibres for photoswitching and autofluorescence measurement.

Nanoparticles:

- Early career researcher and MQRF Dr. Helen (Xiaoxue) Xu and team have succeeded in hybridizing ZnO@SuperDots as unique nanomaterials for multi-modality imaging and sensing purposes
- PhD student Mr. Denimg Liu and ECR Dr. Helen (Xiaoxue) Xu have realised a wet chemistry method for the 3D engineering of sub-50nm nanocrystals with programmable arbitrary shapes and optical/magnetic properties for multi-modality sensing.

- Early career researcher and MQRF Dr. Yiqing Lu and team have successfully demonstrated the lifetime-based multiplexing tau-Dots for multiplexing detection of thousands of analytes in a single test
- AI A/Prof. Andrei Zvyagin and team have developed large scale production methods for luminescent nanoruby nanoparticles
- Development of X-ray stimulated nanoparticles.

Probes for Nanoscopy/Microscopy:

- PhD student Yujia Liu, (co-supervised by PI: A/Prof. Peng Xi (Peking University) and CI A/Prof. Dayong Jin) has discovered a solution for making a luminescence nanoparticle probe with stimulated emission depletion (STED) enhancement and demonstrated a low-power high-contrast super resolution (SETM) nanoscale technique
- Adding additional capabilities to CNBP microscopy facilities through the successful LIEF equipment (National live cell scanning platform for nanoparticle tracking) at Macquarie University which will be remotely accessed at the other Nodes
- Tailoring of custom confocal microscopes for CNBP experiments and nanomaterial characterisation from the visible spectrum to the infrared
- Work on X-ray stimulated nanoparticles will progress into mouse experiments with PI Brain Wilson (University Health Network, Toronto).



Dr. Georgios Tsiminis coupling laser light into an optical fibre, for use in chemical sensing

Research Theme 2: Recognise

Theme Leader: Prof. Andrew Abell



Recognise theme leader Prof. Andrew Abell

Optically-controlled surfaces to recognise molecules in living systems.

We will develop:

- Optically-controlled surfaces to recognise molecules in living systems
- Novel reporter molecules
- Strategies for surface attachments
- Continuous sensing and light-driven regeneration and control.

Summary

The interaction of key biomarkers with more complex biological receptors drives cellular function. These interactions generate a signal, at the molecular level, which then drives key metabolic processes that are essential to life. The ability of these biomarkers to bind to their receptor, in this way, is defined by a mutual complementarity of molecular shape and electronic properties. This association works much like a key fitting into a lock. While this is a useful analogy, the processes are somewhat more complex and dynamic at the molecular level, with each binding partner undergoing conformational or shape change on binding, giving rise to what is referred to as an induced fit and binding. A good example of this is found in the interaction of an enzyme, nature's biological catalyst, with its natural substrate.

The structure and hence function of each enzyme is defined by its linear sequence of constituent amino acids that folds into an exquisite and functional 3-D shape or conformation. This folding is driven by a series of highly specific and well-defined chemical interactions that are themselves programmed by the amino acid sequence. The overall gross structure defines the makeup and chemical properties of the enzyme active site, which then accommodates and binds a specific substrate, with some associated change to its geometry to allow the necessary and proper fit.

Understanding these processes, at the most fundamental molecular level, requires us to first identify key biomarkers that interact within cells, but also the signal molecules that are subsequently liberated. We need specific tools that will let us study or probe these processes and their associated down-stream effects. All this must be done with probes that operate at an exact cellular location and on a precise time frame. The generation of such a biological sensor requires us to develop new ways to control and measure molecular function in solution and on the surfaces to allow precise and repeated measurement. This last point necessitates that the function of a probe can be switched on and off on demand, to allow repeated and timely measurement. We propose to develop the tools to create such sensors that are capable of continuous monitoring of specific

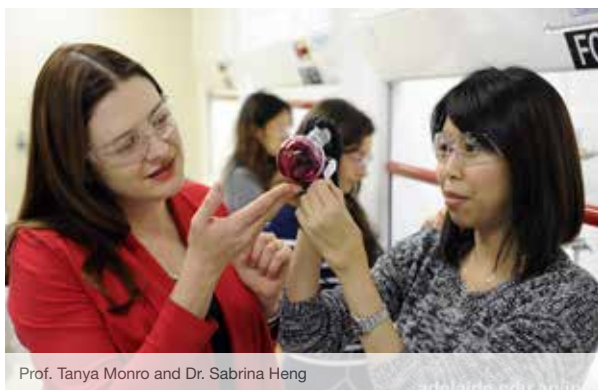
Recognise

Creating smart surfaces for nano sized probes, optical fibres and particles that allow the desired biomolecular and cellular targets to be sensed and detected.



Research Theme 2: Recognise

Building surfaces to identify specific molecules.



biomolecules, rather than single one-off measurements. Work in this theme is focussed on a fundamental investigation into all these points to allow cellular measurements that underpin our defined biological challenges and other key biological processes.

The component molecular switches of the probes are activated photochemically, or by some other external stimulus, to bring about a molecular change that is able to modulate binding and interaction with a target biomolecule. We are developing novel ways to detect these changes, for example through the detection of an associated electrochemical response. We are particularly interested in modular approaches that will allow the assembly of versatile switchable and sensing platforms that can be tailored to a given application or function, much like one might construct a Lego structure from its component building blocks or parts.

As an example, metal ions such as zinc and calcium are essential to proper cellular function and an imbalance in their distribution plays a major role in defining the beginnings of life as well as the processes of aging and disease. These ions can be detected on switchable binding to a suitably designed ligand attached to a probe, with measurement of the resulting fluorescence. The sensor must be compatible with a biological environment, while providing high sensitivity of detection at the single molecule level where and when required.



2014 Progress Report and Plans for 2015

- Developed the first dual ion sensor for cadmium and calcium that is capable of detecting both ions at 100 pM concentrations. These two ions are related in that cadmium toxicity is due to the improper homeostasis of calcium in the cell. This system also has the ability to turn ion-binding on and off.
- Developed a selective calcium sensor to be used in probing intercellular calcium in developing embryos. The calcium sensor probe is highly selective for calcium ions over other biologically relevant ions including magnesium. It has been used to determine calcium concentrations in the media obtained from different fertilization treatments.
- Developed an optical fiber-based multi-ligand ion sensor for aluminum and calcium. This is based on embedding photoswitchable sensor molecules within a polymer matrix, which is then coated onto optical fiber. This system was used to investigate the effect of the environment (i.e. in solution or within polymer) on the binding affinity of the sensor molecule.
- Developed an optical fiber-based biosensor for zinc using a membrane as the biomaterial. This is a highly sensitive and reversible sensor for zinc ions. The sensor was used to differentiate between zinc concentrations obtained from mice that have and have not had bacterial infection. The sensor requires only

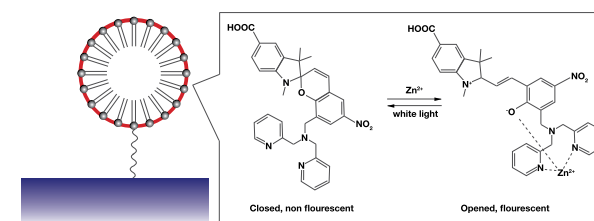
Research Theme 2: Recognise

nanoliter-scale volume of sample to yield a fluorescence response in the presence of zinc ions where traditional methods such as ICP-MS were unable to detect zinc in the same sample.

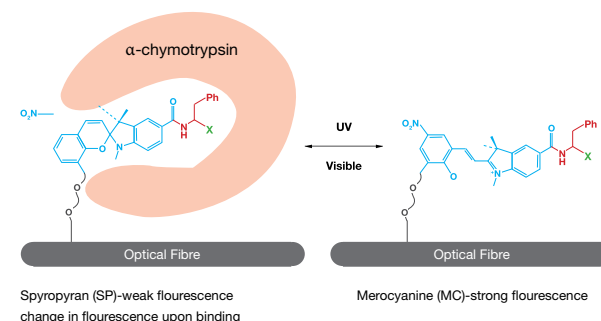
- Developed a first generation of spiropyran-based sensor for glutathione. The first reversible sensor glutathione was developed. This sensor can detect glutathione in solution at 10 μM concentrations. On-going work is concerned with improving the sensitivity of the sensor.
- Developed electrochemical methods to probe changes in the conformation of peptides and peptidomimetics. Delineated fundamental mechanisms and kinetics of the associated electrochemical processes with applications to molecular electronics and biosensors.
- New electrochemical and theoretical data to define the interplay between electron rich side-chains and backbone rigidity on electron transfer in peptides, where until now these effects have been considered in isolation. The study provides important new insights into the role of molecular dynamics in electron transfer within peptides. Findings represent an important step towards the implementation of peptides into molecular electronic assemblies and biological switches.
- Control of molecular and ion transport through a single nanopore or nanopore array is a key process in number of applications including molecular separation, biosensing, energy storage, nanofluidics and

nanoelectronics. The electrochemical and electrical properties of nanopore arrays were investigated by electrochemical impedance spectroscopy (EIS) to explore their capability towards the development of nanopore biosensing devices. The results show a good sensitivity and selectivity for this system as a basis for the development of biosensing devices.

- Developed a new sensor molecule for the detection of hydrogen peroxide in sperm. The new fluorophore is highly effective for detecting hydrogen peroxide in human sperm, and can distinguish between poorly motile and motile sperm. We are now well-placed to answer other important questions in the fertilisation and growth of embryos.
- Development of Metal-binding Peptide Modified Microelectrodes for Selective Detection of Zinc Ions. Metal-binding studies have shown distinct effects on the structural properties of the peptide by different divalent metal-ions. The peptide will be modified for electrode attachment, and the electrochemical response of the peptide monitored upon interaction with divalent zinc.



A Reversible and Highly Sensitive Platform for the Detection of Zinc in Biology.



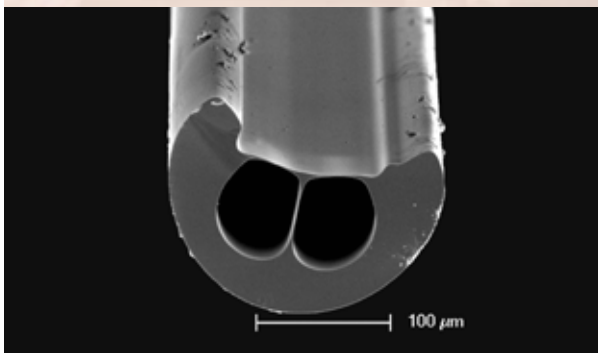
Photoregulation of alpha-Chymotrypsin activity by Spiropyran-based Inhibitors in Solution and Attached to an Optical Fibre.

Research Theme 3: Measure

Theme Leaders: Prof. Ewa Goldys, Prof. Andrew Greentree



Measure Theme Leaders Prof. Andrew Greentree and Prof. Ewa Goldys



An exposed core fibre. The diameter of the fibre is width of a human hair. This unique design enables nanoscale measurements along the length of the fibre.

We Will Develop:

- Nanoscale photonic sensing architectures
- Remote nanoscale assays
- Spatially distributed measurements *in situ* interferometers
- Exploring the fundamental limits of detection.

Summary

While the first two CNBP themes 'Illuminate' and 'Recognise' provide the building blocks for molecular detection inside of the body, the theme 'Measure' focuses on technology integration and using the developed technology for producing new understanding of real biological systems.

Comprehensive characterisation of biological systems at a molecular level is based on complementary approaches of non-invasive label-free and invasive, labelled detection. Our main emphasis for label-free characterisation is single photon fluorescence of endogenous compounds in cells. Here, we carry out a careful quantitative analysis of fluorescent colour of cells and tissues with specific emphasis on cell population properties. Colour is a supremely sensitive indicator of biological processes and its quantification offers a very powerful tool to identify cell groups and analyse biochemistry without intervention into the living

system (other than illumination with LED light). We are able to access key characteristics, such as levels of surface biomarkers, reactive oxygen species, genetic modification and outcomes of chemical interventions. Because this analysis is fully quantitative, we are in a position to test biological hypotheses, such as whether a medical treatment has been effective. Current projects in this area focus on characterisation of the embryos within the 'Spark of Life' Challenge, on the analysis of neuronal cell populations for 'Sensing sensation' and the function of the epithelium. We are supporting multiple projects of our external partners in the area of ophthalmology, diabetes and cancer and have plans for motor neuron disease and monitoring of photodynamic therapy, PDT (a joint effort with Professor Brian Wilson, a global authority in PDT dosimetry and Partner Investigator in our Centre).

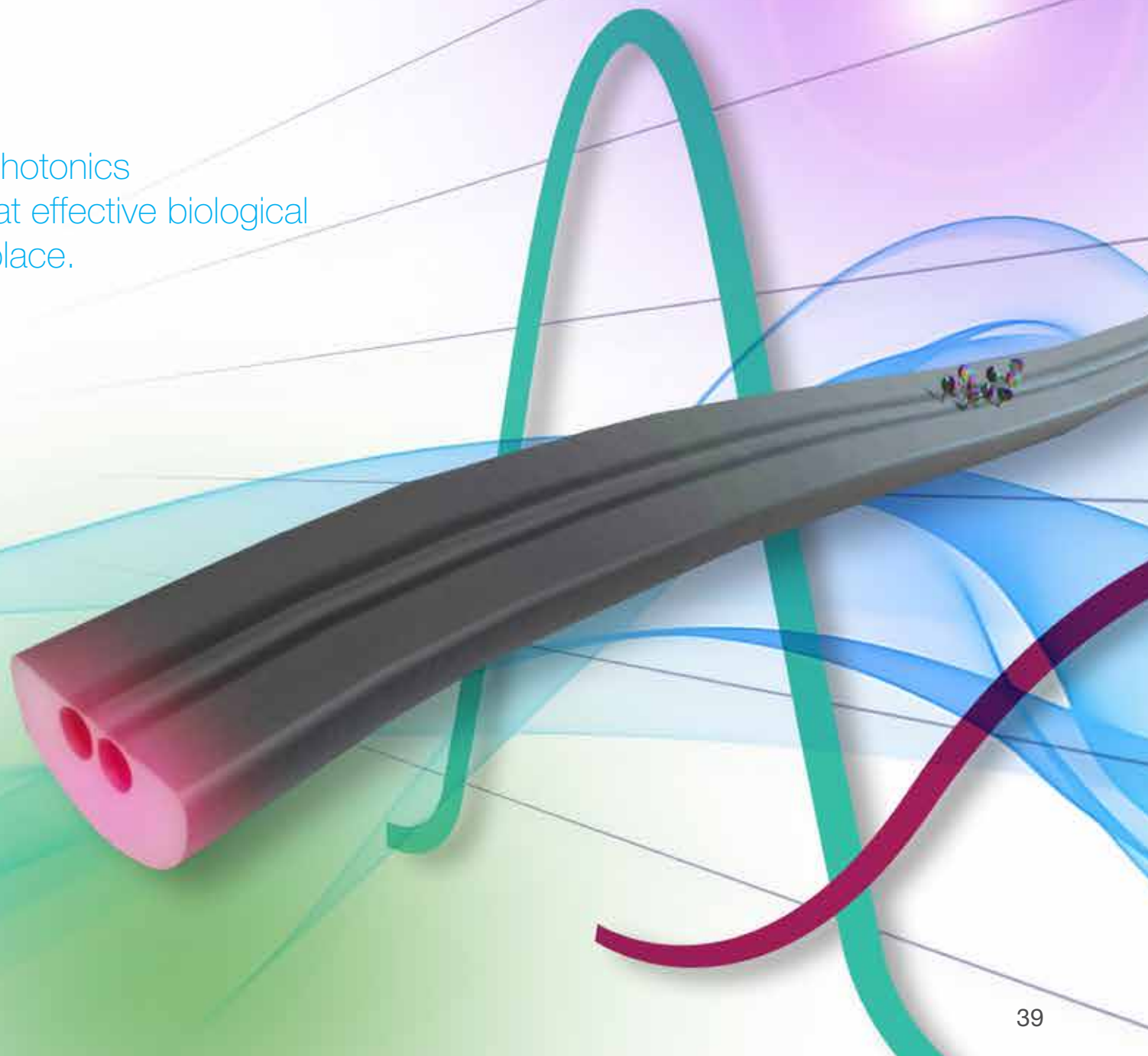
2014 Progress Report and Plans for 2015

Our 2014 research has also explored another property of cells and tissues, that is fluorescence decay times. We carry out investigations of biological systems where key biological information is encoded by these decay times. We are building novel detection systems which can provide the surgeons with unique, real time molecularly sensitive vision.

Raman sensing is another modality where we work together with our PI Prof. Juergen Popp from the Institute of Photonic Technology, Jena. Raman effect is

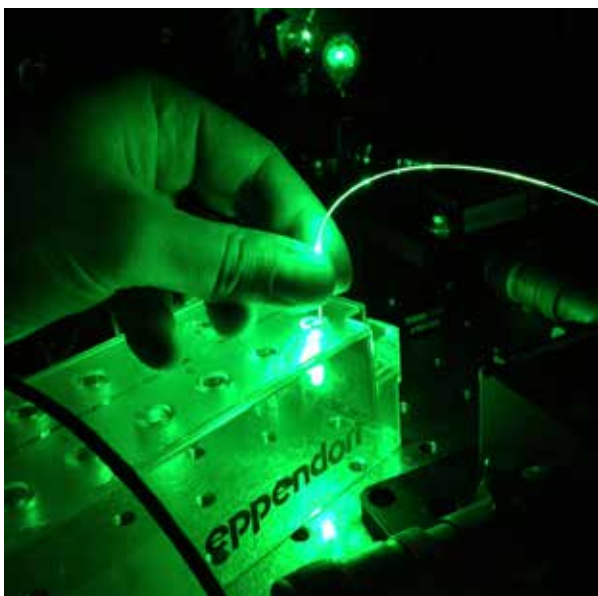
Measure

Creating integrated nanophotonics architectures to ensure that effective biological measurements can take place.



Research Theme 3: Measure

Exploring the fundamental limits of detection.



Laser light is coupled into an optical fibre for use in chemical sensing

sensitive to molecular signatures of important classes of molecules. The program on real-time detection of inflammation in blood vessels (with PI Prof. Stephen Nicholls) uses a Raman probe to provide non-invasive diagnostic of vulnerable plaque via Raman signatures.

Our 2014 program on labelled detection of key molecular species centres around micro and nanoparticle based

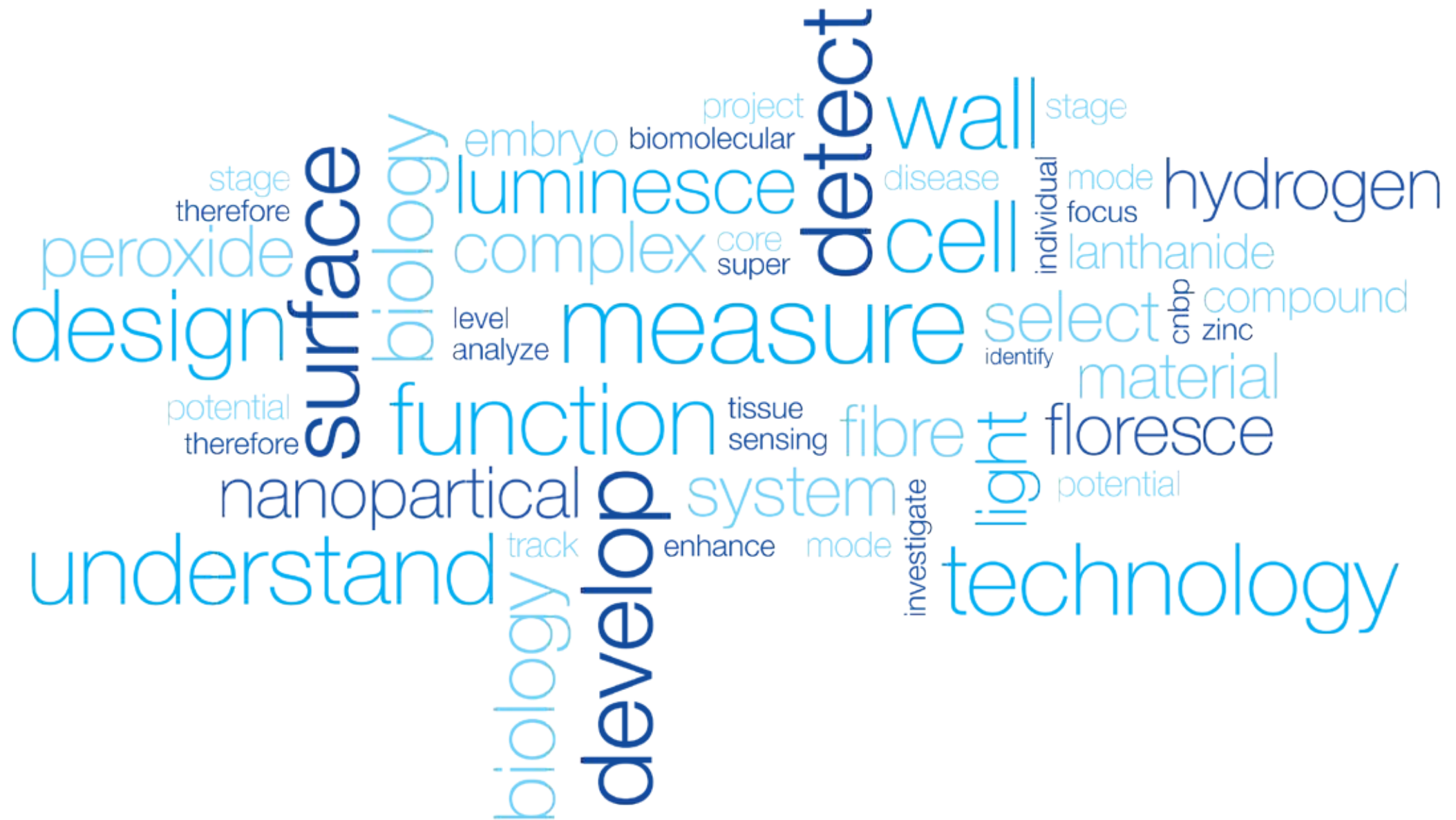
probes and it supplements our work on label-free technologies. Here, the focus is on the development of nanoscale assays, to enable localised sensing and repetitive sensing of small animals. Our emphasis is on two types of molecular species, cytokines, where we combine nano- and microparticle sensors with remote detection, and on metalloproteases. Here we build on the achievements of the themes 'Illuminate' and 'Recognise' and we employ ultra-bright fluorescent particles and tailored surfaces developed elsewhere in the Centre.

Complementing the experimental activities in the 'Measure' theme, Prof. Greentree and his team examining the theoretical work focussed on creating frameworks to probe the limits of detection possible in such architectures. This theory will transcend the conventional approach of extracting information from the predicted electromagnetic fields within the devices to extract maximal information from the measurement system as a whole, considering linear and nonlinear effects.

For every sensing problem it is necessary to ask "how good is the system and how good can it be?" The limits of sensing arise from applying both classical and quantum treatments of information theory with rigorous models of specific architectures. Using our expertise in quantum information science and quantum measurement, the team will use information theoretic

metrics to determine the limits of biosensing across the Centre's programs. To divine these limits requires combining numerical modelling of realistic architectures with an understanding of Hamiltonian level treatments: combining concrete and abstract analyses. Through new collaborations with the National Computational Infrastructure and access to their super computer facilities we will support, extend and fast track the experimental activities of the Centre.

Additionally the 'Measure' theme will leverage our experience in diamond single photon emitters, to work closely with the 'Illuminate' theme in the development and deployment of fluorescent nanoparticles. Here, it will be important to understand how the emission properties of nanoparticles change in response to their environment, and to find new ways to efficiently create and sort fluorescent nanodiamonds (especially non-NV centres). These are as-yet unsolved problems that we will solve together. Our activities will also support the broader nanolamp sensing program that offers a qualitatively different approach to biophotonic applications from single emitters. Here we are working to further develop some of the quantum optics and ensemble processes (including spectral hole burning) that are likely to be observable in these lanthanide systems.



Research Theme 4: Discover

Theme Leader: Prof. Nicolle Packer



Discover Theme Leader Prof. Nicolle Packer

We Will:

- Use advanced molecular analysis to monitor changes in/around cells
- Newly discovered and existing target molecules will be quantitated by –omics technologies, and specific detector molecules will be attached to nanophotonic platforms to answer the biological questions.

Summary

It is one thing to have high sensitivity, super resolution detection instruments and another to make these work in the biological applications that we have identified as being of human interest to understand. This theme literally bridges the physics, chemistry and biology aspects of the Centre by not only discovering relevant molecular targets that are useful to detect to answer our biological questions but also to enable the probes to detect these targets, and importantly, to measure the effects of putting these probes into the biological systems.

More specifically, we will use state-of-art technologies to discover new, and further develop known, molecules that alter in response to cellular perturbations such as pain transmission, fertilization and development and arterial plaque formation. The molecules will be the targets of purpose-built probes to measure the molecular changes that occur in these systems. Initially these probes will be trialled in test tubes and under microscopes, but our

ultimate aim will be to allow simultaneous measurement of molecular changes *in situ*, in real time, at a single location in the body. On the other hand, the use of these types of nanophotonic platforms applied to biological systems will also be monitored for any effects they may have on the cells and tissues, both for understanding the measurements as well as for the safety of future *in vivo* applications.

These outcomes will be achieved by working together with the physicists that develop the photonic probes, the chemists that modify the surfaces of the probes and conjugate the biomolecules to them and the biologists who understand the cellular mechanisms.

2014 Progress Report and Plans for 2015

The Discovery Theme has approached the challenge of understanding the physics and biological aspects of the Centre of Excellence in NanoBioPhotonics by bridging the two disciplines at the molecular level.

Scientific Activities

Macquarie analytical technology, which will form the basis of the 'Discovery' theme was strengthened in 2014 by the procurement (by indefinite loan from Thermo Scientific) of a state of the art liquid chromatography mass spectrometer together with continued technical

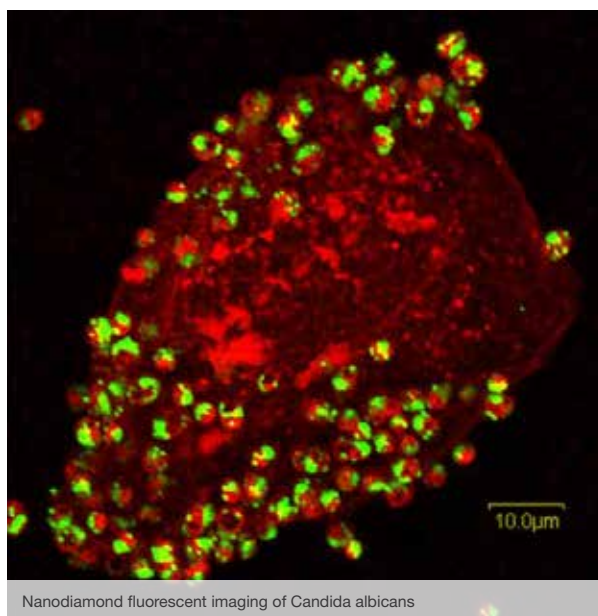
Discover

Determining which molecular targets to focus on and enabling probes to best detect the chosen target.



Research Theme 4: Discover

Exploring the fundamental limits of detection.



assistance from the company. This partnership with a high profile MS company will assist the 'Discovery' theme to uncover and analyse proteins, carbohydrates and lipids that are associated with the biologies under investigation. In addition a BiaCore and preparative liquid chromatograph were purchased through Macquarie University internal funding for CNBP use in the measurement of molecular interactions.

Scientific Progress

The success of the CNBP depends on the different disciplines understanding each other's languages. An associated project funded in 2014 by an ARC Linkage grant to Chief Investigators Jin and Packer at Macquarie University involves two biotech companies who require the development of a diagnostic test involving labelling antibodies against cancer antigens with probes in order to detect early stage cancer cells that are at extremely low levels in urine and blood. This has initiated the conversations between the physicists and the molecular biologists as to the requirements of the different disciplines in biological molecular detection. A PhD student, Yu (Rain) Shi is supervised by Packer and Jin and on 'Bioconjugation of antibodies to superdots'.

During 2014 Chief Investigator Packer established a research collaboration with Prof. Marcus Stoodley of the Australian School of Advanced Medicine and Associate Investigator Dr. Louise Brown at Macquarie University to use nanodiamond-conjugated oligosaccharides to target inflammation sites in the brain. In addition, single cell imaging using mass spectrometry was explored by Packer with Dr. Peter Hoffmann (future Associate Investigator) at Adelaide University to identify potential new targets for visualisation of molecular changes in tissues (Publication has already resulted).

Discovery Theme in 2015

2015 sees the kick-off of the 'Discovery' theme in a big way with the commencement of the four postdoctoral fellows (Arun Dass, Nicole Cordina, Andrew Care and Lindsay Parker) in early February and the concomitant visits of Measure and the three Biological Challenges meeting at Macquarie University as a follow up from the 2014 retreat, in order to consolidate some concrete collaborations. A PhD student, (Chris Ashwood) is due to start in early March on a CNBP project 'Brain Glycoproteomics: association with pain' and other students will be recruited.

It is expected that with all the parts now in place, exciting projects using the available and developing physics based probes for targeting relevant and useful molecules to solve questions in the biological challenges will be initiated and that the promise of this interdisciplinary effort will start to be fulfilled.

Section 3

CNBP in the Community



CNBP in the Community

CNBP researchers are passionate about nanotechnology and biophotonics and we wish to bring the wonders of science to our diverse communities with energy and enthusiasm.

“In 2014 we placed a special focus on encouraging our team to think in Centre mode. By that I mean that we need to be working together across nodes and across disciplines on CNBP priority projects – rather than individual teams working on individual projects. This approach is enabling otherwise unattainable discoveries at the boundaries of disciplines and therefore creating outputs well in excess of the sum of their parts.”

Prof. Mark Hutchinson, CNBP Director

CNBP Community

Inaugural Workshop — January 28-29 2014

Shortly after the announcement of our new Centre of Excellence, key investigators and collaborators gathered at the University of Adelaide to kick start the Centre. With over 80 attendees the workshop provided an opportunity to inform the community and grow the ideas that will shape the scientific direction of the CNBP.

Inter-Node Workshop — July 26 2014

Centre personnel from all three nodes gathered at Macquarie University with the goal of building relationships to forge new collaborations.

Each attendee gave a brief two minute presentation on who they are, and their research interests/expertise. This was followed by interactive round table discussions led by each of the theme/biological challenge leaders with a goal of sharing their own unique challenges. New ideas and new solutions from diverse disciplines were tabled — followed by a final session of blue sky thinking where new CNBP projects were presented for open discussion.

Researchers left the workshop with a new understanding of the breadth of expertise and potential contained within the CNBP research community.

Annual Retreat — November 21-24 2014

The CNBP hosted our Inaugural Annual Retreat in Port Lincoln, South Australia from 21-24 November 2014.

Over 80 researchers from all of our Nodes and Partner Institutions gathered for three days of scientific discovery, networking and teamwork building.

With a strong focus on scientific discussions and relationship development, attendees commented on the sense of collaboration and aura of excitement pulsing through the team with many new friendships and connections built.



CNBP researchers at the Inter-Node workshop.

CNBP in the Community

We will pioneer approaches to transdisciplinary research training.



“If you can’t explain it simply, you don’t understand it well enough.” – Albert Einstein.

“What you do is really awesome and pretty much throughout the whole presentation I had a look of fascination on my face. Now both my friend and I want to become theoretical physicists when we are older. I may take up your offer of work experience in a couple of years as I am only year 8.”

—Email to CNBP researcher from Port Lincoln High School student (female)



Professional Development and Mentoring for CNBP Researchers

Australia is home to many new innovations and technologies

We aim to add to that proud reputation - and to bring our fellow Australians on this journey, engaging them in science that will play an important part in building our economic future. The CNBP will nurture our most precious resource, young Australian researchers, to gain a first rate scientific education and research experience, both in Australia's leading laboratories and those of international and industry partners.

In addition to the Professional Development provided by Local institutions which include (but is not limited to) local inductions, OH&S and other training, the CNBP have organised a number professional development activities for our teams.

Directors Induction at Macquarie University and University of Adelaide — November 5-6 2014

With the commencement of many new researchers in the early months of the Centre, Professor Mark Hutchinson hosted CNBP induction workshops at Macquarie and Adelaide University Nodes. Researchers from RMIT Node travelled to Macquarie University to attend the workshop.

The goal of the workshop was to introduce (or remind) researchers of who we are and our scientific goals, but also what it means to be part of a Centre of Excellence. Centre Values and the meaning of Centre Mode were discussed with researchers leaving the workshop understanding the role that their research project will play in the bigger picture of the CNBP.

Working with the ARC: November 21 2014

CNBP Adelaide Node hosted Ms. Liz Vischer, Director Program Partnership, The Australian Research Council for an student/ECR workshop on ARC grants and being part of a Centre of Excellence. With well over 40 attendees, researchers heard about the goals of the Centre of Excellence Program as well as opportunities for ARC fellowships and other ECR grants.

Social Media for Researchers: November 24 2014

Centre postdocs and students attended an afternoon workshop on social media during the 2014 Annual Retreat. Topics included how to use social media, the responsibility of publicly funded researchers to communicate their research to the public and the career benefits for active communicators.

CNBP in the Community — Early Career Researchers

Science Communication Workshop: December 6 2014

On December 15-16th, Nine ECRs from University of Adelaide, RMIT University, Macquarie University and SAHMRI attended a science communication workshop at the Questacon workshop in Canberra. The workshop was designed to teach participants how to put their best foot forward in media interviews, community talks and scientific presentations.

CNBP would like to thank the ARC Centre of Excellence for Electromaterials science for inviting us to co-sponsor this workshop.

Local Early Career Researcher (ECR) networks

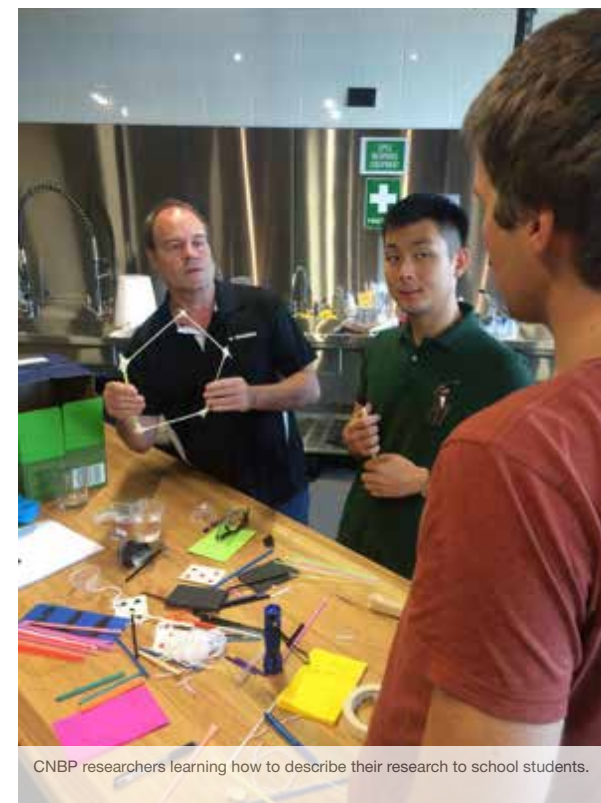
ECR have been established at each Node. With informal “no boss allowed” meetings, this community is working to break down interdisciplinary language barriers and provide peer driven mentorship and support.



Singapore students visit the University of Adelaide for an extended work experience.



Mr. Ben Pullen, Mr. John Horsley and Dr. Mel McDowall at a science communication workshop.



CNBP researchers learning how to describe their research to school students.



CNBP Launch November 21 2014



CNBP Launch 2014 — Prof. Warren Bebbington with Prof. Aidan Byrne

Scientific Community: Centre Workshops for the Science Community

2014 World Congress on Biosensors: Pre-Congress School on Optical Biosensors: Co-Organised by Chief Investigator Prof. Tanya Monro this one day workshop preceded the 2014 World Congress on Biosensors and featured CNBP researches A/Prof. A/Prof. Heike Ebendorff-Heidepriem, Prof. Ewa Goldys, Prof. Jim Piper and Associate Investigator Dr. Alex Francois.

ASCEPT0 MPGCR Satellite Meeting: Organised by CNBP early career researcher Dr. Sanam Mustafa – this workshop introduced audience members to the interdisciplinary approaches adopted by physicists, chemists and biologists to address fundamental and novel biological questions. Key cutting-edge technologies exclusive to the CNBP were described along with examples of current and potential applications.

Macquarie BioFocus Research Centre Conference:

The Macquarie BioFocus Research Centre workshop on 11 December 2014 brought together academics from Physics, Chemistry, Biology and Medicine from within Macquarie University and other Local institutions.

Other Conferences

Centre personnel were on organising committees, participated as Keynote and invited speakers, and gave oral and poster presentations at a range of International, National and local meetings. For a full summary our invitations and conference attendance please see Appendix 1.

Scientific Publications

Centre personnel have published in a range of high impact journals across diverse scientific disciplines including: Optical Material Express; Journal of the American Chemical Society; Human Reproduction; and Langmuir.

For a full list of Centre publications please see Appendix 2.

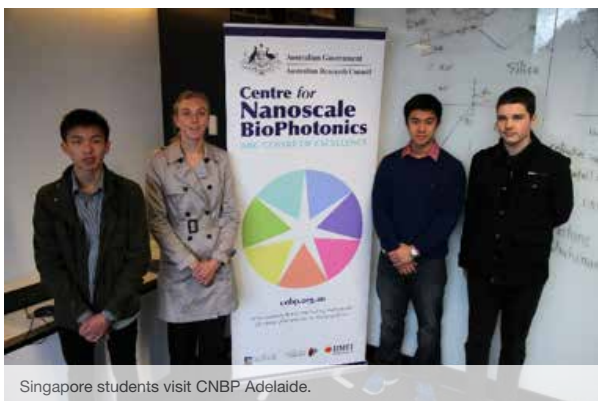
CNBP in the Community — Scientists

We will lead international research in BioPhotonics.



CNBP in the Community — Collaboration

We will engage with leading International Centres.



Singapore students visit CNBP Adelaide.



CNBP Launch November 21 2014.

Visits To Scientific Collaborators

A/Prof. Heike Ebendorff-Heidepriem

IPHT, Jena
City University London
Southampton University

Ms. Lixin Zhang

Peking University
Dalian University
University of Goettingen, Germany

Prof. Ewa Goldys

IPHT, Jena
City University London
Southampton University

Prof. Tanya Monro

City University London

Prof. Andrew Abell

Curtin University, WA
University of Western Australia

A/Prof. Brant Gibson

Bio21 Institute, University of Melbourne

Dr. Sabrina Heng

Massachusetts Institute of Technology, MA USA
Stonehill College MA, USA
Boston College, MA USA

A/Prof. Dayong Jin

Peking University
Fudan University
Jilin University
Sun Yat-Sen University
Beijing University of Science and Technology
Chinese Academy of Science
Changchun Institute of Optics
China University of Geoscience
China Jiliang University
Wenzhou Medical University



Early career researchers from the CNBP join other Centre of Excellence researchers for a science communication workshop at Questacon

CNBP in the Community — Collaboration

International Visitors

Sergey Deyev

Visiting Researcher

Camalia Tan

Student, Nanyang Polytechnic
(Singapore)

Fayth Lim

Student, Nanyang Polytechnic
(Singapore)

Vernise Lim

Student, Nanyang Polytechnic
(Singapore)

Tan Qi An

Student, Nanyang Polytechnic
(Singapore)

Dr. Nelida Rodrigues

Research fellow with
Spark of Life Team

Dr. Christian Leiterer

German Academic Exchange Service
Research Fellowship
IPHT, Jena

Prof. Yafeng Guan

Chinese Academy of Sciences

Prof. Katarina Svanberg

Lund University

Prof. Dennis Matthews

UC Davis, USA

Prof. Brian Wilson

UHN, Toronto

Dr. Hua Shi

Huazhong University Science Technology

Prof. Zhihong Zhang

Huazhong University Science Technology

A/Prof. Peng Xi

Peking University

Dr. Andrew Brown

Senior Director, SPIE

Ivan Antolovic

Visiting Researcher, TU Delft

A/Prof. Daniel Sejer Pedersen

Visiting Researcher

Dr. Jiajia Zhou

Visiting Researcher

Prof. Huang Zhenli

Huazhong University Science Technology

Dr. Piotr Wagacki

Visiting Research Fellow

Prof. Steve Hill

University of Nottingham

Takeshi Ohsima

Japanese Atomic Energy Group

Onoda Shinobu

Japanese Atomic Energy Group

Takahide Umeda

University of Tsukuba



Prof. Yafeng Guan (Chinese Academy of Sciences) with CNBP Partner Investigator Prof. Yonggang Zhu, (CSIRO)



Prof. Dennis Matthews (UC Davis) and Prof. Brian Wilson (UHN, Toronto) with CNBP Deputy Director Prof. Ewa Goldys

CNBP in the Community – Community Engagement

CNBP researchers are focused on using the Centre to showcase amazing science, in encouraging the community to engage with scientific thinking and to inspire future generations to study the wonders of science.

Outreach Cannot be Done as an Afterthought of Research

The Communication and Education Committee will support CNBP researchers in embedding a communication strategy into everything we do. With the knowledge that all projects and all researchers are different, our communication strategy will empower the community to identify the communication methods or technologies that best suit them.

CNBP Launch

The CNBP was officially launched by Senator Bridget McKenzie on Friday 21 November at the University of Adelaide.

We were delighted to welcome special guests including: Senator Bridget McKenzie, Hon Susan Close MP, Hon Gail Gago MP, Hon Rachel Sanderson MP, Aboriginal Elder Mrs. Georgina Williams, Director of the ARC Prof. Aidan Byrne, as well as many International guests and CNBP Partners.

It was wonderful to share this important occasion with members of the CNBP research community from our three Nodes (The University of Adelaide, Macquarie University and RMIT University) as well as Associate Investigators, Committee Members and friends.

CNBP Website and Social Media Platforms

In addition to our events and outreach, a major goal for 2014 was to launch a new CNBP website and create a presence on social media.

Website

A new website cnbp.org.au was launched on November 21st. Designed as a tool to communicate with various communities: scientific, community, youth and schools, media and industry. The site was designed for accessibility across multiple platforms ranging from large screens to small hand held devices (and everything in between).

The CNBP intranet allows our researchers to receive centre information through a designated portal.

Social media channels

CNBP's social media presence can be accessed directly from the CNBP website with a growing twitter community (@CNBPscience, #cnbp) and established accounts in FaceBook, Flickr and YouTube.

KPI tracker

A unique feature of the CNBP website is an integrated custom build KPI tracker system, allowing researchers to simultaneously blog an achievement via the CNBP news feed while reporting KPIs to a central database. Accessed via the CNBP intranet on multiple devices, researchers can report their KPIs with a user friendly form in real time. With the option to flag for confidentiality Centre administrators review and approve each entry for publication directly to the CNBP website.



CNBP in the Community – Community Engagement

We will inspire young people to pursue careers in science.

Youth Education and Mentoring

Many scientists can remember the moment that they were inspired to pursue a career in science. We hope to provide that inspiration to future scientists around the world.

Port Lincoln High School

Four researchers from the CNBP visited Year 8 and 9 students from Port Lincoln High School on Nov 26 2014 to run a series of short workshops about the CNBP and discuss careers in science.

RiAus Science Inspiration

Professor Tanya Monro spoke with over 800 school students during her presentations for the RiAus Science Inspiration. Her talk 'What is photonics and how is it used?' demonstrated her passion for photonics and her interesting and satisfying career.

CNBP in Schools

CNBP researchers visited schools in 2014 speaking at school assemblies and working in class rooms.

Work experience at CNBP

Eight students ranging from Year 11 through to undergraduate students worked with CNBP researchers receiving hands on laboratory experience.

Summer Students

CNBP provides opportunities for undergraduate students to spend time in a research environment during the university summer break.

Lab Tours

110 High School students visited the University of Adelaide for an inspirational workshop by Professor Tanya Monro and participated in laboratory tours of the Braggs building.

ScienceAlive

Members of the Recognise theme met with South Australian students at South Australia's largest National Science Week event ScienceAlive.

For a full list of school and community events please see Appendix 3.



Prof. Andrew Greentree amazes year 8 students at Port Lincoln High School with an exploration of physics, and the way that air can lead to surprising results. In these images we see the use of pressure difference for creation of levitation (top) and a ping-pong ball cannon (bottom)

CNBP in the Community — In the News

Media and Other Publications

Channel 10 News

Interview of Centre Director Professor Mark Hutchinson and Early Career Researcher Dr. Erik Schartner about the Centre Launch on November 21 2014.

666ABC Radio

Professor Mark Hutchinson and Prof. Nicolle Packer were interviewed about the CNBP and their participation in the STA event: The Human Body — The Final Frontier. November 26 2014.

639ABC Radio

A/Prof. Heike Ebendorff-Heidepriem talked about the CNBP and her research.

Port Lincoln Times

Community story highlighting the visit of CNBP researchers to Port Lincoln High School. Published December 1 2014.

Other Publication Highlights

The Conversation

How your parents' diet before your birth impacts your health. Published by Dr. Mel McDowall.

The Australian Hospital and Health Care Bulletin

Nanoscale technology to research from inside human body, The Australian Hospital and Healthcare Bulletin; November 24 2014.

Living Science: Career Resource

Profiles CNBP Chief Investigator Prof. Andrew Abell.

CNBP Video — Creating Windows into the Body

A futuristic glimpse at labs of the future — demonstrating how the tools that CNBP are developing today, will create windows into the body, enabling future researchers to ask new questions.

CNBP Video — Four Theme Animation

At just over one and a half minutes, this animation explains the four scientific themes Illuminate, Recognise, Measure and Discover and how we will use these to enable biologists to ask and answer new questions about life.

To see a comprehensive list of our media and other publications please see Appendix 2.



Stills taken from the CNBP Launch video.



CNBP in the Community — End Users

Seed industries by creating disruptive technologies.

End Users

CNBP researchers are focused on using the Centre to pioneer the fundamental science required to facilitate translational outcomes. This cannot be done as an afterthought of research. The Translation and Impact committees will support CNBP researchers in building translational thinking, and strategy into everything we do. This will help to create an outcome based culture — that celebrates and nurtures innovation.

In this way we will drive the science in directions that will create opportunities for economic and societal benefits as well as attracting to the Centre researchers seeking to make a difference.

Engagement with Government

Professor Nicolle Packer, Dr. Brant Gibson and Professor Mark Hutchinson joined forum host 666 ABC Canberra presenter Genevieve Jacobs, to discuss their extraordinary work, in Science and Technology Australia (STA) Topical Science Forum **The Human Body — The Final Frontier?** on November 23 2014.

The panel discussion was hosted for two audiences, the first an educated general public in Canberra and the second, an invitation only discussion for the Parliamentary Friends of Science Group.

Industry Engagement

Olympus Visit: Members of the Executive Committee met with our Partners Olympus Australia in Melbourne.

Clinician Community

CNBP researchers are actively engaging with medical researchers and clinicians to understand and explore the opportunities of our BioPhotonic devices to drive advances in clinical care.

Outreach to local and international cardiovascular, reproductive medicine and pain/palliative care communities has been achieved as outlined in Appendix 1 and 3.

Commercialisation of Centre Outcomes

We are focused on using the Centre to pioneer the fundamental science required to facilitate translational outcomes — this cannot be done as an afterthought to the research. We intend to drive our science into directions that will create opportunities for economic and societal benefits as well as attracting the CNBP researchers seeking to make a difference.

In anticipation of the commercial potential of research spawning from the CNBP, conversations are underway with key partners to streamline commercialisation pathways.



A/Prof. Brant Gibson, Prof. Nicki Packer and Prof. Mark Hutchinson speaking to the Parliamentary Friends of Science Group in Canberra at a Science Technology Australia (STA) Topical Forum.



The CNBP Executive Management Committee met with Partners Olympus Australia at their impressive showroom and training facility in Melbourne.



The CNBP Executive Management Committee at Olympus Australia.

CNBP in the Community — Awards and Honours



Visiting the University of Adelaide Node



Prof. Yafeng Guan (International Science Committee) with CNBP students and postdocs

Awards and Honours

External recognition for CNBP personnel in 2014 demonstrates the versatility and strengths of our talented team. Awards have been granted from our scientific peers and the wider community. Among our highlights were:

Prof. Mark Hutchinson — Finalist: Life Sciences and Biological Sciences Young Scopus Researcher Awards 2014

Emeritus Professor Jim Piper AM — Queens Honours List and Elected to President of Science Technology Australia

Prof. Andrew Abell — Elected to the University of Adelaide Council

Prof. Tanya Monro — Awarded the Beattie Steel Medal from the Australian Optical Society and an elected Fellow to the Australian Academy of Sciences

Prof. Ewa Goldys — Honorary visiting appointment at the Heart Institute

A/Prof. Jeremy Thompson — Robinson Research Institute Director's Award for research and service to the Institute

Dr. Yiqing Lue — Finalist: President's Award for Excellence, CYTO2014 — XXIX Congress of International Society for Advancement of Cytometry

Ms. Tess Reynolds — 5th International NanoMedicine Conference - Poster Award: Bioconjugate Chemistry Award for Excellence in NanoMedicine Research

Ms. Georgina Sylva — University of Adelaide School of Chemistry and Physics 3 Minute Thesis competition - Awarded 3rd prize

Dr. Sanam Mustafa — ACCEPT — MPGPCR — Travel award from the Adelaide Pharmacology group

Dr. Melanie McDowall — Society for Reproductive Biology Conference — Best Conference presentation

Dr. Sabrina Heng — Australian Nanotechnology Early Career Workshop — Best Poster Presentation

Mr. Jonathan Hall — Elected as the alumni representative to the University of Adelaide Council.

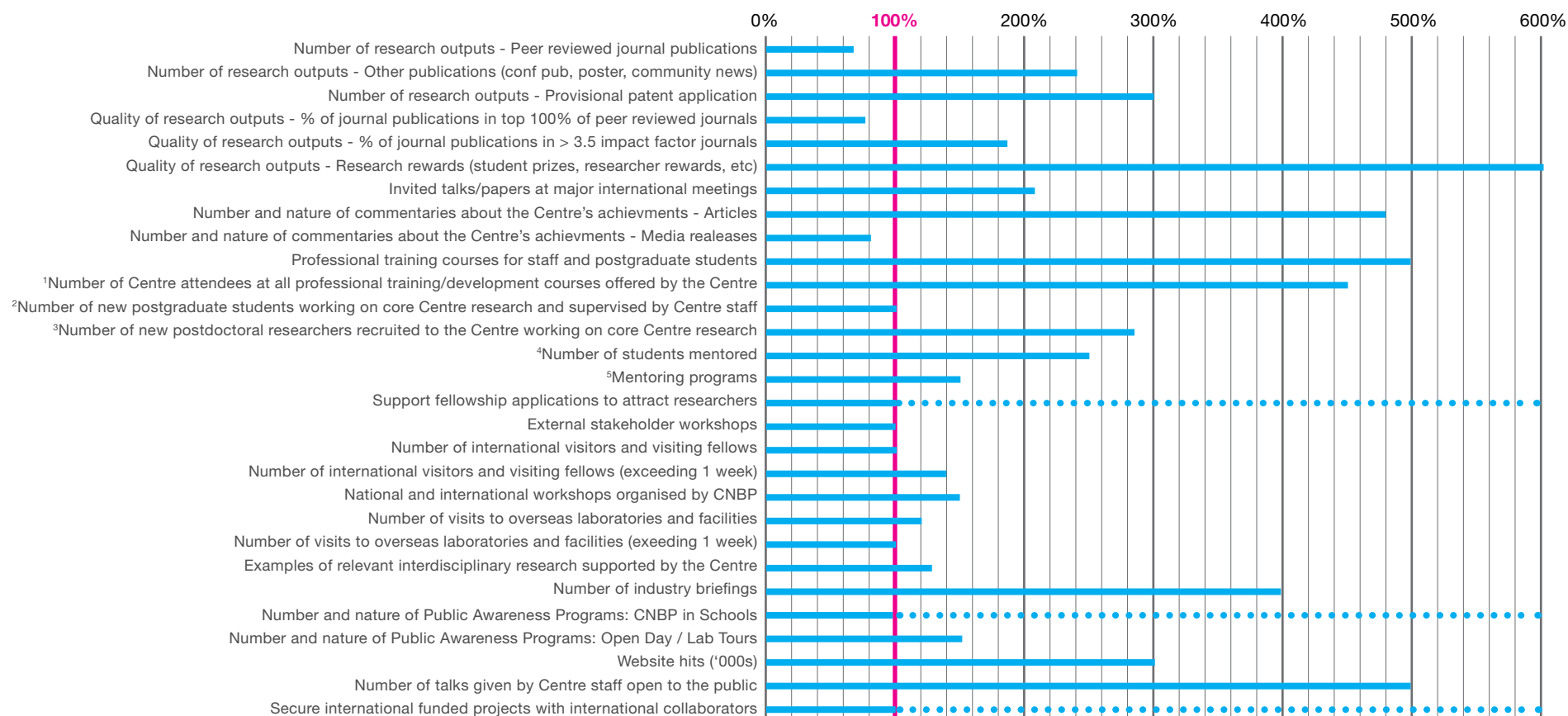
Section 4

KPIs & Financial Statements



KPIs at a Glance

We are proud to be overachieving for the majority of our Key Performance Indicators.



Definitions:

¹Number of Centre attendee's at all professional training/development courses offered by the Centre is defined as number of CNBP personnel attended a minimum of one Centre professional Development.

²Number of new postgraduate students working on core Centre research and supervised by Centre staff is defined as Masters or PhD students commencing in the calendar year.

³Number of new postdoctoral researchers recruited to the Centre working on core Centre research is defined as researchers commencing in the calendar year.

⁴Number of students mentored includes work experience, summer scholars, MSc course work (project), Masters by Research and PhD - including visiting and co-supervised.

⁵Mentoring programs are defined as programs or group activities for school/undergraduate/graduate researchers.

•• Dotted line denotes value of infinity (goal of zero was exceeded).

Financials

Expenditure

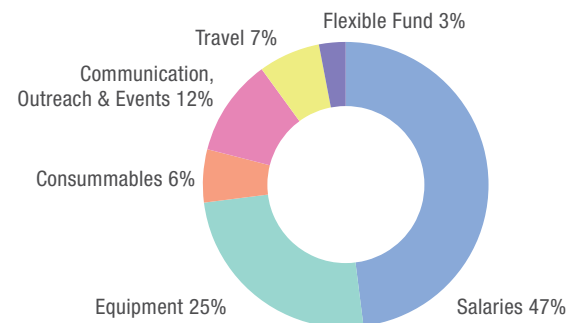
	2014 Expenditure	2015 Projections
Salaries	\$ 784,194	\$ 4,285,399
Consumables	\$ 107,403	\$ 585,500
Equipment	\$ 414,627	\$ 400,000
Travel	\$ 125,710	\$ 395,400
Communication, Outreach & Events	\$ 193,176	\$ 195,000
Flexible Fund	\$ 51,411	\$ 250,000
TOTAL	\$ 1,676,521	\$ 6,111,299

2014 Income

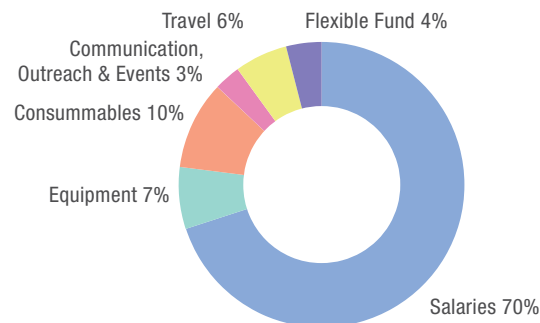
	2014 Income
ARC	\$ 3,385,011.66
Collaborating Institutions	\$ 1,781,724.00
Australian Grants & Partners*	\$ 356,666.67
Other Sponsorship	\$ 909.09
TOTAL INCOME	\$ 5,524,311.42

*Income includes \$40,000 invoiced to Olympus Australia in 2014 but received in 2015

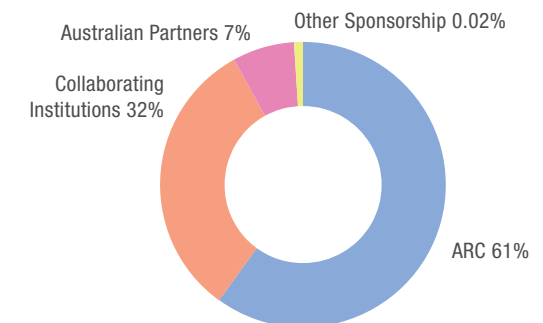
2014 Expenditures



2015 Projection



2014 Income



Partner Organisations

The CNBP has 11 official partners who contribute significant cash, in kind support and infrastructure to CNBP activities.



SAHMRI

PI Prof. Stephen Nicholls and the SAHMRI Heart Health Program is working closely with the Adelaide Node of the CNBP. SAHMRI employs the Inside Blood Vessels Challenge Leader and hosts three University of Adelaide employed part-time researchers working on this challenge. In addition to this substantial in kind contribution of research support and infrastructure, SAHMRI contributed \$50,000 cash towards research consumables, staff travel and communication activities. CNBP researchers working at SAHMRI are active members of the CNBP community attending local or online workshops, professional development activities and the annual scientific retreat.



Bioplatforms Australia

Bioplatforms Australia have made a three-year commitment of \$100,000 per annum to leverage Bioplatforms facilities to generate —omics data in support of the CNBP strategy. Year 1 commitment has been rolled over to 2015/2016 due to the late CNBP start date.



Olympus Australia

Olympus Australia have made a \$40,000 cash contribution to CNBP activities which CNBP has allocated towards salary and expenses for a CNBP Research Fellow working towards shared goals. In addition a \$160,000 in kind contribution provides CNBP with access to Olympus engineers and access to Olympus facilities. Olympus Australia (Melbourne) hosted the CNBP Executive Management Committee for a half day workshop in August, to showcase capabilities and identify projects of mutual interest.



Heraeus

With expertise in high purity silica glass, Heraeus have committed \$10,000 in kind to provide custom build materials for CNBP researchers and to support Dr. Gerhard Schotz (General Manager Photonics and Specialty Fiber Optics) in working with the CNBP community.

Partner Organisations

CSIRO

The CSIRO Biosecurity Flagship Program with PI Prof. Yonggang Zhu are working with the CNBP Measure team. An in-kind commitment of \$52,000 has been spent in part on PI salary, facilities and travel, however 50% of this contribution will carry forward into 2015 due to the late CNBP start date. Prof. Yonggang Zhu attended the CNBP annual retreat in November.



Huazhong University of Science and Technology (HUST)

With a focus on collaborative research and student education HUST have committed \$14,000 a year (for 7 years) to support four students over the life of the centre to spend time in Australia working at CNBP nodes. Existing plans suggest that student travel will commence in late 2015–early 2016 to coincide with the demands of the HUST graduate students structured program. In addition HUST have committed \$10,000 in kind towards the salary and other costs for PI Prof. Qingming Luo and other staff. In 2014 Prof. Zhihong Zhang and Dr. Hua Shi travelled to South Australia to attend the CNBP annual scientific retreat.



Peking University

With a strong commitment in student education and collaborative research, Peking University have committed \$18,000 cash per annum (for 7 years) to support a 1-year living allowance for ten Peking PhD students to spend time at CNBP labs in Australia over the life of the Centre. Working closely with the Macquarie Node of the CNBP PI A/Prof. Peng Xi is joint supervisor for PhD Student Yujia Liu. In addition Peking University is providing in kind support of \$20,000 relevant to salary and support for PIs Prof. Yujie Sun A/Prof. Peng Xi working on Centre activities. In addition A/Prof. Peng Xi visited with CNBP researchers at all three Nodes during a visit to Australia in early 2014.



Institute of Photonic Technology (IPHT)

With a focus on driving research in the scientific basics of photonic processes, IPHT have committed \$172,000 cash to support 1 postdoc and 2 PhD students per annum. Conversations are currently in progress to devise suitable projects for these researchers. In addition IPHT have committed \$14,000 in kind per annum to support salary for PI Prof. Juergen Popp and access to technology.



Partner Organisations



City University London

With a commitment towards student education and collaborative research City University London has committed \$63,500 to support two CNBP PhD students. These students will spend time at CNBP labs in Australia during their PhD. PI Tong Sun is working with CNBP researchers to identify suitable PhD topics for the first two projects to commence in 2015.



University of Southampton (Soton)

With a focus on collaborative research and student education Soton have committed \$23,000 per annum cash (over 7 years) to the CNBP to support two students over the life of the Centre. It is the expectation that these students will spend up to 1 year working at the CNBP Nodes in Australia. This funding was not spent in 2014 and will roll over to 2015. Soton have also committed \$45,000 in kind to support 10% of Prof. Gilberto Brambila's time and other expenses associated with this collaboration.



University Health Network, Toronto (UHN)

With a focus on productive joint research, UHN have committed \$15,000 per annum to support a 0.3FTE postdoctoral researcher working on a CNBP project. Recruitment for this position is underway. In addition UHN are providing in kind support of \$15,000 per annum to support salary, infrastructure and other costs for PI Brian Wilson who travelled to South Australia in November 2014 to attend the CNBP launch and annual scientific retreat.

Other Partners and Grants

We are grateful for the significant financial and infrastructure support provided by other CNBP partners

NSW Trade & Investment's Research Attraction and Acceleration Program (RAAP)

CNBP Chief Investigators Piper, Jin, Goldys and Packer have secured a \$500,000 commitment over three years (2014-2016) to support industrially relevant research at the CNBP.



SA Collaboration Pathways Program – Premiers Research and Industry Fund

Chief Investigators Monro, Hutchinson, Abell, Thompson and Nicholls have secured \$300,000 over three years (July 2014 – June 2017) to support technical salaries, outreach activities and Node travel for Adelaide based centre personnel.



National Computational Infrastructure (NCI)

The CNBP has been awarded 800,000 (\$32,000) core hours of computing time annually, commencing in 2015. In addition the CNBP will have entitlement to persistent storage totaling 8 TBytes.



Pancreatic Cancer Canada Innovation Grant

This is a joint grant between CNBP and our International Partner University Health Network, Toronto. Synchronous radiotherapy enhancement of pancreatic cancer with X-ray induced photodynamic therapy and oxygen generating nanoparticles: Dr. Ralph Da Costa, Professor Shirley XY Wu (University Health Network, Toronto) and Professor Ewa Goldys (CNBP CI).



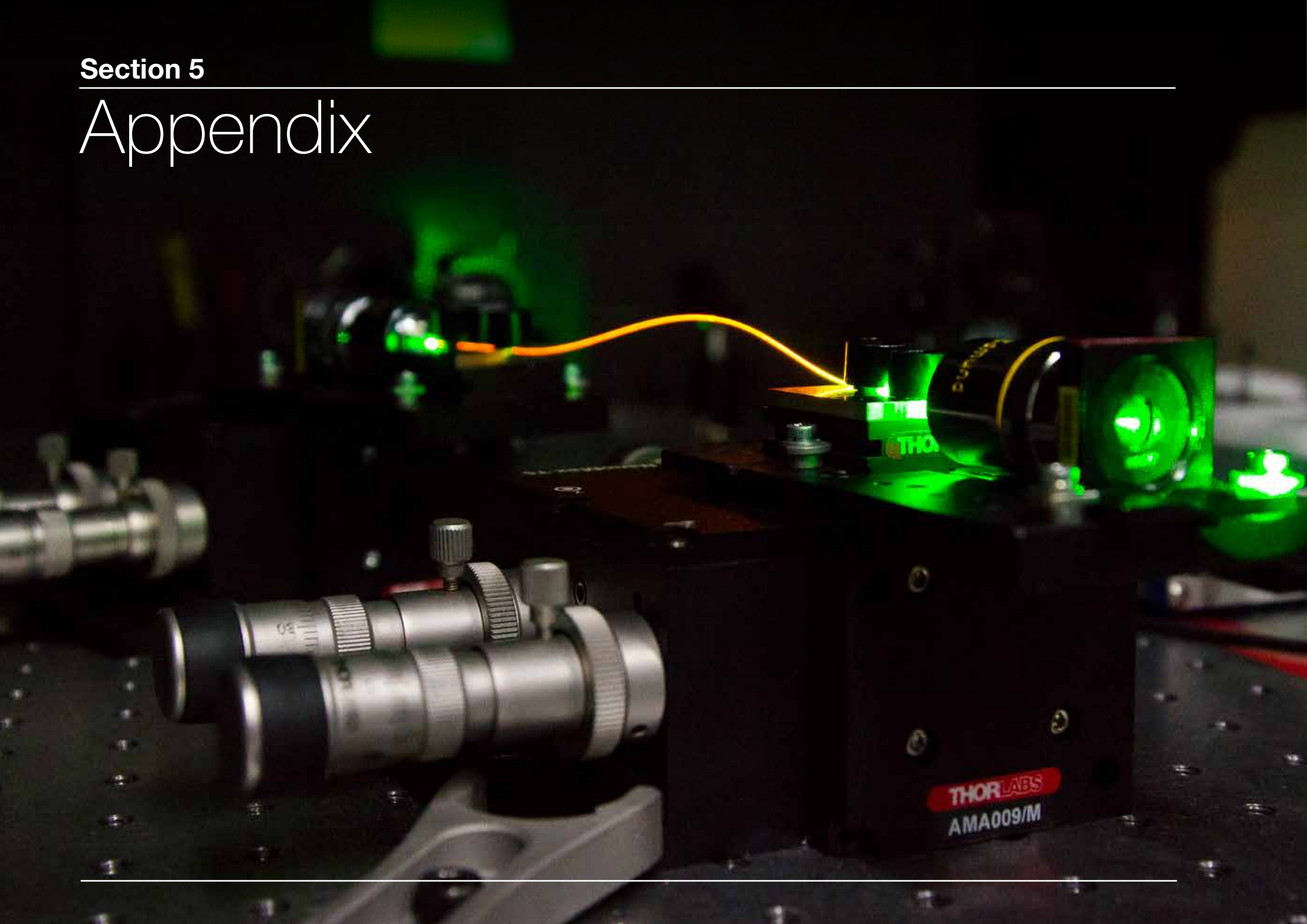
Optofab Node of ANFF

The CNBP is underpinned 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 will drive the research forward.



Section 5

Appendix



Appendix 1: Conference Participation

Attendee	Conference / Meeting Name	Role	Meeting Type
A/Prof. Dayong Jin	2014 Light, Energy and Environment Congress	Invited Talk	International
A/Prof. Heike Ebendorff-Heidepriem	2014 OSA Optics & Photonics Congress on Light, Energy and the Environment	Invited Talk	International
Prof. Ewa Goldys	21st Stem Cell Network Workshop: Bioengineering and Stem Cells (Sydney)	Invited Talk	International
Prof. Tanya Monro	23rd Annual Conference on Microscopy and Microanalysis (ACMM23) and 2014 International Conference on Nanoscience and Nanotechnology (ICONN2014)	Organising Committee	International
A/Prof. Heike Ebendorff-Heidepriem	23rd Annual Conference on Microscopy and Microanalysis (ACMM23) and 2014 International Conference on Nanoscience and Nanotechnology (ICONN2014)	Organising Committee	International
Prof. Mark Hutchinson	2nd Annual Pain Symposium: Pain and Migraine	Invited Talk	International
Ms. Tess Reynolds	5th International NanoMedicine Conference (Sydney)	Poster Presentation	International
Dr. Wei Deng	5th International NanoMedicine Conference (Sydney)	Poster Presentation	International
Prof. Ewa Goldys	5th International NanoMedicine Conference (Sydney)	Invited Talk	International
A/Prof. Jeremy Thompson	7th World Congress on Mild Approaches in Assisted Reproduction	Invited Talk	International
Dr. Sanam Mustafa	ACCEPT — MPGPCR	Invited Talk	International
A/Prof. Heike Ebendorff-Heidepriem	ACOFT 2014	Invited Talk	International
Prof. Mark Hutchinson	ASCEPT-MPGPCR	Invited Talk	International
Dr. Sanam Mustafa	ASCEPT — MPGPCR meeting - Satellite Workshop	Organising Committee	International
Prof. Mark Hutchinson	Australian Pain Society — Annual Meeting	Invited Talk	International
A/Prof. Heike Ebendorff-Heidepriem	Glass and Optical Materials Division (GOMD) of the American Ceramic Society	Invited Talk	International
Prof. Ewa Goldys	OECC/ ACOFT 2014	Invited Talk	International
Dr. Alexandre Francois	Optical Society of America	Poster Presentation	International
A/Prof. Jeremy Thompson	Reproductive tissue banking for fertility preservation: Animal models and applications in humans	Invited Talk	International
A/Prof. Jeremy Thompson	Ruminant Reproduction Symposium (Obihiro, Japan)	Invited Talk	International
A/Prof. Heike Ebendorff-Heidepriem	'Progress in extending non-silica glass properties and fiber fabrication', 6th International Conference on Optical, Optoelectronic and Photonic Materials and Applications (ICOOPMA 2014), Leeds, UK	Invited Talk	International
Prof. Ewa Goldys	SPIE Photonics-Europe Conference	Invited Talk	International
Prof. Ewa Goldys	Translational Centre for Regenerative Medicine, University of Leipzig, Germany	Invited Talk	International
Prof. Tanya Monro	World Congress on Biosensors	Plenary Lecture	International
Emeritus Prof. Jim Piper	World Congress on Biosensors — Biosensor School	Invited Talk	International
Prof. Ewa Goldys	World Congress on Biosensors — Biosensor School	Invited Talk	International
Prof. Tanya Monro	World Congress on Biosensors — Biosensor School	Organising Committee	International
Dr. Hannah Brown	World Congress on Reproduction	Invited Talk	International

Appendix 1: Conference Participation

Attendee	Conference / Meeting Name	Role	Meeting Type
A/Prof. Jeremy Thompson	World Congress on Reproduction — preconference symposium on metabolism	Invited Talk / Session Chair	International
Dr. Melanie McDowall	World Congress on Reproduction — preconference symposium on metabolism	Session Chair	International
Dr. Yiqing Lu	27th Rare Earth Research Conference	Invited talk	International
Dr. Jiangbo Zhao	17th International Conference on Luminescence	Invited talk	International
A/Prof. Dayong Jin	CYT02014, the XXIX congress of international society for advancement of cytometry	Organising committee	International
Dr. Yiqing Lu	CYT02014, XXIX congress of international society for advancement of cytometry	Organising committee	International
Dr. Yiqing Lu	CYT02014, XXIX congress of international society for advancement of cytometry	Oral presentation	International
Prof. Steve Nicholls	Cardiac Society of Australia and New Zealand	Invited Talk	International
Prof. Steve Nicholls	Australian Atherosclerosis Society	Invited Talk	National
Dr. Jinxian Yu	RACI National Congress	Invited Talk	National
Mr. Daniel Stubing	RACI National Congress	Poster Presentation	National
Mr. Malcolm Purdy	RACI National Congress	Poster Presentation	National
Ms. Georgina Sylva	RACI National Congress	Poster Presentation	National
Dr. Jinxian Yu	RACI National Congress	Invited Talk	National
Mr. Daniel Stubing	RACI National Congress	Poster Presentation	National
Mr. Malcolm Purdy	RACI National Congress	Poster Presentation	National
Ms. Georgina Sylva	RACI National Congress	Poster Presentation	National
Mr. Daniel Stubing	22nd Annual RACI Research and Development Topics Conference	Poster Presentation	National
Mr. Malcolm Purdy	ANFF Research Showcase 2014, Canberra	Invited Talk	National
Dr. Sabrina Heng	Australian Nanotechnology Early Career Workshop	Award - Best poster presentation	National
A/Prof. Heike Ebendorff-Heidepriem	Australian Nanotechnology Early Career Workshop	Invited Talk	National
Dr. Sabrina Heng	Australian Nanotechnology Early Career Workshop	Poster Presentation	National
Mr. Jonathon Hall	Australian Nanotechnology Early Career Workshop	Poster Presentation	National
Mr. Roman Kostecki	Australian Nanotechnology Early Career Workshop	Poster Presentation	National
Prof. Tanya Monro	CSIRO OCE cutting edge symposium	Invited Talk	National
Prof. Ewa Goldys	CSIRO OCE cutting edge symposium	Invited Talk	National
Prof. Yonggang Zhu	CSIRO OCE cutting edge symposium	Organising Committee	National
Dr. Sabrina Heng	RACI Division of Interfaces, Colloids and Nanomaterials symposium	Invited Talk	National
Prof. Ewa Goldys	OptoElectronics and Communication Conference and Australian Conference on Optical Fibre Technology (Melbourne)	Invited Talk	National
Dr. Melanie McDowall	Society for Reproductive Biology Conference	Organising Committee/ Invited Talk	National
Dr. Melanie McDowall	Society for Reproductive Biology Conference — Science meets Publican	Co-organiser	National

Appendix 1: Conference Participation

Attendee	Conference / Meeting Name	Role	Meeting Type
Dr. Erik Schartner	Adelaide Centre for Neuroscience Research (ACNR) workshop	Invited Talk	Local
Mr. Stefan Mussolino	Adelaide Centre for Neuroscience Research (ACNR) workshop	Invited Talk	Local
Ms. Vicki Staikopoulos	Flinders University — Annual CNS Collaborators Day Workshop	Poster Presentation	Local
Dr. Sanam Mustafa	Florey International Postgraduate Research Conference	Poster Presentation	Local
Andreiw Xvyagin	Macquarie BioFocus Research Conference	Invited Talk	Local
Igor Ahanovich	Macquarie BioFocus Research Conference	Invited Talk	Local
Dr. Varun Srrenivasan	Macquarie BioFocus Research Conference	Organising Committee	Local
Dr. Wei Deng	Macquarie BioFocus Research Conference	Organising Committee	Local
Ms. Krystana Drozodowicz-Tomsla	Macquarie BioFocus Research Conference	Organising Committee	Local
Dr. Arun Dass	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Attendee	Local
Dr. Erik Schartner	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Attendee	Local
Mr. Steffan Musolino	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Attendee	Local
Ms. Vicky Staikopoulos	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Attendee	Local
Prof. Ewa Goldys	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Invited Talk	Local
Prof. Mark Hutchinson	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Attendee	Local
Dr. Sanam Mustafa	Mount Lofty Workshop on Frontier Technologies for Nervous System Function and Repair	Invited Talk	Local
Dr. Melanie McDowall	Robinson Research Institute Symposium	Invited Talk	Local
Dr. Hannah Brown	Robinson Research Institute Symposium	Session Chair	Local
Dr. Sanam Mustafa	The University of Adelaide — Faculty of Health Sciences Research Day	Invited Talk	Local
Prof. Tanya Monro	University of Melbourne Physics Colloquium	Invited Talk	Local

Appendix 2: Centre Publications

2014 Publications

Generating and measuring photochemical changes inside the brain using optical fibers: exploring stroke; **Georgios Tsiminis**, Thomas S. Klaric, **Erik P. Schartner**, Stephen C. Warren-Smith, Martin D. Lewis, Simon A. Koblar, and **Tanya M. Monro**; Biomedical Optics Express, Vol. 5, Issue 11, pp. 3975-3980 (2014)

Fibre Tip Sensors for Localised Temperature Sensing Based on Rare Earth-Doped Glass Coatings. **Schartner EP, Monro TM**; Sensors (Basel, Switzerland). 2014;14(11):21693-21701. doi:10.3390/s141121693.

Large scale production of biocompatible colloidal nanoalumina; **WAW Razali, VKA Sreenivasan, EM Goldys, AV Zvyagin**; Langmuir 30(50):15091. DOI: 10.1021/la5042629

Dual Sensor for Cd(II) and Ca(II): Selective Nanoliter-Scale Sensing of Metal Ions; **Heng, Sabrina**, Mak, Adrian M., **Stubing, Daniel B., Monro, Tanya M., Abell, Andrew D**; Analytical Chemistry 2014, 86, 3268-3272

Chemical sensing with nanoparticles as optical reporters: from noble metal nanoparticles to quantum dots and upconverting nanoparticles; **Wei Deng, Ewa M. Goldys**; Analyst. 2014 Sep 29;139(21):5321-34. doi: 10.1039/c4an01272k

Practical Implementation, Characterization and Applications of a Multi-Colour Time-Gated Luminescence Microscope; **Lixin Zhang**,; Xianlin Zheng; **Wei Deng, Yiqing Lu**, Severine Lechevallier, Zhiqiang Ye, **Ewa M. Goldys**, Judith M. Dawes, **James A. Piper**, Jingli Yuan, Marc Verelst, & **Dayong Jin**; Scientific Reports, 4, Article number:6597, doi:10.1038/srep06597

Tunable lifetime multiplexing using luminescent nanocrystals; **Lu Y**, Zhao J, Zhang R, Liu Y, Liu D, **Goldys E**, Yang X, **Xi P**, Sunna A, Lu J, Shi Y, Leif R, Huo Y, Shen J, **Piper J**, Robinson J, **Jin D**, Nature Photonics (2014)DOI: 10.1038/nphoton.2013.322;

On-the-fly decoding luminescence lifetimes in the microsecond region for lanthanide-encoded suspension arrays, **Lu Y**, Lu J, Zhao J, Cusido J, Raymo F, Yuan J, Yang S, Leif R, Huo Y, Piper J, Robinson J, **Goldys E, Jin D**; Nature Communications (2014) DOI: 10.1038/ncomms4741, IF = 10.74; [0 citation]

How to build a Time-Gated Luminescence Microscope; **Jin D**, Lu Y, Leif RC, Yang S, Rajendran M, Miller L, Current Protocols in Cytometry (2014) 67: 2.22.1 - 2.22.36, Wiley, (invited review)

Multicolor Barcoding in a Single Upconversion Crystal; Zhang Y, Zhang L, Deng R, Tian J, Zong Y, **Jin D**, Liu X, Journal of American Chemical Society (2014) - DOI: 10.1021/ja5013646

Optogenetics, the intersection between physics and neuroscience: Light stimulation of neurons in physiological conditions; **Wei Deng, Ewa M. Goldys**, Melissa MJ Farnham, Paul M. Pilowsky; American Journal of Physiology – Regulatory, Integrative and Comparative Physiology Published 1 October 2014 Vol. no. ,DOI:10.1152/ajpregu.00072.2014

Nanodiamond in tellurite glass Part I: origin of loss in nanodiamond-doped glass; **Heike Ebendorff-Heidepriem**, Yinlan Ruan, **Hong Ji, Andrew D. Greentree, Brant C. Gibson**, and **Tanya M. Monro** Optical Materials Express (2014) ; Vol. 4, No. 12| DOI:10.1364/OME.4.002608

Multiphoton fluorescence lifetime imaging microscopy reveals free-to-bound NADH ratio changes associated with metabolic inhibition, **K. Drozdowicz-Tomsia, AG Anwer**, MA Cahill, KN Madlum, AM Maki, MS Baker, **EM Goldys**, Journal of Biomedical Optics, 19, 8, art. No 086016, DOI: 10.1117/1.JBO.19.8.086016, (2014)

Fabrication, splicing, Bragg grating writing, and polyelectrolyte functionalization of exposed-core microstructured optical fibers, **Stephen C. Warren-Smith, Roman Kostecki**, Linh Viet Nguyen, and **Tanya M. Monro**, Optics Express, Vol. 22, Issue 24, pp. 29493-29504 (2014)

Appendix 2: Centre Publications

The metabolism of ruminant cumulus oocyte complexes revisited; **Thompson JG**, Gilchrist RB & **Sutton-McDowall ML** (2014), Soc Reprod Fertil Supp.

Chromosome constitution of human embryos generated after *in vitro* maturation 3 (IVM) including 3-isobutyl-1-methylxanthine (IBMX) in oocyte collection medium; Spitz, C., Guzman, L., Mertzaniidou, A., Jacobs, K., Ortega-Hrepich, C., Gilchrist, R.B., **Thompson, J.G.**, De Vos, M., Smitz, J. and Sermon, K. (2014) Human Reproduction DOI:10.1093/humrep/deu329

Unraveling the interplay of backbone rigidity and electron rich side-chains on electron transfer in peptides: the realization of tunable molecular wires; **Horsley JR**, Yu J, Moore KE, Shapter JG, **Abell AD**; J Am Chem Soc. 2014 Sep 3; 136(35):12479-88

3D-printed extrusion dies: a versatile approach to optical material processing; **Heike Ebendorff-Heidepriem**, Juliane Schuppich, Alastair Dowler, Luis Lima-Marques, and **Tanya M. Monro**; Optical Materials Express

Unraveling the interplay of backbone rigidity and electron rich side-chains on electron transfer in peptides: the realization of tunable molecular wires; **Horsley JR**, Yu **J**, Moore KE, Shapter JG, **Abell AD**; J Am Chem Soc. 2014 Sep 3; 136(35):12479-88

Novel polymer functionalization method for exposed-core optical fiber; **Roman Kostecki**, **Heike Ebendorff-Heidepriem**, **Shahraam Afshar V.** Grant McAdam, Claire Davis, and **Tanya M. Monro**; August 2014 | Vol. 4, No. 8 | DOI:10.1364/OME.4.001515 | OPTICAL MATERIALS EXPRESS 1515

Appendix 3: Community Events Including Public Lectures / Talks

Centre Personnel	Brief Description	Date	Description	Details	Reach	Audience
Dr. Krystina Dzorowicz Tomsia	GE Healthcare Symposium	28/05/2014	Invited Talk	Conference	National	Business
Ms. Krystina Dzorowicz Tomsia	GE Healthcare Symposium	28/05/2014	Invited Talk	Editorial board	International	Business Community
Prof. Andrew Greentree	RMIT Founders Day Dinner	13/06/2014	Keynote talk	Outreach	Local	Community
Prof. Tanya Monro	Australian Women's Leadership Symposium	3/07/2014	Invited Talk	Conference	National	Community
Prof. Tanya Monro	Australian Women's Leadership Symposium	3/07/2014	Invited Talk	Outreach	National	Community
Prof. Andrew Greentree	RMIT ECR event	10/07/2014	Invited Talk	Conference	Local	ECRs
Prof. Mark Hutchinson	Pfizer workshop: The Brain: How We View Persistent Pain And What Does This Mean For Further Treatments.	28/07/2014	Invited Talk	Conference	National	Business
Prof. Tanya Monro	CONASTA	7/08/2014	Keynote talk	School	National	Youth
Dr. Kathy Nicholson	Seymour College	11/08/2014	Invited Talk	School	Local	Youth
Dr. Sabrina Heng	Fremont Elizabeth City High School by invitation of the Smith Family Foundation	15/08/2014	Invited Talk	School	Local	Youth
Prof. Tanya Monro	BioSA Technology Transfer Summit	3/09/2014	Invited Talk	Conference	International	Business Community
Prof. Mark Hutchinson	Science In the Pub	8/09/2014	Invited Talk	Outreach	Local	Community
Prof. Tanya Monro	RiAus Science Inspiration	18/09/2014	Invited Talk	School and Outreach	International	Youth
Prof. Ewa Goldys	Perkin Elmer	30/09/2014	Invited Talk	Conference	Local	Business
A/Prof. Jeremy Thompson	Fertility SA	5/11/2014	Invited Talk	Conference	Local	Clinicians
Prof. Tanya Monro	IUSAP General Assembly – Singapore	5/11/2014	Keynote talk	Conference	International	Government
Prof. Mark Hutchinson	Business Briefing: 2nd Annual Pain Symposium: Pain and Migraine	10/11/2014	Invited Talk	Conference	Local	Business
Prof. Andrew Greentree	Vernier Society	13/11/2014	Invited Talk	Outreach	Local	Business
Ms. Vicky Staikopoulos	Year 8 Students, Port Lincoln High School	25/11/2014	Outreach	School	Local	Youth/School
Prof. Andrew Greentree	Year 8 Students, Port Lincoln High School	25/11/2014	Outreach	School	Local	Youth/School
Dr. Arun Dass	Year 8 Students, Port Lincoln High School	25/11/2014	Outreach	School	Local	Youth/School
Dr. Kathy Nicholson	Year 8 Students, Port Lincoln High School	25/11/2014	Outreach	School	Local	Youth/School

Appendix 3: Community Events Including Public Lectures / Talks

Centre Personnel	Brief Description	Date	Description	Details	Reach	Audience
Prof. Mark Hutchinson	Community Event: The Human Body – The Final Frontier?	26/11/2014	Invited talk	Outreach	Local	community
Prof. Nicki Packer	Community Event: The Human Body – The Final Frontier?	26/11/2014	Invited talk	Outreach	Local	community
A/Prof. Brant Gibson	Community Event: The Human Body – The Final Frontier?	26/11/2014	Invited talk	Public lecture	Local	community
Prof. Mark Hutchinson	Parliamentary Friends of Science Event: The Human Body – The Final Frontier?	26/11/2014	Invited talk	Outreach	Local	Government
Prof. Nicki Packer	Parliamentary Friends of Science Event: The Human Body – The Final Frontier?	26/11/2014	Invited talk	Outreach	Local	Government
A/Prof. Brant Gibson	Parliamentary Friends of Science Event: The Human Body – The Final Frontier?	26/11/2014	Invited talk	Government	Local	Government
Dr. Sabrina Heng	Scientist in Schools Program with Lockley Primary School	ongoing twice a year	Invited Talk	School	Local	youth

Appendix 4: Media and Other Publications

Centre Personnel	Description	Date	Type	Details	Audience
Prof. Tanya Monro	2014 Stories of Australia Science profiles Prof. Tanya Monro	12/05/2014	Print and Web Medium	National	Community
A/Prof. Jeremy Thompson	2014 Stories of Australia Science profiles A/Prof. Jeremy Thompson	12/05/2014	Print Medium	National	Community
Dr. Mel McDowall	How Your Parents' Diet Before Your Birth Impacts Your Health; The Conversation	20/05/2014	Web Publication	National	Community
A/Prof. Heike Ebendorff-Heidepriem et al.	Laser focus world: Microstructures Fibers: Microstructured-fiber Properties and Remote-sensing Capabilities	1/07/2014	Web Publication	International	Scientific / Business
Dr. Sabrina Heng	Poster: Australian Nanotechnology Early Career Workshop	10/07/2014	Poster Presentation	National	Scientists
Mr. Jonathon Hall	Poster: Australian Nanotechnology Early Career Workshop	10/07/2014	Poster Presentation	National	Scientists
Mr. Roman Kostecki	Poster: Australian Nanotechnology Early Career Workshop	10/07/2014	Poster Presentation	National	Scientists
Dr. Mel McDowall	Science Stories: A New Approach to Improved IVF success: Blog: The Robinson Research Institute	15/07/2014	Print Medium	Local	Community
A/Prof. Heike Ebendorff-Heidepriem	3D printing capabilities, the South Australian Advertiser	29/07/2014	Print Medium	Local	Community
Prof. Andrew Greentree	Physics 7, 93 (2014): Viewpoint: Diamond and Silicon Get Entangled	1/08/2014	Web Medium	International	Scientists
Prof. Tanya Monro	2014 Postgraduate Survival Guide features Prof. Tanya Monro	24/08/2014	Print and Web Medium	National	Students
Prof. Tanya Monro	Science Comes Alive with Prof. Tanya Monro; Sunday Mail	14/09/2014	Print	National	Community
Prof. Tanya Monro	Prof. Tanya Monro is profiled on ABC TV speaking about the upcoming RiAus Science Inspiration	14/09/2014	Television	national	Community
Prof. Mark Hutchinson	New leadership for the CNBP, IPAS Newsletter	17/09/2014	Web Publication	Local	Community
Dr. Sanam Mustafa	Poster: Florey International Postgraduate Research Conference	25/09/2014	Poster Presentation	local	Scientists
Ms. Vicki Staikopoulos	Poster: Flinders University - Annual CNS Collaborators Day Workshop	3/10/2014	Poster Presentation	Local	Scientists
CNBP	Centre Brochure	15/10/2014	Print	Local	Community
Prof. Tanya Monro	The Measure of Monro, The Adelaide Review	31/10/2014	Print	Local	Community
Prof. Mark Hutchinson	Centre Launch Marks Leap Forward For Science, The Adelaidean	15/11/2014	Web Publication	Local	Community
CNBP	CNBP Launch profiles on Channel 10 News	21/11/2014	Television	National	Community

Appendix 4: Media and Other Publications

Centre Personnel	Description	Date	Type	Details	Audience
CNBP	Four Themes Animation for the CNBP	21/11/2014	Video	International	Community
CNBP	CNBP Launch video — Creating Windows into the Body	21/11/2014	Video	International	Community
CNBP	CNBP Community Handout	21/11/2014	Print	Local	Community
CNBP	5AA Adelaide and Port Augusta, News: CNBP Launch profiled	22/11/2014	Radio	Local	Community
CNBP	Living Science: Career Resource profiles Prof. Andrew Abell	22/11/2014	Radio	Local	Community
CNBP	Mix FM 102.3 Adelaide, 17:00 News: CNBP Launch profiled	22/11/2014	Radio	Local	Community
CNBP	Nanoscale technology to research from inside human body, The Australian Hospital and Healthcare Bulletin; November 24 2014	24/11/2014	Newsletter	National	Clinicians
CNBP	Podcast Community Event: The Human Body — The Final Frontier?	26/11/2014	Podcast	International	community
Prof. Mark Hutchinson	666ABC Radio: The Human Body — The Final Frontier?	26/11/2014	Radio	Local	Community
Prof. Nicolle Packer	666ABC Radio: The Human Body — The Final Frontier?	26/11/2014	Radio	Local	Community
Dr. Mel McDowall	Social Media report from the CNBP Launch and Retreat	30/11/2014	Web Publication	Local	Community
CNBP	Scientists learn, share; Port Lincoln Times;	1/12/2014	Print Medium	Local	Community
A/Prof. Heike Ebendorff-Heidepriem	A/Prof. Heike Ebendorff-Heidepriem talks to ABC 639 about the CNBP and her research	1/12/2014	Radio	National	Community
Prof. Mark Hutchinson	Profile, STA Newsletter,	3/12/2014	Web Publication	National	Government
Mr. Daniel Stubing	Poster: RACI National Congress	7/12/2014	Poster Presentation	International	Scientists
Mr. Malcolm Purdy	Poster: RACI National Congress	7/12/2014	Poster Presentation	International	Scientists
Ms. Georgina Sylva	Poster: RACI National Congress	7/12/2014	Poster Presentation	International	Scientists
Prof. Tanya Monro	Reports plots research course; The Australian	10/12/2014	Print	National	Community
Mr. Daniel Stubing	Poster: 22nd Annual RACI Research and Development Topics Conference	12/12/2014	Poster Presentation	National	Scientists
Dr. Mel McDowall	Social media tracking during November and December	31/12/2014	Web Publication	Local	Community

Notes



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