# AIBN

ANNUAL REPORT 2011

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

# VICE-CHANCELLOR'S MESSAGE

**As one of The University of Queensland's (UQ) premier research institutes, the Australian Institute for Bioengineering and Nanotechnology (AIBN) is intrinsic to UQ's contributions to state, national and global prosperity.**

With world-class research spanning human health, energy, manufacturing and the environment, AIBN makes a substantial contribution to UQ's status as one of the nation's top two universities based on research quality and breadth.

However, UQ is unusual in that its research strengths span basic discovery to translational research and commercialisation. For that reason, not only is UQ in the top 1 per cent of world universities, it is Australia's leading university for research commercialisation and supporting researchers to develop industry partnerships. That is crucial to making a difference on the world stage.

It was the emphasis on research excellence and commercial viability, combined with industry and government partnerships, that contributed to AIBN's success in 2011.

In one of the largest investments in an Australian start-up biotech company, domestic and international investors were brought together in a $15 million partnership to establish Vaxxas Pty Ltd. Its focus is to continue AIBN's pioneering research and development into a needle-free vaccine delivery system.

The development of the next generation of smart medicines, including perhaps the only known treatment for Hendra virus, received a boost through collaboration with Dutch company DSM Biologics and the Queensland Government.

In another development to progress vaccine research, a memorandum of understanding was signed with the Pasteur Institute in Ho Chi Minh City to progress research into a vaccine for pandemic avian influenza.

The US Navy approached AIBN to help with its planned "Green Fleet", which is a credit to AIBN's partnerships and cutting-edge research into biofuels.

The global partnerships AIBN forged in 2011 will continue to realise outcomes during the coming years.

AIBN's ability to gain the confidence of Australian and international investors and partners is a testament to its excellent research and development capabilities. In receiving this support, the institute is acutely aware of its responsibilities to reward the confidence placed in it.

I thank Director Peter Gray and his colleagues for their continued stewardship and vision, and commend the enthusiasm and willingness of AIBN researchers and partners to take commercially useful products to the world.

**Professor Debbie Terry**
Vice-Chancellor
The University of Queensland

# DIRECTOR'S MESSAGE

**AIBN continued to expand its activities in many areas during 2011, and this report provides an overview of some of the activities of the more than 450 people who now make up the institute.**

During the year we were very pleased to welcome two new group leaders. Associate Professor Christine Wells joined AIBN in January and is an internationally recognised researcher in genome biology. She is the Australian member of the Functional Annotation of the Mammalian Genome (FANTOM) consortia, and has published in *Nature* and *Science*.

Professor Ajayan Vinu joined us in September from the National Institute for Materials Science in Japan, and brings his considerable expertise and global reputation in novel functional nanomaterials for energy storage and conversion and environmental protection. Both Christine and Ajayan are rapidly building sizable research groups and contributing on many levels to the institute's activities.

We were sad to farewell two of our foundation group leaders, Professor Sean Smith and Professor Julie Campbell. Sean has moved to a top position in the US as Director of the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory. Julie has retired from full-time research but remains President of the Association of Australian Medical Research Institutes and Director of the Wesley Research Institute.

On the research front, there was the formal release of results from Australia's first Excellence in Research for Australia (ERA) assessment. AIBN played a major role in UQ securing the top rating of five in environmental biotechnology, industrial biotechnology and nanotechnology, with the research areas judged to well above world standard. AIBN research also contributed to UQ achieving the top ERA rating in the fields of macromolecular and materials chemistry, and theoretical and computational chemistry.

During the year, AIBN researchers published 275 peer-reviewed papers, many in top global journals. The number of formal international collaborations, where there is a signed agreement in place between AIBN and another organisation, grew to 236. Interestingly, China is now the country with which we have the second-highest number of links after the US.

This report outlines many of the new research activities conducted during the year, including the ARC's formation of a Special Research Initiative, Stem Cells Australia, in which five of the 19 chief investigators are AIBN group leaders. The company Stem Cells Ltd was also established in 2011 by UQ and Monash University to provide stem cell core activities, with the company's Brisbane node carrying out its work from AIBN laboratories.

AIBN's commercialisation acitivities also expanded on several fronts during 2011. Dr Ian Nisbet was appointed AIBN's Deputy Director (Commercialisation) and brings his considerable global commercial experience to the institute.

Professor Mark Kendall and his team worked with our Uniquest colleagues to form Vaxxas Pty Ltd and secure one of Australia's largest investments to date in a start-up biotechnology company. Vaxxas will commercialise the revolutionary new needle-free vaccine delivery system the team has developed and secured a $15million investment from a group led by OneVentures, with co-investors Brandon Capital, the Medical Research Commercialisation Fund, and US-based HealthCare Ventures.

The many other commercial activities, awards and successes of our researchers are outlined in this report.

The AIBN Student Association, representing our 120 research higher degree students, continued to expand its activities during the year and organised the inaugural AIBN student conference in September. This very successful event followed AIBN's Annual Symposium in July, at which we were honoured to have a presentation by Professor Ian Chubb, Australia's Chief Scientist.

Our thanks to Euan Murdoch, who continued to chair our Queensland Government review board, and who also kindly agreed to chair the new AIBN board established on the recommendation of AIBN's 2010 Review Committee. The new board will play a key role in AIBN's ongoing strategic planning and development.

Finally, 2011 will be remembered as a year which started with the natural calamity of the Brisbane floods in which luckily AIBN was not seriously affected, and ended with major upper management changes at UQ.

The interest and support during the year from Vice-Chancellor Paul Greenfield and Senior Deputy Vice-Chancellor Michael Keniger is very much appreciated, and their experience and guidance has played a key role in AIBN's successes. The ongoing senior management input and advice from Professors Debbie Terry (Deputy Vice-Chancellor (Academic) and Vice-Chancellor) and Max Lu (Deputy Vice-Chancellor (Research) and Senior Deputy Vice-Chancellor) has been seamless and ensured the smooth running of the institute's many activities.

**Professor Peter Gray**
AIBN Director

# OUR VISION

To build a nationally and internationally acknowledged bioengineering and nanotechnology institute recognised for sustained research excellence, with strong collaborative links to leading global research groups and corporations.

# 2011 HIGHLIGHTS

# TECHNOLOGY SEEKS TO CONVERT $CO_2$ TO CLEAN FUEL

**AIBN researchers are working towards an economical, readily available technology that will remove $CO_2$ from the atmosphere and convert it into clean fuel.**

Tackling climate change is a key challenge driving Professor Ajayan Vinu, an ARC Future Fellow and leader of the AIBN group researching multifunctional nanoporous materials for energy and environmental applications.

Professor Vinu joined AIBN in September 2011, after nearly eight years with the National Institute for Materials Science, Japan's top materials institute. He brought to AIBN a wealth of knowledge and contacts with industry leaders in several countries, with the aim of extending his successful research into semiconducting and biomaterials for a clean environment, energy storage and conversion.

Professor Vinu's research group is developing a process for $CO_2$ capture and conversion using a photoelectrochemical (PEC) system that will absorb $CO_2$ and convert it into methanol, a clean fuel for use in direct methanol fuel cells (DMFCs). The second stage of the project will fabricate catalytic support materials for DMFCs for converting methanol into clean energy.

"We will produce new semi-conducting materials to convert $CO_2$ to methanol and use the same materials to fabricate super capacitors to store the energy so you can continuously develop it, store it and convert it," Professor Vinu said.

The project addresses a significant environmental problem – mitigating atmospheric $CO_2$. It will help reduce $CO_2$ levels by developing an efficient, economical PEC semiconductor device, and offer a clean fuel source from the conversion of adsorbed $CO_2$ molecules.

Professor Vinu is working on highly-ordered nanoporous materials with separate functional parts and semiconducting nanostructures with hierarchically ordered pores to be used in the novel technology. The new materials can also act as catalysts for synthesising fine chemicals and pharmaceutical products through organic transformations; and replace existing toxic and environmentally unfriendly catalysts used in industry.

Professor Vinu said the Future Fellowship project was based on innovative research from his team, including the discovery of nanoporous carbon nitride materials.

"I have proposed a novel concept to introduce superbasic metal oxides into the pore channels of nanoporous carbon nitrides or nanoporous metal phosphides. This will generate a nanoporous superbasic material that is expected to be a good adsorbent for the capture of acidic $CO_2$ molecules," Professor Vinu said.

The aims and concepts outlined for the capture and conversion of $CO_2$ into fuels are unique and technically challenging. For example, it would be the first time nanoporous metal phosphides with a large surface area, large pore diameter and uniform pore size distribution were developed. Consequently, novel synthesis methodologies would need to be formulated. Professor Vinu is an expert in the controlled pore filling technique, hard templating, and elemental substitution approaches that form the core of the scientific approach.

In the second stage of the project, a novel electrode for the DMFC will be designed for converting the obtained methanol fuels into energy. The system aims for efficiency and economy using the nanoporous functionalised semiconductor materials with metal and metal oxide nanoparticles as the key technology. The materials are new, cheap and have not been used as catalysts for DMFCs before. The energy produced will be stored using the device fabricated using the same materials.

"One of the challenges is to design a low-cost DMFC using nanostructured catalytic supports with more than 10 times higher surface area and pore volume than currently used supports. This will be achieved using our well-versed technique of controlled pore filling and by growing particles with a size less than 2nm," Professor Vinu said. Increasing the surface area of the materials by changing the synthesis conditions will increase fuel cell durability and efficiency and reduce costs.

*"The project addresses a significant environmental problem – mitigating atmospheric $CO_2$"*

Professor Vinu will collaborate with Dr Toshiyuki Mori, from the National Institute for Materials Science; and one of India's top electrochemists, Dr Srinivasan Sampath, from the Indian Institute of Science in Bangalore, to fabricate fuel cells using an integrated strategy by combining the nanostructured catalyst and the electro-catalyst to make a highly efficient, cost-effective cell.

The successful development of nanoporous metal phosphide and metal nitride materials with redox or semiconducting oxide functionalised surface will be a significant breakthrough in the materials science field and is likely to pave the way for the emergence of new fields of nanomaterials research.

Professor Vinu's aim is to produce a system that will adsorb $CO_2$ and convert it into methanol, for use in DMFCs.

# WEB PORTAL FACILITATES GENOME RESEARCH

**Negotiating through the maze of data available to stem cell researchers was difficult until an AIBN team used the internet to link the information.**

That link is www.stemformatics.org, a portal to a database of experiments describing animal and human stem cells and how they differentiate to become mature cells, tissues and organs. Data from leading stem cell laboratories is supplied in an online format that is easy to search, visualise and export.

AIBN Group Leader Associate Professor Christine Wells and her research group are part of a collaboration that operates the stemformatics.org web portal.

Associate Professor Wells took up her position at AIBN in January 2011, bringing the web-based stem cell resource and a research group with expertise in stem cell differentiation; innate immune function and susceptibility to infectious diseases; genomics; and bioinformatics.

With support from an NHMRC Fellowship, Associate Professor Wells has researched the networks of genes that drive cellular differentiation and activation. She discovered the function of several genes involved in the fight against infection, and which regulate inflammation. Her group aims to further understand stem cell biology and innate immunity.

"We know very little about the information held by our genes, or how different cells use the information to specify their function," she said. Her team seeks to understand how genes and the environment interact, so researchers can better predict disease onset, progress, treatment and outcomes.

As most diseases are the consequence of genetic predisposition and external factors, the group wants to predict who might be vulnerable, track the course of a disease, and predict the best therapeutic outcomes. To do that, the group works across the disciplines of genome biology, bioinformatics, and cell and molecular biology.

The group is among those supplying their findings to the stemformatics portal. It is operated with funding from Stem Cell Australia, through a seven-year Australian Research Council grant. The portal enables researchers to investigate the gene signatures that correlate with stem cell function.

The website's partners are AIBN; the National Centre for Adult Stem Cell Research at Griffith University; the Queensland Centre for Medical Genomics; the Queensland Facility for Advanced Bioinformatics; and the Walter and Eliza Hall Institute.

Associate Professor Wells said groups researching the networks of genes that drive cellular differentiation and activation had a history of co-operation and well-validated statistical tools, but the data was in "unfriendly formats" which were challenging to use.

The human genome was first annotated 12 years ago and, since then, scientists around the world have amassed gene expression data.

Associate Professor Wells describes the human genome as an ancient library. "We have the catalogue, the books, and we've logged into the chapters, but we can't read the data well enough to fully understand it – to order it into a cohesive story."

Scientists need to understand what information is relevant to the biology of stem cells. "What information is turned on – or off – as a stem cell commits to being a kidney, or a nerve? And how does that change for someone who develops a specific disease?" The change may be very subtle. "We need to understand the commentary from the genes in context to understand the disease," Associate Professor Wells said.

The volume of data is massive, but that's where the stemformatics web portal

*"We know very little about the information held by our genes, or how different cells use the information to specify their function."*

comes in. It gives biologists the ability to "play" with the genome by querying the various databases to detect relationships and patterns that researchers working independently may not have identified.

With an understanding of biostatistics, it is easy for biologists to ask initial questions and drill down into more sophisticated ones, enabling them to identify new relationships and formulate new hypotheses.

The portal's developers work with genome biologists globally to build rules about how the information is packaged. All data on the site is peer reviewed and published.

Associate Professor Wells said the website may one day help biologists understand cross-species relationships between stem cells.

"For example, some species have the ability to regrow damaged limbs. If we understand those genetic networks, we may be able to artificially recreate them for use in veterinary or even human medicine. We need to look at the structure of the relationships, as well as the genes themselves."

# AIBN APPOINTS ASSOCIATE GROUP LEADERS

**AIBN took a further step in 2011 to recognise the work of early and mid career researchers, with the appointment of three Associate Group Leaders. Dr Trent Munro, Associate Professor Zhi Ping (Gordon) Xu and Dr Kristofer Thurecht were appointed following an extensive selection process.**

They join AIBN Associate Group Leaders Dr Annette Dexter, Associate Professor Aijun Du and Associate Professor Idriss Blakey.

Associate Group Leaders are senior members of the AIBN research community and are fundamental to the institute's ongoing success and long-term viability. The institute has created the role to recognise the achievements of outstanding early and mid-career researchers.

Associate Group Leaders' activities may develop to a level where they can be considered for promotion to AIBN Group Leader.

Dr Thurecht is a polymer chemist, conducting research in the lab of AIBN Group Leader Professor Andrew Whittaker. He also has an appointment at UQ's Centre for Advanced Imaging.

His work involves developing polymers for various applications, particularly nanomedicine and molecular imaging. An ARC Future Fellowship has secured Dr Thurecht's continued research on novel polymeric imaging devices to detect and monitor diseases.

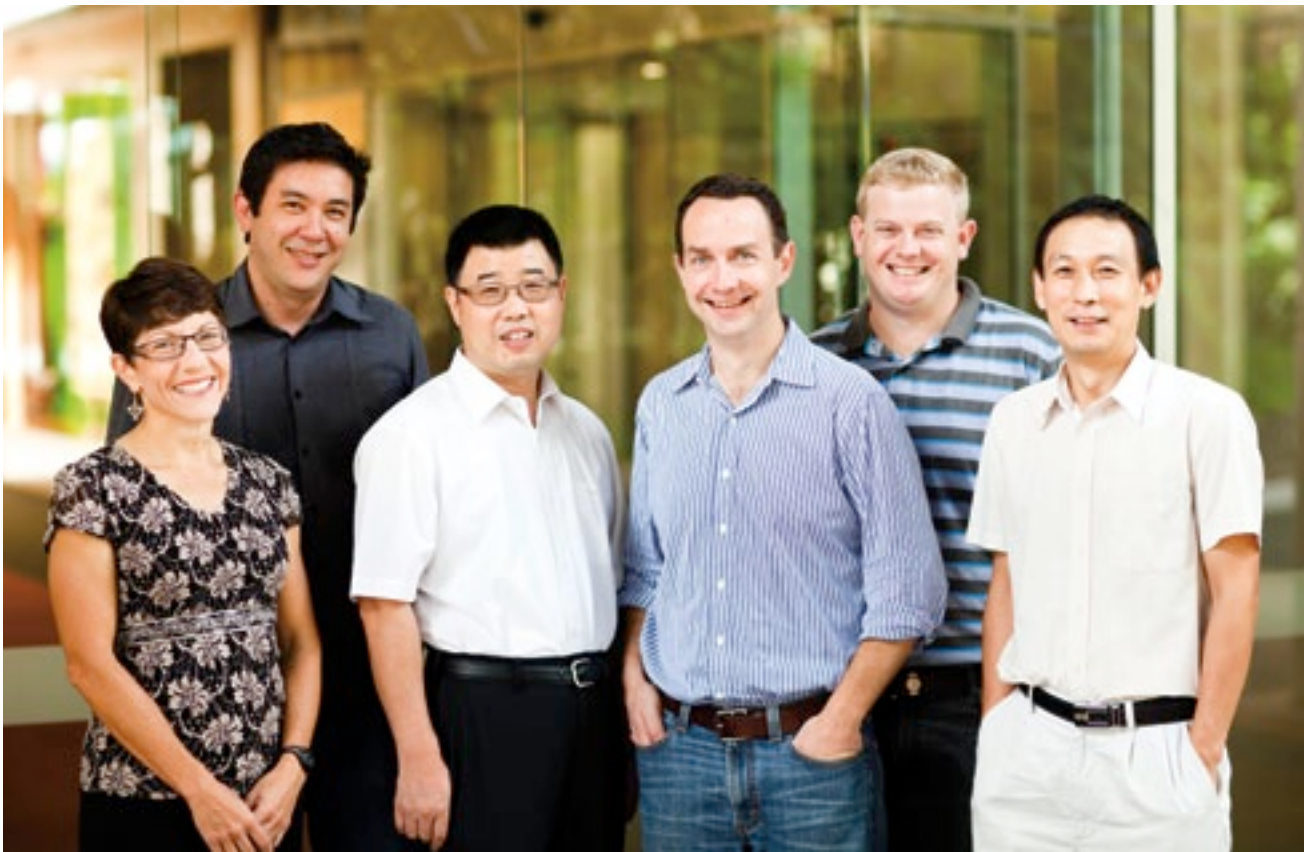
Dr Munro is a biotechnologist working in the research group of AIBN Director Professor Peter Gray. His research focus is on the production and discovery of biopharmaceuticals. Dr Munro is integral to AIBN's National Biologics Facility, which produces high-quality recombinant proteins for the Australian biotech industry.

Dr Munro will continue his research work in 2012 on therapeutic monoclonal antibodies to treat infections caused by antibiotic resistant bacteria.

Associate Professor Xu is a materials scientist and part of Professor Max Lu's research group.

Associate Professor Xu's research is in the development of clay nanomaterials for biomedical applications in drug, vaccine and gene delivery.

The UQ Vice-Chancellor's Senior Research Fellowship will progress his research in nanobiotechnology towards pre-clinical testing in animal disease models.



# INVESTMENT HELPS MOVE RESEARCH TO COMMERCIALISATION

**Biotechnology company Vaxxas Pty Ltd was established in 2011 to ensure AIBN Professor Mark Kendall can progress his needle-free vaccine delivery system through clinical testing and along the pipeline to become a medical device product for widespread use.**

An investment syndicate, led by OneVentures, with co-investors Brandon Capital, the Medical Research Commercialisation Fund and US-based HealthCare Ventures, was instrumental in the establishment and an investment of $15 million.

The investment is the largest to date for an Australian start-up biotechnology or medical device company.

The $15 million will be used to continue developing the Nanopatch, a silicon device with thousands of small projections designed to deliver vaccine to abundant immune cells in the skin. In contrast, needles put vaccine into muscle, missing the immune "sweet spot" of the skin.

Professor Kendall's research group has already shown in animal studies that Nanopatch delivery enhances immunogenicity for seven different vaccines – compared to a needle and syringe. That can improve the reach of vaccines, including achieving protection against influenza with only 1/150$^{th}$ of the regular needle and syringe dose.

In addition to improving delivery efficiency, the Nanopatch has the potential to dramatically improve patient convenience and reduce complications associated with needle phobia, needle-stick injuries and cross contamination, which are key global health issues.

The Nanopatch is designed for thermostability and may not need refrigeration, potentially making transport cheaper and easier, particularly to developing nations around the world. Professor Kendall said in the developed world about 14 per cent of a vaccine's costs were in maintaining the cold chain. In the developing world the impact was even greater.

"It is estimated up to half the vaccines in Africa aren't working properly because of a breakdown in the cold chain," Professor Kendall said. "The Nanopatch also offers a way to stop needle-stick injuries during vaccination – which again is a particularly important problem in Africa, with a third of vaccines affected by other complications brought about through cross contamination needle-stick injuries."

OneVentures General Partner Dr Paul Kelly said the significance of the $15 million investment was not just in its size.

"This investment syndicate includes Australian and international investors, which is a real vote of confidence in the Nanopatch approach and an appreciation for the potential of the technology to revolutionise vaccine delivery worldwide," he said.

Dr Kelly has joined the board of directors of Vaxxas, along with Brandon Capital Partners Managing Director Dr Stephen Thompson; HealthCare Ventures Managing Director Douglas E Onsi; and UniQuest General Manager of Life Sciences Dr Dean Moss.

The $15 million investment was negotiated by UniQuest Pty Ltd, The University of Queensland's main commercialisation company.

# NEXT-GENERATION SMART MEDICINES

**AIBN is part of a collaboration that will eventually develop next-generation smart medicines at a specialist facility already under construction in Brisbane.**

The Queensland Government and Dutch company DSM Biologics are working with AIBN as part of the collaboration, which involves developing biologics at a $65 million scale-up facility at the Princess Alexandra Hospital.

The facility, owned by Queensland Government entity BioPharmaceuticals Australia Pty Ltd, is next to the $345 million Translational Research Institute, also under construction. DSM Biologics will operate the mammalian cell Good Manufacturing Practice production facility to produce clinical and commercial grade biologics for global markets. It is scheduled to open in mid-2013.

Biologics are medicines based on natural proteins, developed using DNA technology. They offer new treatment options for a wide range of diseases, including cancer and auto-immune disorders, and could resolve a wide variety of medical conditions for which there are no other treatments. Biologics-based medicines now account for 17 per cent of total global therapeutic sales.

In 2011, AIBN and DSM Biologics signed a memorandum of understanding, completing a vital link in the chain between biopharmaceutical research and manufacturing.

DSM Biologics is a contract manufacturer that will take early-stage projects, some developed in collaboration with AIBN researchers, to the next stage of commercial development. DSM has high-level international contract manufacturing experience and expertise, ensuring protocols, procedures and quality control at the facility meet global regulatory requirements.

DSM Biologics President Karen King said the agreement with AIBN significantly strengthened and deepened DSM Biologic's links and involvement with Brisbane researchers.

"The expertise at AIBN is very complementary to DSM's skills. AIBN has world-class experience in mammalian cell line development," she said.

AIBN Director Professor Peter Gray said the collaboration was a product of the Queensland Government's Smart State strategies and fitting recognition of the skill base and facilities developed in the state. "The collaboration with DSM will ensure Australian bioresearchers can rapidly progress from lab work to late-stage research in a clinical setting using high-purity material developed in Brisbane," he said.

AIBN's Dr Trent Munro, whose research focuses on engineering mammalian cells to improve their efficiency and utility in producing complex proteins that are increasingly being used as biopharmaceuticals, said the facility would be "the biological plant of the future".

The facility is Australia's only one capable of completing the entire process, from drug discoveries and early work in labs, including those at AIBN, to commercial production at the DSM facility.

# A FUEL OF THE FUTURE

**AIBN is involved in research that aims to develop a strong, sustainable biofuel industry, with a major role in the Queensland Sustainable Aviation Fuels Initiative (QSAFI).**

AIBN researchers under the leadership of Professor Lars Nielsen are developing ways to convert sugar cane to a viable biofuel as a sustainable alternative to today's jet fuel. They are also conducting techno-economic modelling on the processes to convert three potential biomass feedstocks – sucrose from sugar cane; autotrophic algae; and the oily seeds of a tree called Pongamia.

There are multiple partners involved in the initiative, including the Queensland Government, which is injecting $2 million over three years into the $6.5 million initiative; institutes at The University of Queensland; other universities; commercial partners; and future fuel users.

QSAFI partners include Boeing, IOR Energy, Mackay Sugar, Virgin Australia and US integrated renewable products company Amyris Inc.

Amyris Inc has a key role in the sugar cane conversion technology. AIBN's strong expertise in microbe engineering and systems biology will improve the process of converting sugar cane to aviation fuel. Boeing is conducting lifecycle analyses on the three feedstock conversion processes to assess sustainability, while IOR Energy is contributing its expertise in the oil refining and fuel delivery industry. Feedstock supplier Mackay Sugar Ltd brings sugar industry expertise and Virgin Australia provides an end-user perspective.

The project is at the concept analysis stage, but the goal is commercial biofuel manufacturing from sugar cane in Queensland by the end of the decade. The US Navy is particularly keen on the initiative's progress, given its 2011 commitment to having half its energy use from alternative sources by 2020.

AIBN Systems and Synthetic Biology Group business manager Dr Robert Speight said the techno-economic modelling was computer-based research that involved examining each step in the processes from biomass to fuel.

The team has established a "wiki-style" webpage to disseminate results and obtain feedback from the biofuels community. "It's a dynamic process because new data continually comes to light," Dr Speight said.

Sugar cane conversion involves engineering yeasts to produce compounds that could be used as a bioaviation fuel. A long-term goal is to establish a biofuel manufacturing plant at Mackay, in central Queensland. While bioaviation fuel is a key focus, particularly given Virgin Australia and Boeing's participation in the initiative, Dr Speight said there was also potential for other long-distance transport vehicles. For example, Mackay Sugar is interested in an alternative fuel for trains to transport harvested cane.

Dr Speight said Amyris technology already made a direct diesel replacement that was powering bus fleets overseas, but developing the correct blend of hydrocarbon molecules to match current aviation fuels was more complex.

If a match is achieved, there is the potential for a "drop-in" biofuel to replace aviation fuels without requiring aircraft modifications or changes to fuel distribution infrastructure. "It is vital blends of fuel molecules meet strict criteria for properties like flashpoint, energy density, fluidity and freezing point to ensure they are suitable and safe for aircraft use."

Jet fuels account for 5 per cent of the world's fuel use and 15 per cent of the transport use in Australia. Unlike ground transport, where electric or hydrogen cars may provide an alternative, aviation depends on liquid fuels with high energy content.

*"The project has taken advantage of the world-class facilities at AIBN that were established through significant state and federal government support."*

# QUEENSLAND HEALTH FUNDS EXPERIMENTAL THERAPEUTIC

**Hendra virus is transmitted from bats to horses and then to humans. Of the seven people known to have been infected, only three have recovered.**

While development of a human vaccine is unlikely, given the cost and need for lengthy clinical trials, AIBN researchers have produced batches of a monoclonal antibody that may be a potential therapeutic for Hendra virus (HeV) infection in humans. However, because there have been no clinical trials, the experimental therapeutic would be used only in emergencies and with approval from an ethics committee and the Therapeutic Goods Administration.

AIBN biotechnologist Dr Trent Munro said US scientist Professor Chris Broder developed the antibody. His lab provided cells that were producing the antibody and an AIBN team at the National Biologics Facility (NBF) developed a process to produce large amounts of high-quality antibody.

The project has taken advantage of the world-class facilities at AIBN that were established through significant state and federal government support for production of complex therapeutic proteins. NBF was established at AIBN in 2007 to assist Australian biotechnology companies and academic researchers bridge the gap between lab experiments and the cell line and bioprocesses required to produce material at a pilot scale.

Professor Broder's team had synthetically produced a portion of the virus and created an antibody that specifically recognised it. "Antibodies can be produced using recombinant DNA technology, where the gene encoding the antibody is transferred to a cell that can express large amounts of the protein," Dr Munro said. The antibody binds to a protein on the surface of virus particles, blocking the virus's entry to healthy human cells, potentially allowing the recipient's own immune system to fight the virus.

After several major outbreaks of HeV in Queensland and northern NSW, Queensland Health recognised the need for a stockpile of batches of the antibody and provided $480,000 in funding to AIBN, with $180,000 of this coming in 2011. AIBN received another $40,000 in 2011 from the Alister Rodgers Memorial Fund, established to honour the life of a Rockhampton veterinarian who died in 2009 after contact with an infected horse. Dr Rogers received the antibody treatment in the late stages of his battle with HeV, using US-produced antibodies.

His family agreed the funding should be used for AIBN to produce an additional high-quality batch of the antibody, for the CSIRO to use at its Australian Animal Health Laboratory (AAHL) in Victoria to finalise pre-clinical and animal studies to determine efficacy.

It was at the AAHL that HeV was first identified and characterised by Professor Linfa Wang. Professor Wang leads AAHL's Virology Group, which is studying emerging bat viruses, including HeV. The group is also studying a related virus, Nipah, which can be transmitted from bats to humans via pigs and directly from human to human. In two recent studies, Professor Wang and Professor Broder showed the HeV antibody offered complete protection against HeV and Nipah virus using animal models of infection.

AIBN and AAHL's ongoing research with the HeV antibody aims to determine its shelf life, to see how long it can be stored. Given the expense of producing it, scientists are keen to ensure it remains viable for as long as possible. The AAHL team is also working on a potential vaccine for horses to prevent infection.

Dr Munro said it was relatively hard for humans to contract HeV, particularly now people working with sick horses were more aware of the need for protective clothing, but the Nipah virus was responsible for many deaths in south-east Asia. Given the close relationship between the viruses, much of the research being conducted into HeV will be potentially applicable to Nipah.

# COLLABORATION TARGETS CANCER TREATMENT

**AIBN researchers and Sydney bioscience company EnGeneIC Ltd have teamed up to develop a new cancer treatment, using supercharged antibodies that specifically target tumours with a sophisticated drug delivery vehicle.**

An AIBN research team, comprising Associate Professor Stephen Mahler, Dr Trent Munro and Dr Martina Jones, in collaboration with EnGeneIC, secured a $352,000 Australian Research Council Linkage-Projects grant in 2011 to advance the research.

EnGeneIC has developed bacteria-derived nanoparticle minicells that have special properties, allowing them to be packed with conventional anti-cancer drugs and an anti-cancer therapeutic called small interfering RNA (siRNA). The minicells, known as EnGeneIC delivery vehicles (EDVs), combine with bispecific antibodies, developed by Associate Professor Mahler and his AIBN colleagues.

The antibodies target cancer cells and leave healthy ones untouched. The researchers hope the targeted delivery will dramatically reduce the side effects of chemotherapy treatment, in which drugs flood the entire body, leading to unpleasant side effects such as hair loss, fatigue, nausea and painful inflammation.

"The non-specific action of drugs used for cancer treatment is a major problem," Associate Professor Mahler said. "The targeted minicell circumvents problems associated with cancer treatment, such as development of multi-drug resistance and limited drug potency due to an inadequate concentration at the cell surface. The minicell is a drug delivery vehicle capable of packaging a variety of drugs at concentrations thousands of times greater than other known particles. The tumour-specific antibodies target the minicells to tumours, which could lead to improved cancer survival rates."

While EngeneIC successfully developed the EDV, it had less success with bispecific antibodies. Conventional antibodies bind to only one entity, but Associate Professor Mahler and his team developed variants that also bind to specific tumour cells. The next stage involves producing the antibodies in a certified good manufacturing practice facility and moving to clinical trials, which could occur within 12 to 18 months.

In a paper published in July 2011 in the journal *Nature Biotechnology*, EnGeneIC collaborators Dr Jennifer MacDiarmid and Dr Himanshu Brahmbatt demonstrated that their targeted minicells, containing siRNA molecules and cytotoxic drugs, showed an enhanced anti-tumour activity compared to conventional cancer drug therapies.

EnGeneIC initially began working with AIBN as a client of the institute's National Biologics Facility (NBF).

**Fast facts**

- The AIBN antibodies have two arms.
- One arm binds to an EnGeneIC minicell (EDVs) and the other to a cancer cell.
- The EDVs are delivered inside cancer cells via endocytosis, the process of cells engulfing molecules.
- Once inside, EDVs release the chemotherapeutic drugs into the cytoplasm.

# CELL REPROGRAMMING POTENTIAL FOR REGENERATIVE MEDICINE AND DRUG SCREENING

**AIBN researchers played a major role in 2011 in overcoming a significant barrier in the translation of stem cell-based therapy. This has encouraging potential for regenerative medicine and drug screening.**

AIBN Associate Professor Ernst Wolvetang, in collaboration with the UQ Centre for Clinical Research (UQCCR), has developed a new method to convert induced pluripotent stem cells (iPSC) into mesenchymal stem cells (MSC).

It is a breakthrough for patients with a range of serious diseases because MSC can potentially be used to repair bone and other organs, such as the heart. The new method could one day replace harvesting of bone marrow, presently conducted through highly-invasive procedures, such as lumbar punctures.

Human iPSC, artificially derived from skin cells, can be cultured indefinitely and can generate every cell type of the human body, so they are the cell type of choice for stem cell-based regenerative medicine and a discovery platform for understanding the molecular basis of human disease and development.

Associate Professor Wolvetang said the ability to make human MSC in large numbers in the laboratory "is an exciting step in the future widespread clinical use of MSC".

Animal trials with iPSC-derived MSC in dogs and horses, in collaboration with the UQ-based Queensland Alliance for Agriculture and Food Innovation and researchers at the University of Utrecht, in the Netherlands, will precede their use in humans.

The UQCCR collaborative research was published in the February 2012 edition of the journal *Stem Cells Translational Medicine*.

Associate Professor Wolvetang has also made significant progress in his research on Down Syndrome (DS) iPSC. His research group has identified which chromosome 21 genes are over-expressed in DS iPSC. That provides an opportunity to understand what combination of genes on the extra copy of chromosome 21 interact with genes on other chromosomes to lead to the far higher incidence of diseases among people with DS, including leukaemia, Alzheimer's, heart and immune system defects.

Associate Professor Wolvetang is collaborating with University of NSW Professor David Ma to examine the pathways that lead to leukaemia in people with DS.

He also has a collaboration with Queensland Institute of Medical Research Professor Martin Lavin and patient advocate group Brashat Organisation, resulting in generation of iPSC from children with the rare degenerative, inherited disease ataxia-telangiectasia. That forms the basis for novel disease models, drug screening platforms and potential future patient-specific stem cell therapies.

Associate Professor Wolvetang founded a nationwide network of more than 50 researchers, called Cell Reprogramming Australia (CRA). Based at AIBN, CRA will host an annual conference and a two-week workshop in 2012.

"Australia's a relatively small player in the international field, but we can make an impact by working together," he said.

The ability to conduct research with iPSC reduces ethical issues associated with stem cell research and allows the generation of patient-specific stem cells. Associate Professor Wolvetang said cell reprogramming and iPSC provide a powerful screening platform for new pharmaceutical drugs in the short term and may allow the return of disease-free cells to the human body in the longer term.

# COLLABORATION AIMS TO STEM INFECTIOUS DISEASES

**Researchers from AIBN are working in collaboration with colleagues from the Pasteur Institute in Ho Chi Minh City, Vietnam to progress work in vaccine development for pandemic avian influenza.**

AIBN Professor Anton Middelberg and UQ Protein Expression Facility's Dr Linda Lua started work in 2011 on a pilot study in vaccine development for pre-pandemic $H_5N_1$, with evaluation to be conducted at the Pasteur Institute.

The development work at AIBN is using bacteria to produce virus-like particles (VLPs). These are shells of the virus, but contain no viral genetic material, so they can elicit a strong immune response but are inherently safe.

Researchers hope the VLP technology can be tailored for any infectious disease and potentially deliver vaccines in weeks, rather than months, stopping a virus from causing a pandemic. Grafting elements of a dangerous pathogen to VLPs would enable the directing of an immune response towards a new or existing disease.

Research that allowed the VLP approach to address specific diseases was furthered when Professor Middelberg was awarded the Queensland Smart Futures Premier's Fellowship in 2010. Professor Middelberg said the $2.5 million grant would allow the VLP approach to be taken "to the next level".

The research at the core of the collaboration with the Pasteur Institute aims to design and produce a vaccine candidate tailored for influenza strains prevalent in Vietnam.

The VLP platform will be evaluated for efficacy at the Pasteur Institute using animal studies, drawing on expertise in infectious disease surveillance; vaccine control and manufacture; and testing.

Professor Middelberg said the collaboration with the Pasteur Institute was an important step in developing the VLP technology.

"We believe VLPs have the potential to take vaccine technology to a new level and tackle emerging diseases in a safe, effective way," he said.

"VLPs are very effective. They cause an enhanced immune response that has both cell and antibody components. You can freeze-dry them so there is no need for a cold chain in the developing world and they can be given by nasal puffer, overcoming the need for a syringe.

"We need to prove the efficacy of the VLP technology. Our agreement with a highly-regarded agency such as the Pasteur Institute will allow us to move in that direction."

World Health Organisation figures show strains of $H_5N_1$ have been responsible for 331 deaths globally since 2003, with 59 reported in Vietnam.

"A billion plus people in Asia want a healthy future and deserve protection against new threats such as bird flu," Professor Middelberg said. "The VLP technology is ideally suited to those markets. The product can be manufactured in Australia and easily shipped."

**Fast facts**

- The Pasteur Institute has a network of 32 sites, including one in Ho Chi Minh City, Vietnam.
- The Ho Chi Minh City institute has 250 researchers.
- Founded in Vietnam in 1891, it is the first Pasteur Institute outside Europe.
- The institute is the agency for public health in the south of Vietnam, with responsibility for infectious disease surveillance and prevention, biomedical research, vaccine control, manufacture and testing.

# AIBN PLAYS VITAL ROLE IN STEM CELL COLLABORATION

**Advances in regenerative medicine are expected to flow from the establishment of Stem Cells Australia in 2011, with AIBN researchers to play a major role.**

AIBN Director Professor Peter Gray joined the leadership group of the new collaboration initiative, established with $21 million in funding from the Federal Government's Australian Research Council.

Stem Cells Australia aims to link the country's leading experts in bioengineering, nanotechnology, stem cell biology, advanced molecular analysis and clinical research to solve human health problems.

The collaboration supports excellence in stem cell research and leads public debate and discussion about the important ethical, legal and societal issues associated with stem cell science.

The unique multidisciplinary approach will foster and train the next generation of Australian stem cell scientists, cementing Australia's future position in the field.

Five of the 18 chief investigators are from AIBN, bringing to the organisation expertise in fields of pluripotent stem cells, cellular differentiation, conversion of stem cells to blood cells, control over stem cell behaviours and cellular metabolism. With multi-disciplinary approaches seen as the future of research into complex problems in human health, AIBN is in a unique position to bring to bear its powerful combination of bioengineering and nanotechnology.

"AIBN has a highly inter-disciplinary research environment. The combination of biology, nanotechnology and engineering has the potential to change our lives," Professor Gray said.

"For example, scientific breakthroughs occurring in the field of stem cells and tissue regeneration are opening up many new opportunities for treating disease but, for the potential to be realised, we need to learn how to target new treatments to just the right part of the body – and how to grow very complex cells in a controlled fashion.

"Stem Cells Australia will promote the sharing of ideas, techniques and skills and develop new research direction. AIBN will play a major role. We can be justifiably proud of that."

Associate Professor Ernst Wolvetang will bring to Stem Cells Australia his expert knowledge in the field of pluripotent stem cells, which can generate every cell type of the human body without the ethical concerns of embryonic stem cells or the fear of rejection.

At the forefront of work to convert stem cells into red or white blood cells is Professor Lars Nielsen. Professor Nielsen is working with collaborators from the Australian Red Cross and the Peter MacCallum Cancer Centre to arrest the risk of neutropenia in cancer patients undergoing chemotherapy. He is also developing a process to generate red blood cells for blood transfusion.

Professor Justin Cooper-White has a focus on developing polymer-based structures to control stem cell behaviours, with particular emphasis on regenerating meniscal and heart tissue.

Associate Professor Christine Wells has developed a collaborative platform called Stemformatics, which allows researchers to share information about gene behaviour and cellular differentiation.

Professor Michael Monteiro will bring to Stem Cells Australia his expertise in the synthesis of novel nanoparticles, with application in drug delivery and tissue regeneration.

Working as part of Professor Gray's research group, Dr Trent Munro has experience in developing recombinant proteins to make suitable surfaces for human embryonic stem cells.

Stem Cells Australia was established by the University of Melbourne, The University of Queensland, Monash University, the University of New South Wales, the Walter and Eliza Hall Institute for Medical Research, the Victor Chang Cardiac Research Institute, the Florey Neuroscience Institutes and the CSIRO.

Professor Darren Martin's polymer research is close to breaking into a global plastics industry worth billions of dollars a year.

# MODIFIED PLASTICS APPROACHING COMMERCIALISATION

A nanoparticle additive that transforms conventional thermoplastic polyurethane (TPU) is at the heart of Professor Martin's research, which has the potential to revolutionise consumer products, from elite sporting equipment to industrial components.

Professor Martin and his research group combined engineered synthetic nanoparticles with the TPU to enhance the material's performance.

Several companies in the US, Europe and Australia tested the materials in 2011. The success of the trials led to formalised co-development and scale-up activities for a number of specific applications.

Professor Martin is exploiting the technology's obvious commercial potential in his role as Chief Scientific Officer of start-up company TenasiTech, established at UQ several years ago.

"Polyurethane is a ubiquitous polymer," Professor Martin said. "It's a huge market. We've worked extremely hard and travelled the globe to really understand the complete supply chain, the opportunities, and how we can most effectively enage with suppliers, manufacturers and users."

The key to the potentially huge payoff is tiny. "We engineer nanoparticles," Professor Martin said. "They're like little plates, one nanometre thick. We've invented a way of dispersing these into one of the liquid components that is a precursor for all polyurethanes."

The particles make up only 2 per cent of the resulting TPU's weight and it is only fractionally more expensive than the polyurethane itself.

"The nanoparticles improve strength, toughness, tear strength, durability at high temperatures and better chemical resistance – all useful properties."

TenasiTech has partner companies, including three that are interested in a specific application – one in elite sporting goods; another in rubber engineering components; and the third in membrane applications for water treatment.

"There are other applications we can follow. A lot of the attributes that are attractive to these initial three applications are desirable to many other applications.

"We have the capacity to make hundreds of kilograms of the material. That is one of the unique things about this technology.

It's heavily industrialised already. It's not a nanotechnology that still sits in a 5mL beaker in the lab somewhere. It's very robust and scalable."

Through the UQ School of Chemical Engineering and AIBN, Professor Martin began exploring the idea. When the research showed promising results, UQ commercialisation company UniQuest became involved, with seed investor Uniseed backing the company soon after.

"Now we've got two granted patents, another in progress, and two more are shaping up," Professor Martin said. "The concept has become exponentially more applied. We believe it is world's best practice in terms of a nanocomposite approach to polyurethane materials. We have already made the world's strongest polyether-based TPU, but we think we can do better."

# LICENCE AGREEMENT SIGNED WITH INTEGRATED PACKAGING

**Research to develop better agricultural film to protect crops has resulted in industry support and recognition in 2011, with a major award and a licence agreement.**

AIBN Professor Peter Halley's research group won the Cooperative Research Centres (CRC) for Polymers Chairman's Award for Excellence in Commercialisation.

The CRC also signed a licence agreement with major plastic film supplier Integrated Packaging to produce a range of degradable polyethylene films for agriculture and industry.

That followed six years of research involving UQ's School of Chemical Engineering; AIBN; Queensland University of Technology; CSIRO; Integrated Packaging; and Birchip Cropping Group.

The work involved creating polyethylene for agricultural films and wraps that can protect crops and products but break down over time to avoid pollution.

Agricultural applications included greenhouse films, which kept soil moist and protected potato crops and native trees from the cold. Mulch films had the same properties and also controlled weeds.

Professor Halley said the project started in UQ and QUT labs and moved to farms for successful field trials of the films, demonstrating the real-life relevance of the research.

"This has been one of the most challenging and complex projects I have been associated with, involving national and international partners," he said.

"The Chairman's Award is kudos for the younger researchers and a reward for the research team's focus on working towards the production of a commercial product."

More than 500 films were tested during the research, involving field tests at UQ's farm at Pinjarra Hills. Films were tested for protective properties during the crop's first four to six weeks and for degradation during the crop cycle to stop plants overheating closer to harvest.

CRC for Polymers chairman Dr Peter Coldrey said the project was an excellent example of the world-leading technology that could be developed by bringing together a multidisciplinary team drawn from five organisations.

UQ researchers, including Bronwyn Laycock, Greg Cash, Emilie Gauthier and Paul Luckman, developed a polyethylene material, combining an additive created at QUT that encouraged degradation.

Thermal and ultra-violet tests were conducted on the material to determine which would be most suitable for scaling up for commercial purposes. That was where Integrated Packaging came in, with experience in scaling up and quality control.

Project researchers began the technology transfer in 2011 for Integrated Packaging to start developing the films ahead of sales to agriculture and industry.

# SIMPLE SOLUTION TO PHOSPHATE POLLUTION

**Phosphates cause water pollution, such as algal blooms, but AIBN researchers believe they are on the right track to developing a simple solution.**

Materials scientist Professor Chengzhong (Michael) Yu is working on nanoporous materials that absorb phosphates quickly and cleanly.

The work received a boost in 2011, when Professor Yu received a grant from the Environmental Biotechnology Cooperative Research Centre.

With assistance from PhD student Jie Yang, Professor Yu demonstrated the efficacy of the material and twice had results published in the *Journal of Materials Chemistry*.

The research demonstrated that up to 97 per cent of phosphates were quickly removed from water containing low concentrations of the mineral using the nanoporous material.

Phosphorus has wide applications in industry and agriculture. Phosphates in fertilisers are washed away by rain and end up in waterways, promoting algal blooms and resulting in the death of waterway marine life.

Phosphorus is non-renewable and forecast to be depleted in less than 100 years. Reuse of phosphorus is an important issue for the world.

Not only is it important for researchers to develop ways to remove phosphorus from waterways, they are challenged to find a way to reuse it. The next step is to re-use captured phosphates to form fertilisers to complete the cycle.

Professor Yu said the nanoporous material incorporated metals in a porous matrix with a designed and finely controlled pore structure to attract phosphates and lock them in.

“Taking advantage of the designer pore structure, the uptake capacity has been demonstrated to be significantly higher than commercially-available absorbents,” he said.

Researchers kept in mind a need for the material to be suitable for use in bags, which could be easily removed from waterways. The bags could, for example, be placed in sugarcane fields to catch run-off during rain, with phosphates captured and purified water able to drain away.

# NANOMATERIALS SHOW GREAT PROMISE IN POLLUTION MITIGATION

**Computer design is playing an increasing role in developing nanomaterials to mitigate pollution, with AIBN researchers at the forefront of the research.**

Researchers from AIBN's Computational Bio and Nanotechnology Group are using computer design to develop innovative nanomaterials for $CO_2$ capture and gas separation.

The design work can predict which materials work efficiently and effectively as a membrane for flue gas separation at sites such as power plants or syngas purification at coal-powered electricity stations.

### Gas separation

Using chemistry and environmental engineering, Associate Professor Aijun Du has designed a graphydine membrane for hydrogen purification from syngas. The work involves Professor John Zhu from UQ's School of Chemical Engineering.

Former AIBN Group Leader Professor Sean Smith is playing an important role in moving the technology from computer modelling to a product. In his new role at Oak Ridge National Laboratory in the US, he has developed the graphydine membrane and will test its performance.

"There are some membranes being used for hydrogen purification from syngas at the moment," Associate Professor Du said.

"The selectivity of these membranes is not satisfactory. Our computer modelling shows our graphydine membrane has a very high selectivity of hydrogen compared to the existing membranes.

"The challenge is to demonstrate we have a way of reducing the cost of gas separation by producing an efficient alternative. We believe we are on the way to doing that."

### Carbon capture

Associate Professor Du is also working alongside PhD student Yan Jiao and computational scientist Dr Qiao Sun to further develop a low-energy carbon capture alternative.

As part of his Australian Research Council QEII Fellowship, Associate Professor Du is developing carbon nanotubes and aluminium nitride materials.

The researchers have demonstrated that the nitride materials show strong binding of $CO_2$ and published results in leading journal *Chemical Communication* in 2011.

"Current technologies are highly energy intensive," Associate Professor Du said. "Our research aims to develop materials that can capture $CO_2$ and separate it with a low energy cost.

"That is where computer design comes in. It can predict new materials that can capture $CO_2$ effectively – and keep costs low."

But the work does not end there, with a proposal to develop a new concept to electrochemically capture $CO_2$. That is considered important in industrial processes and in transport and mining.

Associate Professor Du said novel nano-technologies for reducing carbon emission were an area of great research interest, but that did not end with carbon capture.

"The aim is to ultimately have nanomaterials to capture $CO_2$ first and then design a catalyst for converting it into an alternative fuel cell. We see a way forward in this challenge."

# CONFIDENCE GROWS IN UNDERSTANDING SOLAR ENERGY CONVERSION

**AIBN researchers have made advances in designing materials with the potential to combine low-cost solar energy conversion with no carbon emissions.**

Researchers from AIBN's Computational Bio and Nanotechnology group have collaborated with researchers in the US and China on a project aiming to develop efficient surfaces for solar-hydrogen production.

The collaboration combines physics, chemistry and materials science to develop an understanding of the mechanism for solar-hydrogen production.

Findings of the group were published in the *Journal of the American Chemical Society* in 2011, showing titania monolayer sheets were a key to shedding light on a possible route toward assembling and using exfoliated ultrathin layered sheets.

AIBN's Dr Chenghua Sun said ultrathin layered sheets had shown great promise and received significant attention because of their potential uses in photocatalysis processes, low-cost solar cells, DNA sequencing, anti-bacterial agents and optical devices.

Dr Sun said the material could be made with the desired thickness and a well-tailored architecture, ensuring precision and giving researchers confidence in the materials being produced.

"The fundamental understanding of how the stacked nanosheets match plane by plane and what kind of relationships might exist between the sheets is limited," he said.

"My focus is to build on this understanding and determine what kinds of surfaces are most efficient to transfer solar energy to water to produce hydrogen."

The work involves Princeton University's Professor Annabella Selloni; Dr Gang Liu from the Chinese Academy of Sciences; AIBN Group Leader and ARC Centre of Excellence for Functional Nanomaterials director Professor Max Lu; and former AIBN Group Leader Professor Sean Smith, now at the Oak Ridge National Lab in the US.

UQ researchers involved in the work include Professor Jin Zou, from the School of Mechanical and Mining Engineering and the Centre for Microscopy and Microanalysis; and School of Chemical Engineering's Professor Lianzhou Wang.

"Our research may offer a new option for the design of photocatalysts for solar-hydrogen production, to produce low-cost hydrogen fuel from water, without leading to any carbon emissions," Dr Sun said.

"The major challenge is how to ensure the adsorbed sunlight is being used efficiently. It is essential to understand the mechanism of energy conversion involved in a water-splitting process."

**AIBN researchers have had success in 2011 in developing carbon nanospheres that show promise as low-cost catalyst supports for fuel cells.**

Professor Max Lu's research group has been working on nanocarbons for high-performance electrodes suitable for energy storage in lithium-ion batteries and super-capacitors.

Researchers in the Lu group prepared carbon nanospheres via carbonisation of polymer nanospheres synthesised using a modified chemical process known as the Stöber method.

The work was published in 2011 in leading chemistry journal *Angewandte Chemie* International Edition.

The modified process has the versatility to tune the nanospheres from 200 to 1000 nanometres, making them suitable as superb adsorbents for applications in water treatment, drug delivery, electrodes and catalyst supports.

Choosing an alcohol with a different alkyl chain, such as methanol, ethanol or isopropanol, enables the researchers to adjust the size of the nanospheres.

"This is an innovative and facile synthesis procedure," Professor Lu said. "It is economical and suitable for scale-up industrial production."

"The developed carbon nanospheres have shown great potential as electrodes for batteries and supercapacitors, and high catalytic activity when used as catalyst support in fuel cells," he said.

# NEW CHEMICAL TWIST BRINGS POTENTIAL FOR CLEAN ENERGY

# INFRASTRUCTURE FACILITATES RESEARCH

**Research infrastructure housed at AIBN has continued to be invaluable during 2011. Expertise in nanofabrication, metabolomics and biologics played a part in progressing cutting-edge research in medicines, vaccine delivery and antibody production.**

The infrastructure supported Queensland and Australian businesses undertaking research, development and innovation. Staff expertise and facility equipment is available to the broader Australian research community, which includes industry, academia and private organisations.

### ANFF-Q

The Australian National Fabrication Facility, Queensland node (ANFF-Q) worked closely with researchers around the country, including those at the University of Western Australia, the University of South Australia, Queensland University of Technology and Griffith.

Nanofabrication work on the Nanopatch, a needle-free vaccine delivery device being developed at AIBN, was completed in-house using ANFF-Q facilities and capabilities.

ANFF-Q staff played an important role during the early stages of research on the Nanopatch in assisting with the development of the numerous processes required to realise the vision of the research. The Nanopatch is still in development – and researchers are continuing to use ANFF-Q facilities – with the support of newly-established biotechnology company Vaxxas Pty Ltd and $15 million in investment to progress the work towards a commercial outcome.

Industry also accessed ANFF-Q's critical mass of high-end equipment during 2011. Among the industry users was mining services company SkillPro, which benefited from staff expertise, cutting-edge capabilities and quick turn-around to develop a mining safety product.

With federal and state government funding, ANFF-Q has been able to secure additional equipment, including deposition and metrology tools, and further clean room space. This is due to be installed and in use at ANFF-Q in mid-2012, enhancing the ability to provide support to researchers at every stage of their projects and industry in progressing their commercial activities.

### Biologics

Biologics research had a significant boost at AIBN in 2011. Support from the federal and state governments assisted in the creation of the newly-named National Biologics Facility (NBF) in 2011, with 15 staff members housed in the AIBN building.

Funding from the Education Investment Fund and Super Science Initiative also allowed a strategic partnership with CSIRO in Melbourne and the creation of a second node of the facility. The partnership further enhanced the capability and knowledge base that exists in early stage biologics technology in Australia.

The facility supported AIBN's role in a collaboration with Queensland Health, CSIRO's Australian Animal Health Laboratory and the Henry M Jackson Foundation in 2011 to manufacture batches of a monoclonal antibody that may be a potential therapeutic for Hendra virus infection in humans. Funding obtained from the Alister Rodgers Memorial Fund enabled batches of the antibody to be provided to CSIRO's Professor Linfa Wang and his research group for testing in animal trials.

World-class experience in mammalian cell line development will ensure NBF is an important component in completing a link in the chain between biopharmaceutical research and manufacturing in Brisbane.

Cell line and bioprocess development is at the heart of AIBN research in biologics. The research led to an agreement in 2011 that will result in AIBN researchers working closely with counterparts from DSM Biologics. The global company, based in the Netherlands, will run a $60 million mammalian cell good manufacturing practice production facility under construction at the Princess Alexandra Hospital as part of the $345 million Translational Research Institute.

In another collaboration, cultured mammalian cells are being developed at AIBN using the NBF's capabilities and staff expertise to develop therapeutic-grade biologics for clinical studies. This is part of a collaboration with Biosceptre, through investment company Medigen, to further develop a bio-process for antibody production ahead of pre-clinical trials for biologics targeting cancerous tumours.

### Metabolomics

Metabolomics Australia, Queensland Node (MA-Q) continued to supply key analytical support for projects requiring the identification and quantification of chemicals and metabolites of biological importance. MA-Q recruited a new manager in 2011, with Dr Mark Hodson bringing more than 10 years of metabolomics experience and team leadership in pharmaceuticals and biotechnology.

With state and federal government funding, MA-Q expanded its bioinformatics capabilities through acquisition of additional equipment for metabolomic analysis.

MA-Q projects in 2011 covered a wide spectrum of metabolomics applications. AIBN projects included analyses needed for the production of industrial chemicals, bioplastics from sugarcane, biopesticides from insect cell viruses and biofuels from yeast fermentations.

Analysis of biofuel production is an integral part of the Queensland Sustainable Aviation Fuel Initiative work to develop the production of advanced aviation biofuel from sugar cane. The yeast engineering and analysis is performed in partnership with the US biotech company Amyris.

Collaborations within UQ included an assessment of *Streptococcus pneumoniae* strains and an analysis of anti-epileptic drug concentrations in plasma and brain tissue.

In the wider community MA-Q provided metabolomic analysis for a diverse range of projects from groups within CSIRO and the Australian Wine Research Institute in Adelaide. Dr Louise Conwell, at the Royal Children's Hospital in Brisbane, collaborated with MA-Q in 2011 on research on juvenile diabetes and the Dow Chemical Company took advantage of MA-Q facilities through collaboration with Professor Lars Nielsen's research group.

# NEW RESOURCE FOR STEM CELL RESEARCHERS

**The Australian research community received a boost in 2011, with the establishment of Stem Cells Ltd to provide specialist stem cell products, advice, training and services.**

UQ and Monash University established the not-for-profit company with Federal Government funding, through Bioplatforms Australia Ltd.

Based at AIBN, it aims to provide expert staff, protocols and technology platforms to sustain and grow Australia's research capacity in stem cells science.

Stem Cells Ltd enables scientists to access valuable stem cell strategies for modeling human diseases. In many cases, that is the way to better understand the disease and possible treatments.

Services include cell line characterisation, custom generation of patient-specific induced pluripotent stem cell lines, multiple stem cell products and training in exemplar methodological approaches to stem cell biology.

Stem Cells Ltd Queensland manager Victoria Turner and her team work with stem cell scientists to advance research into diseases such as schizophrenia, Down syndrome, Parkinson's disease and heart disease.

The team works closely with AIBN Associate Professor Ernst Wolvetang, whose research and leadership provides a scientific foundation for Stem Cells Ltd's generation of induced pluripotent stem cell lines, enabling the facility to remain at the forefront of cutting-edge research.

"Stem cell research is an exciting and rapidly expanding field that is vital for basic research and understanding of diseases," Ms Turner said.

"Stem cells are set to have a major impact on healthcare and innovation, offering novel scientific insights to direct the treatment of a multitude of diseases and potentially develop therapies when cells become damaged by illness or injury.

"The promise of stem cell research is yet to be fully realised but Stem Cells Ltd is providing the necessary infrastructure to capitalise on the potential."

*"The promise of stem cell research is yet to be fully realised but Stem Cells Ltd is providing the necessary infrastructure to capitalise on the potential."*

# ARC FELLOWSHIPS

**Prestigious Australian Research Council (ARC) fellowships were awarded in 2011 to three researchers at AIBN, recognising work in personalised therapies for disease monitoring; devices for tumour cell detection; and plastics made from sugar cane.**

**Dr Kristofer Thurecht** has been awarded an ARC Future Fellowship to continue his research on novel polymeric imaging devices to detect and monitor diseases.

Dr Thurecht aims to develop a new way of detecting and treating diseases such as cancer, exploiting polymer chemistry to create advanced macromolecular architectures. These macromolecules deliver potent therapies to specific parts of the body where disease is present. The delivery and efficacy of the therapies can then be monitored using molecular imaging.

Understanding how the polymers' physical and chemical properties affect the efficacy of treatment and diagnosis is of particular importance to Dr Thurecht.

"This is a very dynamic field that crosses many boundaries into different science disciplines," Dr Thurecht said. "Advances in molecular imaging and delivery techniques have the potential to greatly benefit cancer therapies."

**Dr Muhammad Shiddiky** received an ARC Discovery Early Career Researcher Award (DECRA), recognising his work in developing a microfluidic device for sensitive detection of tumour cells.

Fitted with an electric fluidic circuit, the device has electrodes to analyse rare cells and proteins and detect cancer in early stages.

Dr Shiddiky said one of the major challenges was to demonstrate the microfluidic device was effective, accurate and could be easily manufactured. That was important in ensuring industry would be interested in developing the device and making it available globally at a reasonable cost.

**Dr Jens Krömer** will use his ARC Discovery Early Career Researcher Award to continue work on a fermentation process that turns sugar cane into environmentally-friendly chemicals, reducing the reliance on petrochemicals.

The fermentation process involves baker's yeast turning sucrose from sugar into chemical precursors, in the hope of creating plastics for use as fiber, coatings, packaging and other industrial applications. That will be achieved by using a systems biology approach to redesign the metabolism of a cell into a cell factory.

It involves the application of modern physiological tools to gain deep insight into the cellular processes, then targeted genetic manipulation to alter the outcome from cellular growth to production of environmentally-friendly chemicals.

The Future Fellowships scheme aims to address opportunity gaps for mid-career researchers and academics, many of whom would otherwise be lost to international competitors. The new DECRA scheme is a separate element of the ARC Discovery program, providing more focused support and creating more opportunities for early career researchers.

# RECOGNITION FOR AIBN'S INNOVATIVE RESEARCHERS

**Research innovation and entrepreneurial strategies at AIBN have been recognised during 2011 with several major awards. The awards acknowledge work inside the lab as well as moves to progress research towards commercial outcomes.**

**Professor Mark Kendall's** research group was recognised with one of the most prestigious awards in Australian science in 2011, receiving the Eureka Prize for Research by an Interdisciplinary Team. The group was listed as a finalist for the same prize the previous year.

The AIBN group worked with engineers, mathematicians, material scientists and immunologists from other research institutes around Australia on a needle-free vaccine delivery device, the Nanopatch.

The research involved input from laboratories of cervical cancer vaccine inventor Professor Ian Frazer, at the Translational Research Institute at Brisbane's Princess Alexandra Hospital; Professor Michael Roberts, Director of the Therapeutics Research Unit at The University of Queensland's School of Medicine; and the University of Melbourne's Professor Lorena Brown, from the Department of Immunology and Microbiology.

Collaboration was an important element in awarded research involving AIBN **Professor Peter Halley**. His research group won the Cooperative Research Centres (CRC) for Polymers Chairman's Award for Excellence in Commercialisation in 2011.

The award recognised six years of work to develop polyethylene for agricultural films and wraps. The polyethylene protects crops and breaks down over time to avoid pollution. The research involved UQ's School of Chemical Engineering; AIBN; Queensland University of Technology; CSIRO; Integrated Packaging; and Birchip Cropping Group.

**Professor Mark Kendall's** research on the Nanopatch has been recognised as inspiring and innovative, with an overall win in *The Australian* Innovation Challenge. Professor Kendall's work was also recognised in the Manufacturing and High-tech Design category.

He said the AIBN research group would use the $30,000 in combined prize money to develop innovative new ideas that may otherwise not be funded.

The Innovation Challenge aimed to unearth the nation's best ideas and put the spotlight on inspiring innovators who work for the greater good of others.

AIBN commercialisation associate **Dr Aoife Cullen** was one of only five Australians selected in 2011 for a scholarship to attend an intensive business studies program at Stanford University in Palo Alto, California.

In recognition of innovative and entrepreneurial thinking, Dr Cullen obtained a scholarship worth $8000 from the University of Sydney's United States Studies Centre to attend the Stanford Summer Institute for Entrepreneurship. The course combined lectures, entrepreneurial projects, small group discussions, guest entrepreneurs and workshops to provide a comprehensive understanding of business fundamentals and the process of launching a new venture.

Stanford is regarded as one of the world's leading research universities in computer science, mathematics, natural sciences and social sciences. More than 50 Stanford faculty, staff and alumni have won the Nobel Prize and alumni have founded many prominent technology companies.

**Professor Michael Monteiro** received a 2011 Australian Leadership Award from the Australian Davos Connection (ADC) Board, recognising outstanding work in contributing to a vision for the country's future.

Professor Monteiro's work on the synthesis of polymer nanostructures opened avenues for new drug and vaccine delivery carriers, stem cell 'on-demand' scaffolds, paints and pressure-sensitive adhesives.

Professor Monteiro received his award from Governor-General Quentin Bryce at the ADC Summit in Melbourne.

Winners become part of the summit's leadership award alumni and are invited to events that help them build on their network of contacts in government, academia and business. The summit brings together leaders from business, government, the public sector, academia and the broader community to improve their understanding of key issues affecting Australia.

**Dr Trent Munro** received the Sanofi-Aventis Award for Better Health at the Australian final of the Trailblazer competition. He had earlier won The University of Queensland's final of the competition, receiving a $3000 prize for his idea of recombinant monoclonal antibodies that target bacteria, especially drug-resistant bacteria such as the golden staph superbug.

With collaborators at UQ, Dr Munro has identified antigens – or biomarkers – to use against superbugs. The biomarkers allow the antibodies to attach to bacteria and turn on the body's immune response to rapidly clear the infection.

"Being part of the Trailblazer competition was a big boost for this project and will hopefully lead to significant extra funding to get us to the next stage of development," Dr Munro said.

UQ's main research commercialisation company UniQuest runs the Trailblazer competition, with the aim of encouraging academics and students to consider the commercial potential of their ideas.

AIBN students were recognised with a host of prestigious awards and scholarships during 2011. They are detailed in the Student Experience section of this report.

**Group Leader Professor Sean Smith accepted a high-level position in the US in 2011, ending a successful five-year tenure at AIBN.**

Professor Smith led AIBN's Computational Bio and Nanotechnology group to international recognition for diversity in forging cross-disciplinary applications for molecular modelling. The work raised the profile and perceived impact of theoretical chemistry in areas such as nanotechnology and nanomedicine research.

His research group's strengths in theoretical modelling helped the AIBN-based ARC Centre of Excellence for Functional Nanomaterials develop an international reputation.

"I take heart that my work at AIBN had a progressive impact in persuading researchers atomistic modelling can play a very important role in advanced nanotechnology – and will play an increasing role as we move the field forward," Professor Smith said.

The applications of Professor Smith's research included nanocomposite materials for mobile hydrogen storage applications; nanoparticles and biological dendrimers for gene delivery; fluorescent protein photophysics for cellular imaging; and fundamental quantum dynamical methodology for combustion and atmospheric chemistry.

Collaborations with other AIBN research groups included work with Professor Mark Kendall to model Nanopatch indentations for developing a needle-free vaccine delivery system; and with Professor Andrew Whittaker in developing artificial retinal fluid using polymer gels.

Since taking up his new role as Director of the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory, Professor Smith has continued to collaborate with the Computational Bio and Nanotechnology group. He has retained links with other AIBN research groups, notably Professor Max Lu's group on nanomaterials for energy storage and conversion.

The Oak Ridge centre is collaborative and multidisciplinary, developing a set of scientific synergies that will accelerate the discovery process through a focus on understanding nanoscale materials, assemblies and phenomena.

*"I take heart that my work at AIBN had a progressive impact in persuading researchers atomistic modelling can play a very important role in advanced nanotechnology."*

# SEAN SMITH MOVES TO THE US

# JULIE CAMPBELL RETIRES

**Foundation Group Leader Professor Julie Campbell retired from AIBN in 2011, leaving a legacy of research excellence, grant successes and inspiring the young.**

Professor Campbell is a world leader in smooth muscle biology and the first to discover smooth muscle cells can exist in a spectrum of phenotypes controlling biology and response to disease stimuli. Her findings have helped researchers understand how atherosclerotic plaque forms and develop potential prevention strategies.

Professor Campbell was also the first to discover that bone marrow cells contribute to intimal thickening in arteries subjected to injury. She worked on an artificial blood vessel grown in the peritoneal cavity of the person into whom it will be grafted.

During a 38-year career as a biomedical researcher, she was the Director of the Wesley Research Institute and President of the Association of Australian Medical Research Institutes. She was a NHMRC Fellow for 30 years, securing six rounds of funding of five years each.

Professor Campbell was awarded the Wellcome Australia Medal; was later made a Fellow of the Australian Academy of Science; awarded the Centenary Medal; received a Queensland Greats Award; been made an Officer of the Order of Australia; and named Queensland Businesswoman of the Year in the public and not-for-profit section.

"I am most proud of my role as honorary Secretary of Education for the Australian Academy of Science," she said. "My portfolio was to develop inquiry-based science education programs."

A primary school program called *Primary Connections: Linking Science with Literature* was taught in more than half of Australia's schools and incorporated into the National Science Curriculum.

"I believe all scientists have a duty to inspire and encourage young Australians to marvel at and be curious about the world around them."

Professor Campbell wound back her research activities at AIBN in 2010 to focus on providing advice to young women in research, particularly in professional development, grant applications and collaboration. She continues her work at the Wesley Research Institute.

**Fast facts**

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# ENGAGING WITH SCHOOLS

**AIBN continues to foster relationships with schools around Queensland as part of its outreach activities. Researchers and students were involved in visiting schools; offering placements in AIBN labs; ongoing mentoring of students; and conducting guided tours of AIBN facilities in 2011.**

School visits took researchers and students to rural and regional areas such as Charleville, Innisfail and Maryborough, with assistance from the Australian Academy of Technological Sciences and Engineering's (ATSE) Science Ambassador program and CSIRO Scientists in Schools initiative.

Charleville School of Distance Education gave Professor Anton Middelberg an opportunity to conduct online science classes for Year 1 students in June. Older students took part in a science challenge during a return visit in November.

ATSE Science Ambassador Nathan Boase explained the applications and challenges of his polymer chemistry research during visits to schools in Innisfail, Maryborough and Chelmer, tailoring his message for the various age groups.

Queensland Academy for Science, Mathematics and Technology welcomed AIBN students and researchers to the school five times during 2011, with presentations covering topics such as next-generation vaccinations, targeted drug delivery and tissue engineering.

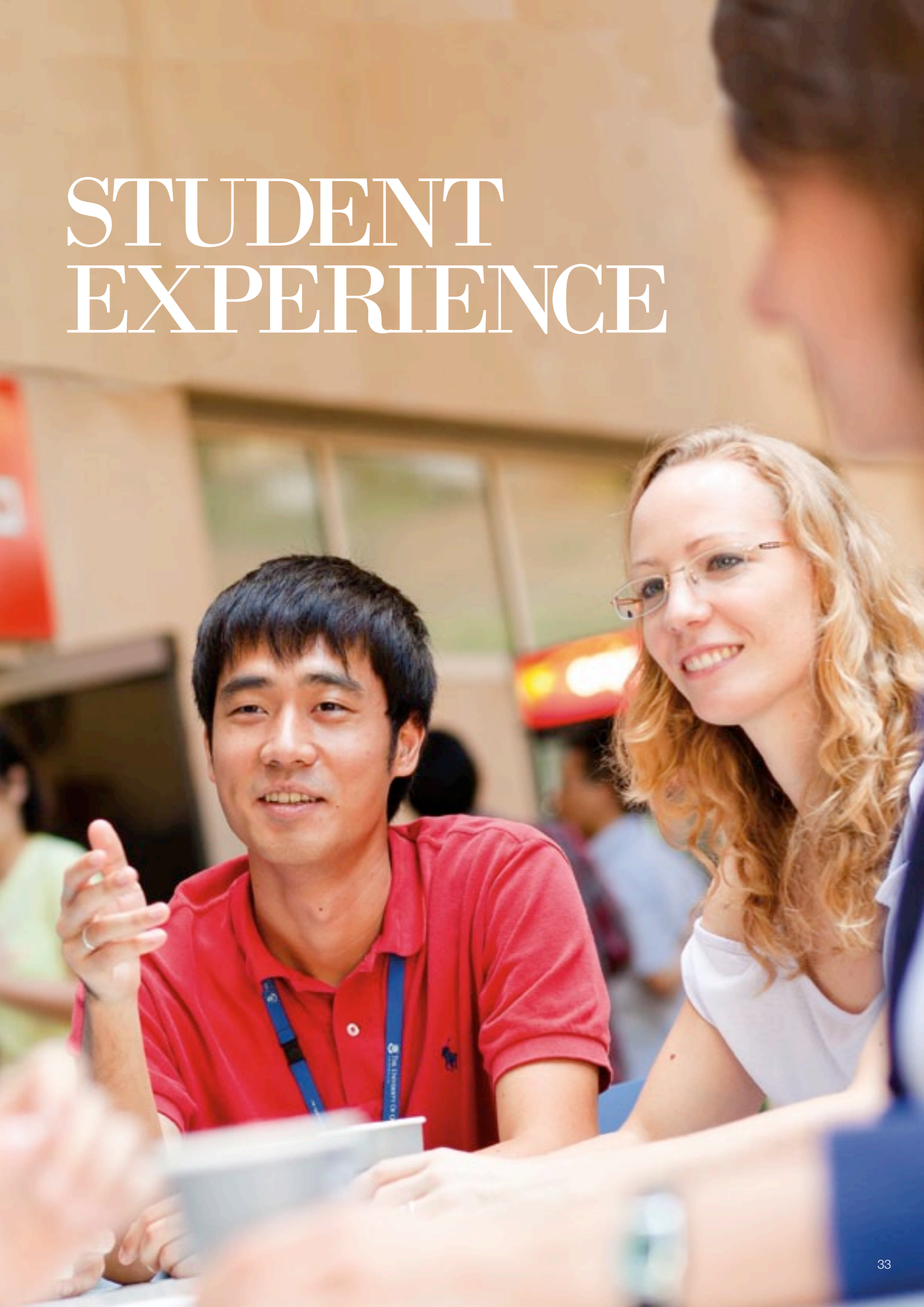
The school also placed students in the labs at AIBN, offering them an insight into cutting-edge research and a chance to see how scientists progressed their work with a combination of experimentation, collaboration and education.

Kenmore State High School established a mentorship with AIBN for two of its enthusiastic science students, resulting in a fruitful exchange of information and plans to expand the program in 2012.

As part of the AIBN Ambassador Program, researchers and students conducted tours of the institute's facilities with demonstrations of the equipment and explanation of the research projects, detailing real-life applications. The program benefited in 2011 from the support and involvement of an enthusiastic AIBN Student Association, under the leadership of president and PhD student Alexandra Depelsenaire.

AIBN's outreach activities aim to foster an interest in science; create an understanding of the value of science in the everyday lives of Queenslanders; and present science to students as both a potential area of study and career path.

# STUDENT EXPERIENCE



# RHD REPORT

**Significant achievements were recorded in AIBN's high-quality student research program in 2011, including strong student growth and increasing PhD completions. The research higher degree program's cohort reached 120, with diverse international representation and an almost even split between male and female students.**

PhD completions reached a new record, with 13 PhD and one MPhil awarded in 2011. That was up from eight students awarded in 2010. The PhD graduates were Yalun Arifin, Joe Codamo, Zi Gu, James Hudson, Chalida Klaysom, Kirsten Lawrie, Daria Lonsdale, Richard Mills, Guak-Kim Tan, Drew Titmarsh, Xuan Truong, David Wang and Xiao Xia Yan. Ajay Makarand Orpe graduated in late 2011 with an MPhil.

Dr Lonsdale and Dr Klaysom were each awarded a Dean's Commendation for Outstanding Research Higher Degree Thesis from UQ.

The commendation gives formal recognition to outstanding PhD and MPhil graduates who demonstrated excellence in a research higher degree and have been commended by advisers and independent examiners for substantial contribution to their fields. No more than 10 per cent of research higher degree graduates are recognised in this way each year.

Dr Lonsdale was recognised for her work in polymer chemistry, with a focus on synthesis of complex polymer topologies and their self-assembly in water, which has applications in biomedical fields and materials science.

Dr Klaysom's commendation was for her work on novel organic/inorganic nanocomposite membranes for electro-dialysis application in water recovery.

Research student contributions are valued at AIBN. As part of providing students with a comprehensive scientific skill set and successful foundation for a career, AIBN encourages and financially supports engagement and research activities that take students outside the institute. That provides students with personal development opportunities and opens AIBN's doors to potential collaborations and networking with the best minds from around the world.

With that culture in place, student Oliver Squires was able to attend the One Young World global forum in Zurich, Switzerland as the convening Australian ambassador and lead debate about topics including global warming, poverty, human rights, freedom of speech, ethical business practices, world peace and healthcare.

The forum allowed Mr Squires to hear from world leaders and activists such as Nobel Peace Prize Laureate Desmond Tutu, musician Bob Geldof, Norwegian Crown Prince Haakon and soccer star Clarence Seedorf. The trip to Zurich was made possible with sponsorship from UQ Deputy Vice-Chancellor (Research) and AIBN Group Leader Professor Max Lu.

### Conference prizes

Students can be proud of their success in giving award-winning presentations at leading conferences and the prizes they have been awarded at gala events during 2011.

Amanda Pearce won the CRC-P Prize, awarded by the Cooperative Research Centre (CRC) for Polymers at the Australasian Polymer Symposium in Hobart. The prize recognised her high quality, well-presented thesis research about functional hyperbranched polymers for prostate cancer theranostics.

While still a student, Dipti Vijayan was runner-up in the Best Poster Presentation at the Brisbane ECR Poster Symposium, recognising her standing among researchers who are within five years of the start of their careers.

Cuauhtemoc Licona Cassani was one of 12 young scientists selected to present at the International Symposium on the Biology of Actinomycetes in Puerto Vallarta, Mexico, with a chance to talk about his work on microbial physiology and secondary metabolism at the young scientists' plenary symposium.

### Travel awards

AIBN students travelled to international conferences and spent time in labs around the world in 2011, using travel awards and scholarships. The success in obtaining those accolades recognises the high-quality research, innovation and commercial potential of the AIBN cohort's work.

PhD student Azlin Fazlina Osman travelled to Pennsylvania State University in the US, after being awarded a UQ Graduate School International Travel Award. It allowed Ms Osman to perform broadband dielectric spectroscopy experiments to advance her polymer chemistry studies.

Elizabeth Mason was the only student among 13 academics invited to a Radcliffe Institute for Advanced Study exploratory workshop on variation at Harvard University, Boston. The workshop covered research on variation in defining phenotype and disease, with plans for resulting outcomes to be submitting to a major academic journal. While Ms Mason was at Harvard, she worked in the labs of leading computational biologist and genome scientist Professor John Quackenbush.

Pamela Alejandra Jaramillo-Ferrada received two Australian Stem Cell Centre awards in 2011, recognising her thesis research in tissue engineering and regenerative medicine. The centre awarded Ms Jaramillo-Ferrada an International Postgraduate Supplementary Scholarship and a travel award to present at the Annual Conference of the Australasian Society for Biomaterials and Tissue Engineering in Queenstown, New Zealand.

Also receiving two accolades in 2011 was PhD student Nick Fletcher. He received a student travel bursary to travel to the Australian Peptide Conference at Hamilton Island in October.

UQ awarded Mr Fletcher a 2011 UQ Trans-Pacific Fellowship, allowing him to travel to Seattle, US, to complete research; learn about primary cell culturing techniques; and build inter-institutional links during a month in the labs of University of Washington Professor Buddy Ratner.

### Engagement

Kelly Hitchens and Sean Muir participated in The University of Queensland's Three Minute Thesis (3MT) competition. Ms Hitchens won the AIBN round and Mr Muir took out UQ's Combined Institutes final, giving him a place in the highly-competitive UQ Final.

The competition challenges students to strip away the jargon and explain their research in a compelling way to a general audience within three minutes.

Four AIBN students played a major role behind the scenes at the Royal Australian Chemical Institute's Student Symposium in Brisbane in August. Nathan Boase led an AIBN team of Yami Chuang, Yosephine Andriani and Nick Fletcher in organising the annual event. It featured polymer chemist and tissue repair and regeneration specialist Professor Graeme Georgen as plenary speaker and a full-day program of student presentations.

# GRADUATES 2011

### Yalun Arifin

**Qualifications** BEng (Chem) *University of Surabaya*, MSc (Biochem, ChemEng) *Delft University of Technology*, PhD *UQ*

**PhD awarded** August 2011

**Supervisors** Professor Lars Nielsen, Dr Claudia Vickers, Dr Jens Kroemer

**Thesis title** Sucrose metabolism in *Escherichia coli* W (ATCC 9637)

**Research project** The research involved studying sucrose use in *E. coli* W to understand characteristics essential for metabolic engineering the cell to produce high-value products from sucrose.

**Graduate position** Chair of Chemistry Department at Surya College of Education, Gading Serpong, Tangerang, Indonesia. Current research is on butanol fermentation by *Clostridium acetobutylicum* using agricultural by-products.

### Annie Chen

**Qualifications** BSc (Chem/Nanotech, Hons) *UQ*, PhD (Bioeng) *UQ*

**PhD awarded** October 2011

**Principal supervisor** Professor Matt Trau

**Thesis title** Nanotechnology-based proteomic biosensors

**Research project** The objective of the PhD research was to fabricate a multiplexable and adaptable 3-D particle-based proteomic immunoassay to provide highly accurate early-stage disease diagnosis for clinical purposes.

**Graduate position** NCRIS Facility Manager, National Imaging Facility, UQ.

### Joe Codamo

**Qualifications** BSc (Biotech, Hons) *UNSW*, PhD *UQ*

**PhD awarded** July 2011

**Supervisors** Professor Peter Gray, Dr Trent Munro

**Thesis title** Process development and characterisation of transient expression technology in CHO cells

**Research project** The project involved further characterisation of an episomal-based expression system in CHO cells. That led to significant improvements in biologics production, which in turn enhanced the system's industrial relevance.

**Graduate position** Bioprocess Engineer with DSM Biologics, Groningen, the Netherlands.

### Sophia Gu

**Qualifications** BSc *Anhui Agricultural University China*, PhD *UQ*

**PhD awarded** August 2011

**Principal supervisor** Professor Max Lu

**Thesis title** Inorganic layered double hydroxide nanoparticle-based anti-restenotic drug delivery system

**Research project** The thesis demonstrates, both in vitro and in vivo, the potential of an inorganic layered double hydroxide nanoparticle-based drug delivery system for anti-restenotic therapies.

**Graduate position** Postdoctoral Research Fellow at AIBN.

### James Hudson

**Qualifications** BE (Chem, Biol, Hons I) *UQ*, PhD *UQ*

**PhD awarded** February 2011

**Co-Supervisors** Professor Justin Cooper-White, Associate Professor Ernst Wolvetang, Associate Professor Gary Brooke

**Thesis title** Development of functional myocardium for regenerative treatment of heart disease

**Research project** The thesis involved developing contractile patches of myocardium for potential therapeutic treatment of heart failure. The thesis focused on an inter-disciplinary field, involving polymer synthesis; characterising polymer of mechanical properties; characterisation of in vivo response to polymers; stem cell biology; and differentiation of cardiomyocytes from human embryonic stem cells.

**Graduate position** Postdoctoral fellowship from the German Cardiology Society to cover position in a world-leading cardiac tissue engineering lab at the German Heart Research Center in Goettingen, Germany.

### Chalida Klaysom

**Qualifications** BSc and MChemEng *Chulalongkorn University, Bangkok*, Thailand, PhD (ChemEng) *UQ*

**PhD awarded** May 2011

**Principal supervisor** Associate Professor Lianzhou Wang

**Thesis title** Novel organic – inorganic nanocomposite ion-exchange membrane for water purification in desalination

**Research project** The research is in the field of material design and development, especially in membrane materials with desirable properties suitable for different applications, such as desalination, water treatment and purification and energy conversion devices, including batteries, redox flow batteries and fuel cells.

**Graduate position** Postdoctoral fellow at KU Leuven, Leuven, Belgium.

### Kirsten Lawrie

**Qualifications** BSc (Chem, Hons I) *UQ*, PhD *UQ*

**PhD awarded** December 2011

**Principal supervisor** Professor Andrew Whittaker

**Thesis title** Extreme ultraviolet irradiation of poly(olefin sulfone)s: towards applications as EUV lithographic materials

**Research project** The density of circuit elements on microchips has doubled roughly every 12 to 18 months, resulting in smaller, faster and cheaper computing and storage devices. However, it is now recognised that the traditional technique for printing circuit patterns – optical lithography based on refractive optics – cannot continue to sustain this rapid growth. Extreme ultra violet (EUV) lithography is recognised as the technique that will enable the semiconductor industry to continue to evolve. The thesis project investigated a unique class of polymeric materials, the poly(olefin sulfone)s, as candidates for EUV photoresist materials.

**Graduate position** Research Administration Officer at UQ Research and Innovation.

### Daria Lonsdale

**Qualifications** BSc (Pharma Chem) *Griffith*, BSc (Hons I) *Griffith*, PhD *UQ*

**PhD awarded** December 2011

**Principal supervisor** Professor Michael Monteiro

**Thesis title** Synthesis of complex polymer topologies and their self-assembly in water

**Research project** Recent advances in living radical polymerisation techniques have allowed for the synthesis of well-defined polymers and polymer architectures, especially when combined with highly efficient coupling techniques. In this thesis, the main objective was to synthesise well-defined polymers with complex topologies and to study their self-assembly behaviour in water. In particular, efforts were focused towards developing an efficient synthetic methodology, with the aid of theory, to produce cyclic polymers in high purity.

**Graduate position** Graduate program, Science and Infrastructure Division of the Federal Department of Industry, Innovation, Science, Research and Tertiary Education, Canberra.

### Richard Mills

**Qualifications** BEng (Hons) *UQ*, PhD *UQ*

**PhD awarded** December 2011

**Principal supervisor** Professor Justin Cooper-White

**Thesis title** Modulation of mesenchymal stem cell behaviour via integrin-extracellular matrix interactions

**Research project** The thesis investigated the response of human bone marrow derived mesenchymal stem cells (hMSCs) to changes in a number of micro-environmental cues. Central to this investigation was the role of integrin-extracellular matrix interactions on hMSC behaviour, particularly their adhesion, migration and differentiation.

**Graduate position** Postdoctoral researcher at the Karolinska Institutet's Department of Cell and Molecular Biology in Stockholm, Sweden.

### Guak-Kim Tan

**Qualifications** B Biomedical Sciences (Hons) and M Medical Science (Physiology, Distinction) *University of Malaya*, PhD *UQ*

**PhD awarded** August 2011

**Principal supervisor** Professor Justin Cooper-White

**Thesis title** Development of a biomimetic scaffold for meniscal tissue engineering

**Research project** The project focused on developing a biomimetic, surface-engineered scaffold for knee meniscal repair. It showed the resultant biomimetic scaffold can facilitate redifferentiation of passaged meniscal cells and promote a chondroinductive response of human bone marrow-derived mesenchymal stem cells, resulting in an engineered construct with matrix resembling that of the native meniscus tissue. The biomimetic scaffold elicited only mild inflammatory responses in the rat model – an important prerequisite for its use as a cell carrier for clinical applications.

**Graduate position** JSPS Postdoctoral Research Fellow at the Institute for Frontier Medical Sciences, Kyoto University, Japan.

### Drew Titmarsh

**Qualifications** BE (Chem, Hons) *UQ*, PhD *UQ*

**PhD awarded** July 2011

**Supervisors** Professor Justin Cooper-White, Associate Professor Ernst Wolvetang

**Thesis title** Microbioreactor arrays for screening and controlling pluripotent stem cell expansion, maintenance and differentiation

**Research project** The project involved developing microbioreactor arrays – a kind of fluidic chip that uses microfabrication techniques found in the semiconductor industry to miniaturise the way assays are performed on cells. Hundreds or thousands of assays are then integrated on one chip, increasing experimental throughput. This is an enabling technology for stem cell research, bioprocess development, and pre-clinical drug testing.

**Graduate position** Postdoctoral Fellow at AIBN, commercialising the technology developed in the PhD, supported by a UniQuest Pathfinder grant.

### Vinh Truong

**Qualifications** BEnvSc (Hons) *UQ*, PhD *UQ*

**PhD awarded** March 2011

**Principal supervisor** Associate Professor Idriss Blakey

**Thesis title** Synthesis of well-defined hydrogel network using click chemistry for drug delivery

**Research project** The project involved synthesis of a range of hydrogels – polymer networks that can absorb large amounts of water – for drug delivery. The hydrogels were prepared using bioorthogonal click chemistry to give a well-defined structure with tunable mechanical properties and degradability.

**Graduate position** Postdoctoral Fellow at the University of Warwick, UK, working on synthesis of polysaccharide hydrogels for cartilage tissue engineering.

### David Wang

**Qualifications** BApplSci (Medical Radiation Technology, Distinction) *QUT*, BBiotech (Chem Biotech, Hons I) *UQ*, PhD (Polymer Chemistry/Material Science) *UQ*

**PhD awarded** September 2011

**Supervisors** Dr Firas Rasoul, Professor Andrew Whittaker

**Thesis title** Development of injectable biodegradable hydrogels for the controlled delivery of bioactives for the treatment of alveolar bone loss associated with periodontitis and peri-implantitis

**Research project** Dental implant failure is caused primarily by poor osseointegration between the titanium screw and the surrounding alveolar bone. The project aimed to develop an injectable, *in-situ* crosslinkable biodegradable gel to put into the defect around the screw to promote osseointegration.

**Graduate position** Postdoctoral Fellow at the School of Chemical Engineering, UQ.

# STUDENT ASSOCIATION PLAYS VITAL ROLE

**The AIBN Student Association (ASA) provided a valuable support network, advocacy role and social outlet for students in 2011, with an expanded events schedule, increasing institute participation and a full program of engagement activities.**

The ASA was established to provide a support network and promote co-operation between students and research groups at AIBN.

Those aims were well and truly met in 2011, under the leadership of ASA president Alexandra Depelsenaire, vice president Clementine Pradal, secretary Kebaneilwe Lebani, treasurer Maria Buchsteiner and executive officers Nathan Boase, Nicholas Fletcher, Veronica Martinez Salazar and Yami Chuang.

Among highlights of the ASA calendar was the first AIBN Student Conference, with keynote speakers, student presentations, poster sessions and a conference dinner involving participants from UQ's various research institutes. The ASA attracted sponsors for the conference, helping to meet the costs of hosting the event.

The sessions attracted more than 150 students and early career researchers. They gave students the opportunity to hone presentation skills in a familiar setting and obtain valuable feedback from their peers. Many of the more than 50 students presented to a scientific audience for the first time at the conference.

Further support was provided to students in 2011 through a PhD skills workshop, with speakers sharing their knowledge in scientific writing and experiences as postdoctoral researchers.

The ASA introduced a buddy system to help new students settle into the institute, find their feet as a PhD student and – in many cases – develop a support network in a new city or university. Among those welcomed to AIBN in 2011 were researchers and students from the University of Canterbury following the devastating earthquake in Christchurch, New Zealand. They spent about three months continuing their research at AIBN while rebuilding work continued on their campus facilities.

Demonstrating their support for the New Zealand researchers, the ASA organised a fundraising barbecue to aid the city's rebuilding efforts. Additionally, more than $1000 was contributed to the Queensland Premier's Disaster Relief Appeal through a similar fundraising barbecue following the January 2011 floods.

Other ASA activities included an all-of-institute Christmas party; Melbourne Cup festivities; the annual staff versus students soccer match; a games night; sports day; trivia night; student feedback sessions; and an active role in promoting, supporting and participating in the Three Minute Thesis competition.

The ASA took a leading role in engagement activities during 2011, with involvement in the AIBN Ambassador Program. Mr Boase travelled to Innisfail, Maryborough and Chelmer to speak to school students about life as a science student. Fellow ASA executive officers took numerous groups of visitors around the AIBN building during the year, presented demonstrations of their research and explained their relevance to improving people's lives. That was part of tours organised for school groups, prospective PhD students, industry delegations, visiting researchers and the public.

The ASA achievements in 2011 were recognised with short-listing in three categories of the UQ Union Club of the Year awards. Maria Buchsteiner was a finalist in the Treasurer of the Year category. The Student Conference was listed for Event of the Year and the ASA was a finalist for Faculty or School-based Club of the Year.

Ms Depelsenaire and Mr Boase gained additional recognition, each receiving a 2011 Award for Outstanding Contribution to the AIBN Community from Director Professor Peter Gray at a gala ceremony.

Activities in 2011 helped the ASA build a reputation for excellence beyond AIBN, built a strong track record of events and engagement and ensured a healthy financial position to underscore continued activities in 2012.

# SUMMER INTERN INTAKE ALMOST DOUBLES

**AIBN is proving successful in attracting undergraduate students to its Summer Research Scholarship Program.**

The program attracted 23 students from three universities in late 2011, almost double the previous year's intake.

The program allowed students to experience life in an AIBN lab, gaining skills for careers in engineering, chemistry and biology. It attracted students from UQ, Griffith University and Edith Cowan University in Perth.

Students completed tasks such as detecting biomarkers in saliva to determine the risk of heart disease in patients; and characterising hydrogels suitable for encapsulating medicines.

The program gave students exposure to the research environment; allowed them to explore the possibility of research careers; and displayed the breadth of AIBN's various research fields.

It was established to allow highly motivated undergraduate students to spend eight to 12 weeks undertaking focused research projects.

Students worked on projects that investigated the behaviour of cancer cells as part of a tissue engineering and microfluidics research project; and screened medical candidates for several diseases.

Other projects in which they assisted involved developing efficient catalysts for eliminating pollution in cars; and designing nanoparticles for use as intelligent medicine and gene delivery vehicles.

As well as gaining valuable research skills, students had access to cutting-edge research facilities; received career mentoring; and some received credit towards an undergraduate degree. Some students qualified for scholarships, with UQ and AIBN sharing the costs.

Students gave professional 10-minute presentations of their research and submitted written reports of their work.

Some will be co-authored on publications arising from their research – a testament to the quality of the projects provided by their AIBN advisers and to the talent and commitment of the students themselves.

The experience has inspired some students to continue their research projects at AIBN, spending time in the lab between semester commitments. Some have already expressed an interest in returning for another summer or a PhD project. One such student is Adam Hand.

The Edith Cowan University undergraduate engineering student spent the time in the lab of AIBN Professor Mark Kendall to learn about the Nanopatch, a needle-free vaccination device with thousands of small projections designed to deliver vaccine to immune cells in the skin.

Mr Hand's lab work involved improving and automating the dry coating procedure of vaccines for use on the Nanopatch.

"In only 12 weeks I believe I have experienced more and learnt more than I could have ever hoped to learn in a classroom," he said.

"The program has opened my eyes to a completely different and fascinating field that I would have never imagined entering when originally enrolling in engineering.

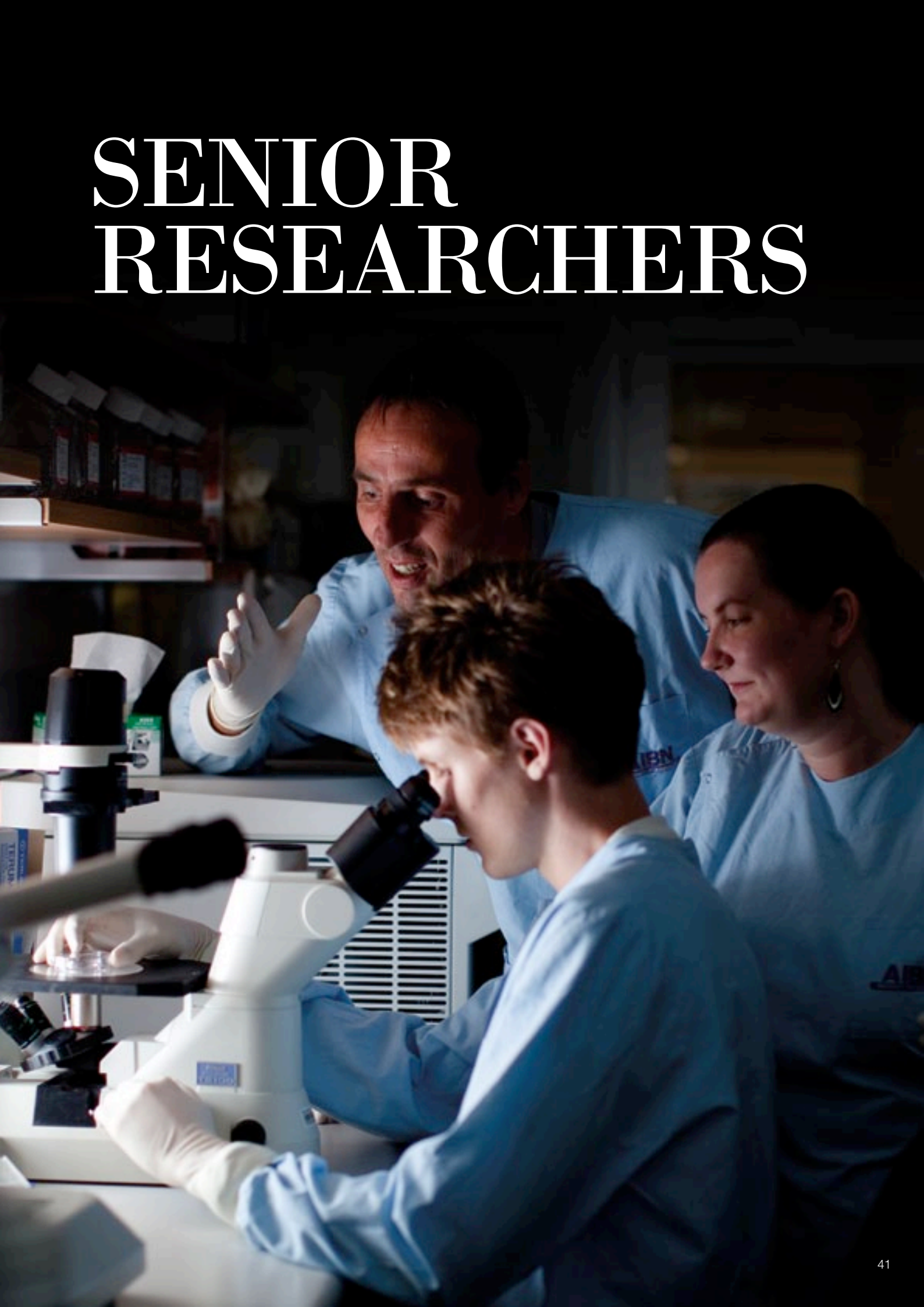
"The experience I gained at AIBN, in my eyes, is priceless. I have enjoyed my work immensely and I hope I can continue to work at AIBN further down the line."

# RESEARCH HIGHER DEGREE STUDENTS

Suad Alateeq
Samah Alharbi
Eid Alosime
AbdulKarim AlSultan
Nasim Amiralian
Will Anderson
Yosephine Andriani
Melisa Anggraeni
Colin Archer
Yalun Arifin
Nathan Boase
Mareike Bongers
Timothy Brennan
Marion Brunck
Michele Bruschi
Maria Buchsteiner
Sandy Budi Hartono
Jessica Cameron
Donna Capararo
Xiaojing Chen
Xiaoli Chen
Panagiotis Chrysanthopoulos
Ya-Mi Chuang
Joe Codamo
Jacob Coffey
Natalie Connors
Holly Corbett
Michael Crichton
Licona Cuauhtemoc
Alexandra Depelsenaire
Stefanie Dietmair
Thanh Tam Doan
Hai-Yan Dong
Jingjing Duan
Liam Fearnley
Erika Fiset
Nicholas Fletcher
Wanli Johnny Fu
Marianne Gillard
Stephen Goodall
Yadveer Grewal
Ryan Harrison
Alejandro Hidalgo-Gonzalez
Zi Gu
Zakaria Hidayatul
Kelly Hitchens
Md Daloar Hossain
Jia Hou
James Hudson
Hoai Huynh
Sani Saite Jahnke
Siddharth Jambhrunkar
Pamela Jaramillo Ferrada
Atikah Kadri
Li Pin Kao
Chalida Klaysom
Jakov Kulis
Geoffrey Lawrence
Kirsten Lawrie
Kebaneilwe Lebani
Hui Hui Lee
Pearl Lee
Peng Li
Ji Liang
Wing On Liew
Soo Lim
Chunli Liu
Daria Lonsdale
Derong Lu
Paul Luckman
Benoit Maisonneuve
Veronica Martinez Salazar
Elizabeth Mason
Sainimili Vaubula Mateyawa
Leila Matindoost
Stefano Meliga
Richard Mills
Sean Muir
Jamileh Nabizadeh
Hoang Quan Nguyen
Yuting Niu
Huey Wen Ooi
Camila Orellana
Ajay Makarand Orpe
Azlin Fazlina Osman
Gillian Osmond
Ramkumar Palanisamy
Venkateswaran Sankaran Pedinti
Warren Pilbrough
Amirali Popat
Clementine Pradal
Ramanathan Pudhukode Vaidyanathan
Kun Qian
Anthony Raphael
Tania Rivera Hernandez
Suriana Sabri
Anne Sandstrom
Miriem Santander Borrego
Jessica Schwaber
Khaled Sebakhy
Abhijit Shrotri
Michael Song
Oliver Squires
Frances Stahr
Guak-Kim Tan
Karin Taylor
Nilay Thakar
Drew Titmarsh
Thi-Bich-Trinh Tran
Nguyen Tran Thi Dat
Nghia Truong Phuoc
Xuan Truong
Jennifer Turner
Dipti Vijayan
David Wang
Kewei Wang
David Wibowo
Thomas Williams
Xiao Xia Yan
Jie Yang
Tianyu Yang
Meihua Yu
Bi Yun Zeng
Hongwei Zhang
Jun Zhang
Yao Zheng
Ruifeng Zhou
Yian Zhu

*List includes graduating students and those in a UQ RHD program undertaken at AIBN during 2011.

# SENIOR RESEARCHERS



# Next-generation technologies for protein research

Professor Kirill Alexandrov's research group is developing new methods for rapid in vitro synthesis of proteins and analysis of their structure and function.

Advances in life sciences and biotechnology are driven by an ability to replicate the building blocks of life in vitro, modify them, and use them in academic and industrial applications. Much biotechnological progress in the past 40 years has stemmed from advances in analysis and synthesis technologies for DNA and proteins. However, while orders-of-magnitude cost reduction was achieved in DNA sequencing and synthesis, the protein technologies have changed comparatively little.

Professor Alexandrov's research group is focusing on filling this technological gap. The group has developed a novel cell-free protein expression system based on protozoan *Leishmania tarentolae*. It has demonstrated that, using this technology, large sets of genes can be converted into proteins within hours. Group researchers combined the technology with single molecule spectroscopy to quantitatively analyse protein:protein interactions in multiprotein assemblies. The approach has been used to study multi sub-unit complexes controlling membrane transport in eukaryotic cells.

Professor Alexandrov has research projects in:

- developing high-yield cell-free protein expression system based on *Leishmania tarentola*;
- single molecule quantitative analysis of protein:protein protein:small molecule interactions using in vitro expressed proteins; and
- *in vitro* reconstitution and structural analysis of multiprotein complexes.

**Key publications in the past five years:**

Kovtun O, Mureev S, Jung W, Kubala MH, Johnston W, Alexandrov K. (2011) Leishmania cell-free protein expression system. *Methods* 55(1), 58-64.

Kovtun O, Mureev S, Johnston W, Alexandrov K. (2010) Towards the construction of expressed proteomes using a *Leishmania tarentolae* based cell-free expression system. *PLOS One* 5, e14388.

Mureev S, Kovtun O, Nguyen UTT, Alexandrov K. (2009) Species-independent translational leaders enable the rapid development of novel cell-free expression systems. *Nature Biotechnology* 27, 747-752.

* Joint appointment with UQ's Institute for Molecular Biosciences.

## PROFESSOR KIRILL ALEXANDROV

ARC FUTURE FELLOW AND GROUP LEADER

# ASSOCIATE PROFESSOR IDRISS BLAKEY

ARC FUTURE FELLOW AND
ASSOCIATE GROUP LEADER

## Functional polymers for value-added applications

Associate Professor Idriss Blakey's research interests span the synthesis of functional polymeric materials and nanomaterials; and advanced characterisation of materials and surfaces.

Associate Professor Blakey and his team have key strengths in bringing together these two areas by developing a fundamental understanding of the structure-property relationships for polymers and polymer-based nanomaterials. That understanding enables the design and synthesis of improved materials for different applications, including biomedical imaging, sensors, photolithography and drug delivery.

The team and key collaborators cover many disciplines, including polymer physical chemistry, synthetic chemistry, pharmacy, biomaterials, spectroscopy and oncology.

Achievements include:

- initiating an ARC-funded program to develop multimodal biomedical imaging agents;
- publishing research findings in high-impact, high-ranking journals;
- maintaining strong links with the semiconductor industry, such as with Intel Corp and Sematech (an international consortium of semiconductor companies), and developing links with Dow Chemical Company; and
- being awarded an ARC Future Fellowship.

Active research projects include:

- smart contrast agents for enhancing performance of magnetic resonance imaging;
- high-performance polymers for computer chip manufacture;
- self-assembly of hybrid nanoparticles for biosensors;
- biodegradable polymers for drug delivery; and
- modification of polymer surfaces.

**Key publications in the past five years:**


Munnemann K, Kolzer M, Blakey I, Whittaker AK, Thurecht KJ. (2012) Hyperbranched polymers for molecular imaging: designing polymers for parahydrogen induced polarisation (PHIP). *Chemical Communications* 48(10), 1583-1585.

Blakey I, Merican Z, Rintoul L, Chuang Y-M, Jack KS, Micallef AS. (2012) Interactions of iodoperfluorobenzene compounds with gold nanoparticles. *Physical Chemistry Chemical Physics* 14(10), 3604-3611.

Lawrie KJ, Blakey I, Blinco JP, Cheng HH, Gronheid R, Jack KS, Pollentier I, Leeson MJ, Younkin TR, Whittaker AK. (2011) Chain scission resists for extreme ultraviolet lithography based on high-performance polysulfone-containing polymers. *Journal of Materials Chemistry* 21, 5629-5637.

Blakey I, Yu A, Howdle SM, Whittaker AK, Thurecht KJ. (2011) Controlled polymerisation of lactide using an organo-catalyst in supercritical carbon dioxide. *Green Chemistry* 13(8), 2032-2037 (cover article).

Yu A, Liu H, Blinco JP, Jack K S, Leeson M, Younkin TR, Whittaker AK, Blakey I. (2010) Patterning of tailored polycarbonate-based non-chemically-amplified resists using extreme ultraviolet lithography. *Macromolecular Rapid Communications* 31(16), 1449-1455.

Thurecht KJ, Blakey I, Peng H, Squires O, Hsu S, Alexander C, Whittaker AK. (2010) Functional hyperbranched polymers: Towards targeted *in vivo* $^{19}$F magnetic resonance imaging using designed macromolecules. *Journal of the American Chemical Society* 132(15), 5336-5337.

Blakey I, Thurecht KJ, Whittaker AK. (2010) High-pressure real-time $^{129}$Xe NMR: Monitoring of surfactant conformation during the self-assembly of reverse micelles in supercritical carbon dioxide. *Chemical Communications* 46(16), 2850-2852.

Merican Z, Schiller TL, Hawker CJ, Fredericks PM, Blakey I. (2007) Self-assembly and encoding of polymer-stabilised gold nanoparticles with surface-enhanced Raman reporter molecules. *Langmuir* 23(21), 10539-10545.

Blakey I, George GA, Hill DJT, Liu H, Rasoul F, Rintoul L, Zimmerman P, Whittaker AK. (2007) Mechanism of 157 nm Photodegradation of Poly[4,5-difluoro-2,2- bis(trifluoromethyl)-1,3-dioxole-co-tetrafluoroethylene] (Teflon AF). *Macromolecules* 40(25), 8954-8961.

# PROFESSOR JUSTIN COOPER-WHITE

GROUP LEADER

## Smart surfaces, scaffolds and diagnostic microdevices for stem cell expansion, tissue engineering and early disease detection

Professor Justin Cooper-White and his research group are focused on developing novel solutions for repairing damaged or diseased tissues using regenerative medicine principles and early disease detection using point-of-care devices.

The research group designs and develops complex, polymer-based structures and devices tailored for investigation and manipulation of biological systems and, in particular, to invoke control over stem cell behaviours and tissue genesis.

Projects include investigations into engineering surfaces for stem cell attachment and phenotype control; tailored polymeric scaffolds for drug delivery, cell delivery and stem cell-based tissue engineering; cell-based diagnostic microdevices for mapping cellular microenvironments and drug discovery and screening; and microfluidic devices for manufacturing functional microparticles and early disease detection.

Professor Cooper-White's challenge in developing instructive surfaces and scaffolds is to encourage growth and appropriate behaviours from primary cells and multipotent and pluripotent stem cells, and then encourage the generation of functional tissue in an appropriate time frame from those cells, while also breaking down safely in the human body once the damaged or diseased area has been repaired.

His research group's work in diagnostics is split into two areas. The first is about developing novel point-of-care devices that allow rapid and accurate detection of biomarkers of disease from biological fluids such as saliva. The second is about developing novel cell-based devices that allow a patient's own cells to be cultured and efficiently differentiated into desired tissue end points (for example, cardiac muscle tissue) and using these cells and tissues for rapid screening of drugs for more personalised medicine formulations. The work also aims to discover new drug targets for diseases such as cardiovascular disease.

**Key publications in the past five years:**


Tan GK, Dinnes DLM, Butler LN, Cooper-White JJ. (2010) Interactions between meniscal cells and a self assembled biomimetic surface composed of hyaluronic acid, chitosan and meniscal extracellular matrix molecules. *Biomaterials* 31(23), 6104-6118.

Hudson JE, Mills RJ, Frith JE, Brooke G, Jaramillo-Ferrada P, Wolvetang EJ, Cooper-White JJ. (2011) A defined medium and substrate for expansion of human mesenchymal stromal cell progenitors that enriches for osteo and chondrogenic precursors. *Stem Cells and Development* 20(1), 77-87.

Tan G-K, Dinnes DLM, Myers PT, Cooper-White JJ. (2011) Effects of biomimetic surfaces and oxygen tension on redifferentiation of passaged human fibrochondrocytes in 2D and 3D cultures. *Biomaterials* 32(24), 5600-5614.

Cameron AR, Frith JE, Cooper-White JJ. (2011) The influence of substrate creep on mesenchymal stem cell behaviour and phenotype. *Biomaterials* 32(26), 5979-5993.

Hudson JE, Brooke G, Blair C, Wolvetang EJ, Cooper-White JJ. (2011) Development of myocardial constructs using modulus-matched acrylated polypropylene glycol triol substrate and different nonmyocyte cell populations. *Tissue Engineering - Part A* 17(17-18), 2279-2289.

Chau LT, Rolfe BE, Cooper-White JJ. (2011) A microdevice for the creation of patent, three-dimensional endothelial cell-based microcirculatory networks. *Biomicrofluidics* 5(3), art. no. 034115.

Mills RJ, Frith JE, Hudson JE, Cooper-White JJ. (2011) Effect of geometric challenges on cell migration. *Tissue Engineering - Part C: Methods* 17(10), 999-1010.

Titmarsh D, Hidalgo A, Turner J, Wolvetang EJ, Cooper-White JJ. (2011) Optimisation of flow rate for expansion of human embryonic stem cells in perfusion microbioreactors. *Biotechnology and Bioengineering* 108(12), 2894-2904.

Hudson JE, Titmarsh DM, Hidalgo A, Wolvetang EJ, Cooper-White JJ, (2011) Primitive cardiac cells from human embryonic stem cells. *Stem Cells & Dev*. 2011 Nov 9 (Epub ahead of print).


# Peptide surfactants and peptide hydrogels

## DR ANNETTE DEXTER

ARC FUTURE FELLOW AND
ASSOCIATE GROUP LEADER

Dr Annette Dexter's research interests span the areas of control of oil-water mixtures and peptide hydrogels.

Controlling stability in oil-water mixtures (emulsions) principally involves designing and testing peptide surfactants that can stabilise emulsions in high salt, including sea water and blood serum, with applications in:

- drug delivery;
- industrial fluids; and
- enhanced oil recovery.

Separately, Dr Dexter has demonstrated that specific ion effects can be used to control the stability of emulsions formed with conventional, non-peptide surfactants, with potential benefits in waste water treatment and disposal of industrial emulsions.

Dr Dexter interacts closely with the AIBN start-up company Pepfactants Pty Ltd, of which she is a founding co-inventor, in developing applications for designed peptides as green surfactants. In 2010, that involved sponsored research for a multinational household and personal care company on the use of designed peptides as cleaning agents. A current trial project is addressing the incorporation of peptides as functional surfactants in industrial lubricants.

Work on peptide hydrogels similarly involves the design of new peptides, in this case with the aim of forming soft supports for living cells, potentially leading to non-toxic injectable implants for new tissue generation, for example in repairing eye or spinal cord. An exploratory project is also in progress, jointly with the University of Western Australia, to use the peptide gels in burn healing.

Dr Dexter has successfully:

- filed two Australian provisional patents on emulsion stability control and formation of salt-resistant peptide emulsions;
- demonstrated pH-controlled assembly of an elastic hydrogel using a single designed helical peptide; and
- demonstrated the successful design of heat-resistant, digestion-resistant mini-proteins for low-cost bioproduction of peptide surfactants.

Dr Dexter has research projects in:

- peptide surfactants for reversible control of foams and emulsions;
- biological production of peptide concatemers;
- specific ion effects in self-assembly and colloid stability; and
- peptide hydrogels for tissue repair and drug delivery.

**Key publications in the past five years:**


Fletcher NL, Lockett CV, Dexter AF. (2011) A pH-responsive coiled-coil peptide hydrogel. *Soft Matter* 7, 10210-10218.

Dexter AF. (2010) Interfacial and emulsifying properties of designed -strand peptides. *Langmuir* 26(23), 17997-18007.

Malcolm AS, Dexter AF, Katakdhond JA, Karakashev SI, Nguyen AV, Middelberg APJ. (2009) Tuneable control of interfacial rheology and emulsion coalescence. *ChemPhysChem* 10(5), 778-781.

Middelberg APJ, He L, Dexter AF, Shen HH, Thomas RK. (2008) The interfacial structure and Young's modulus of peptide films having switchable mechanical properties. *Journal of the Royal Society Interface* 5(18), 47-54.

Dexter AF, Middelberg APJ. (2007) Switchable peptide surfactants with designed metal binding capacity. *Journal of Physical Chemistry C* 111(28), 10484-10492.

Dexter AF, Malcolm AS, Middelberg APJ. (2006) Reversible active switching of the mechanical properties of a peptide film at a fluid-fluid interface. *Nature Materials* 5(6), 502-506.

# DR KRASSEN DIMITROV

GROUP LEADER

## Single-molecule technologies for diagnostics

Dr Krassen Dimitrov's research group is developing new diagnostic technologies involving single-molecule nanolabels for use in accurate and sensitive determination of marker molecules associated with disease and found in small amounts of biological samples.

The nanolabels are translocated with magnetic forces through a nanometer-sized electronic sensor, for digital readout. Dr Dimitrov's group is developing the technology with a specific focus on diagnostics for tropical infectious diseases such as malaria and dengue fever.

Applications include biomedical research, forensics, agribusiness, and biosurveillance.

### Key publications in the past five years:


Thomson DAC, Dimitrov K, Cooper MA. (2011) Amplification free detection of Herpes Simplex Virus DNA. *Analyst* 136, 1599-1607.

Qin G, Darain F, Hui W, Dimitrov K. (2011) Surface modification of permalloy (Ni80Fe20) nanoparticles for biomedical applications. *J Nanoparticle Res* 13(1), 45-51.

Rahaie M, Ghai R, Babic B, Dimitrov, K. (2010) Synthesis and characterisation of DNA-based micro- and nanodumbbell structures. *J Bionanosci* 3(2) 73-79.

Babic B, Ghai R, Dimitrov K. (2007) Induced movement of the magnetic beads and DNA-based dumbbell in a micro fluidic channel in *Proceedings of SPIE: BioMEMS and Nanotechnology III* ( Nicolau DV, Abbott D, Kalantar-Zadeh K, Matteo TD, Bezrukov SM, Eds).

Babic B, Ghai R, Dimitrov K. (2008) Magnetophoresis of flexible DNA-based dumbbell structures. *Applied Physics Letters* 92(5). Article number 053910.

Geiss GK, Bumgarner RE, Birditt B, Dahl T, Dowidar N, Dunaway DL, Fell HP, Ferree S, George RD, Grogan T, James JJ, Maysuria M, Mitton JD, Oliveri P, Osborn JL, Peng T, Ratcliffe AL, Webster P J, Davidson EH, Hood L, Dimitrov K. (2008) Direct multiplexed measurement of gene expression with colour-coded probe pairs. *Nature Biotechnology* 26(3), 317-325.

Wang H, Padmanabhan H, Dimitrov K. (2010) Controlled assembling of biomolecule-functionalised magnetic nanoparticles. *ICBB 2010: International Conference on Biotechnology and Bioengineering.* Tokyo, Japan, May 26-28, 2010.


### Awards and prizes:

Nominated for the 2010 ENI Award for Energy Research

# Materials development and characterisation

The main body of Professor John Drennan's research relates to understanding the relationship between microstructural characterisation and the physical property of materials. A central focus involves developing improvements in the conduction of oxygen ions in materials, which has application in solid oxide fuel cells.

Tight microstructural control at the atomic level is a key factor in developing a new range of materials that have longer operating life and better properties.

The expertise of Professor Drennan and his research group in this area has led to projects involving other refractory systems.

The group is turning its attention to materials for extreme environments and is developing a novel system for protecting critical components in hypersonic scram jets – a serious challenge for materials science.

The group is examining the development of zinc oxide (ZnO) soaps in artists' paints. This phenomenon can be devastating to an artwork, resulting in the formation of large, unsightly protrusions, which can crack and severely damage painting. Researchers are examining, through very detailed microstructutral analysis, the mechanism responsible for ZnO soaps.

Funded through an Australian Research Council Industry Linkage Project with major galleries across Australia and several in the US and Asia, the project is examining the first stages of deterioration of ZnO particles at the atomic level with a view to developing curatorial protocols to minimise damage.

**Key publications in past five years:**


Yuan P, Liu N, Zhao LZ, Zhou XF, Zhou L, Auchterlonie GJ, Yao XD, Drennan J, Lu GQ, Zou J, Yu CZ. (2008) Solving complex concentric circular mesostructures by using electron tomography. *Angewandte Chemie-International Edition* 47(35), 6670-6673.

Yuan P, Zhou XF, Wang HN, Liu NA, Hu YF, Auchterlonie GJ, Drennan J, Yao XD, Lu GQ, Zou J, Yu CZ. (2009) Electron-tomography determination of the packing structure of macroporous ordered siliceous foams assembled from vesicles. *Small* 5(3), 377-382.

Knibbe R, Auchterlonie GJ, Mori T, Lashtabeg A, Drennan J. (2010) Glass-phase movement in yttria-stabilised zirconia/alumina composites. *Journal of the American Ceramic Society* 93(5), 1494-1500.

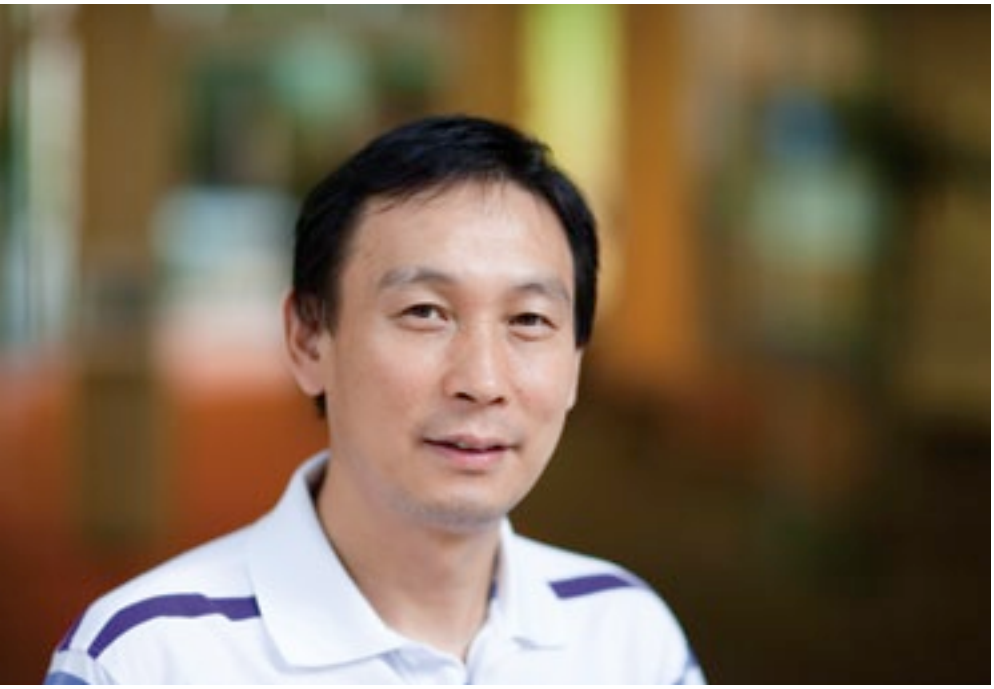
Li Z P, Mori T, Auchterlonie G J, Zou J, Drennan J. (2011) Two types of diffusion at the cathode/electrolyte interface in IT-SOFCs. *Journal of Solid State Chemistry* 184(9), 2458-2461.

Ou DR, Mori T, Togasaki H, Takahashi M, Ye FE, Drennan J. (2011) Microstructural and metal-support interactions of the Pt-$CeO_2$/C catalysts for direct methanol fuel cell application. *Langmuir* 27(7), 3859-3866.


## PROFESSOR JOHN DRENNAN

GROUP LEADER

# Theoretical modelling for smarter nanoelectronic devices and energy storage



## ASSOCIATE PROFESSOR AIJUN DU

ARC QEII FELLOW AND
ASSOCIATE GROUP LEADER

Associate Professor Aijun Du has research interests in clean energy, environmental science and nanoelectronics.

His research focuses on tackling band-gap problems, charge/spin transport issues, hydrogen storage and $CO_2$ capture in nanoscale materials. The aim is to develop improved devices for nano-electronics, spintronics, energy storage and conversion. As well as aiming to develop truly smaller, faster and smarter electronics materials, there is the potential for the research to open a new knowledge-based electronics industry and create emerging energy technologies in Australia.

Associate Professor Du has strong interactions with the chemical engineering, environmental science, computational chemistry and condensed matter physics disciplines.

Some key research achievements in 2011 included predicting that new experimentally-synthesised graphydine possess a direct gap of 1.2 eV similar to silicon. This finding highlights a new avenue to overcome the bandgap problem of graphene in building novel carbon based nanoelectronics.

The research also included predicting that inhomogeneous planar substrate (g-C3N4) opens a 70 meV gap in g-C3N4 supported graphene, a feature that can potentially overcome the graphene's band-gap hurdle in constructing field effect transistors.

Associate Professor Du also predicted strong electronic coupling at the graphene/titania interface, leading to enhanced visible light response in the novel nanohybrid.

The Computational Bio and Nanotechnology group has research projects in:

- nanomaterials for hydrogen storage;
- nanomaterials for $CO_2$ capture and activation;
- materials for nanoelectronics and spintronics;
- materials for catalysis applications; and
- advanced theoretical modelling methods.

**Key publications in the past five years:**


Du AJ, Sanvito S, Li Z, Wang DW, Jiao Y, Liao T, Sun Q, Ng YH, Zhu ZH, Amal R, Smith SC. (2012) Hybrid Graphene and Graphitic Carbon Nitride Nanocomposite: Interfacial Charge Transfer, Gap Opening and Enhanced Visible Light Response. *J Amer Chem Soc* 134, 4393.

Zheng Y, Jiao Y, Chen J, Liu J, Du AJ, Liang J, Zhu ZH, Jaroniec M, Lu GQ, Qiao SZ. (2011) Highly Efficient Oxygen Reduction on Metal-Free Catalyst. *J Amer Chem Soc* 133, 20116.

Du AJ, Zhu ZH, Smith SC. (2010) Multifunctional Porous Graphene for Nanoelectronics and Hydrogen Storage: New Properties Revealed by First Principle Calculations. *J Amer Chem Soc* 132, 2876.

Du AJ, Chen Y, Zhu Z, Lu M, Smith SC. (2009) C-BN Single Walled Nanotubes from Hybrid Connection of BN/C Nanoribbons: Prediction by ab initio density functional calculations. *J Amer Chem Soc* 131, 1682.

Du AJ, Chen Y, Zhu ZH, Amal R, Lu M, Smith SC. (2009) Dots versus Antidots: Computational Exploration of Structure, Magnetism and Half-metallicity in Boron-Nitride Nanostructures. *J Amer Chem Soc* 131, 17354.

Du AJ, Smith SC, Lu M. (2007) Formation of Single Walled Carbon Nanotube via the Interaction of Graphene Nanoribbons: ab initio Density Functional Calculations. *Nano Letters* 7, 3349.

Yao X, Wu CZ, Du AJ, Zou J, He Y, Zhu ZH, Wang P, Cheng HM, Smith SC, Lu M. (2007) Metallic and Carbon Nanotubes-Catalysed Coupling of Hydrogenation in Magnesium. *J Amer Chem Soc* 129, 15650.

Du AJ, Smith SC, Yao XD, Lu M. (2007) Hydrogen Spill-over mechanism on a Pd doped Mg surface as revealed by ab initio Density Functional Theory Method. *J Amer Chem Soc* 129, 10201.

# Bioengineering of mammalian cell protein expression and stem cell systems

## PROFESSOR PETER GRAY

AIBN DIRECTOR AND GROUP LEADER

Large complex proteins that make up the majority of biologics approved for human therapy can only be produced in mammalian cell expression systems. Such systems can carry out complex assembly and post-translational modification for a molecule's biological activity.

Mammalian cell expression systems use Chinese hamster ovary (CHO) cells as the production host. Although CHO cells have been widely used to produce human therapeutics, there are still opportunities to improve them as production hosts. Those opportunities include improving properties of the host CHO cell line's ability to grow at high rates and to high cell densities in bioreactor systems, and the ability to rapidly select clones producing the protein of interest at high rates.

Professor Peter Gray's research aims to reduce bottlenecks present when CHO cells are used to produce biologics and includes:

- developing a CHO cell transient protein expression system, allowing researchers to produce, within a few days of obtaining DNA coding for the protein of interest, the desired protein for characterisation and testing of a new potential biologic. The transient CHO system developed, Epi-CHO, makes use of episomal plasmid replication and plasmid segregation on cell division to allow the protein to be produced over several weeks, and has resulted in the highest productivity reported for a CHO transient system;
- high-throughput approaches that allow the rapid selection of clones which stably express high levels of the desired biologic;
- developing and patenting a FACS-based system capable of rapidly scanning pools of cells at up to 70,000 cells per second, and select those few cells from the population that are expressing high levels of the desired biologic; and
- using modern 'omics' approaches to gain better understanding of cellular metabolism to allow development of host cell lines with improved bioreactor performance and improved specific productivity of the desired protein.

The research approaches, which have been used to gain a greater understanding of mammalian cell processes, are now being applied to the development of bioprocesses based on embryonic stem cells.

With stem cells the challenge is to accurately define the physical and chemical environment that allows the controlled proliferation and subsequent differentiation of the cells, and then translate these conditions into processes that can be scaled up to produce the number of cells required for clinical testing.

### Key publications in the past five years:


Codamo J, Munro TP, Hughes BS, Song M, Gray PP. (2011) Enhanced CHO cell-based transient gene expression with the Epi-CHO expression system. *Molecular Biotechnology* 48(2), 109-115.

Prowse ABJ, Chong F, Gray PP, Munro TP. (2011) Stem cell integrins: Implications for ex-vivo culture and cellular therapies. *Stem Cell Research* 6(1), 1-12.

Dietmair S, Timmins NE, Gray PP, Nielsen LK, Kromer JO. (2010) Towards Quantitative metabolomics of mammalian cells: Development of a metabolite extraction protocol. *Analytical Biochemistry* 404(2), 155-164.

Prowse ABJ, Doran MR, Cooper-White JJ, Chong F, Munro TR, Fitzpatrick J, Chung TL, Haylock DN, Gray PP, Wolvetang EJ. (2010) Long-term culture of human embryonic stem cells on recombinant vitronectin in ascorbate free media. *Biomaterials* 31(32), 8281-8288.

Jones ML, Seldon T, Smede M, Linville A, Chin DY, Barnard R, Mahler SM, Munster D, Hart D, Gray PP, Munro TP. (2010) A method for the rapid, ligation-independent reformatting of recombinant monoclonal antibodies. *Journal of Immunological Methods* 354(1-2), 85-90.

Pilbrough W, Munro TP, Gray PP. (2009) Intraclonal Protein Expression Heterogeneity in Recombinant CHO Cells. *PLoS ONE* 4(12), e8432. doi: 10.1371/journal.pone.0008432.

Ladewig K, Niebert M, Xu ZP, Gray PP, Lu GQ. (2009): Efficient siRNA delivery to mammalian cells using layered double hydroxide nanoparticles. *Biomaterials* 31(7), 1821-1829.

Prowse AE, Wolvetang E, Gray PP. (2009) A rapid, cost-effective method for counting human embryonic stem cell numbers as clumps. *Biotechniques* 47(1), 599-606.

Vari F, Munster DJ, Hsu JL, Rossetti TR, Mahler SM, Gray PP, Turtle CJ, Prue RL, Hart DNJ. (2008) Practical blood dendritic cell vaccination for immunotherapy of multiple myeloma. *British Journal of Haematology* 143(3), 374-377.

Gray PP, Pilbrough W, Codamo G, Munro TP. (2008) Speeding up the production of recombinant proteins by CHO cells. *J Biotechnol* 136(S1), S8.

Xu ZP, Niebert M, Porazik K, Walker TL, Cooper HM, Middelberg APJ, Gray PP, Bartlett PF, Lu GQM. (2008) Subcellular compartment targeting of layered double hydroxide nanoparticles. *J Control Release* 130(1), 86-94.

# PROFESSOR PETER HALLEY

GROUP LEADER

## Biofluids characterisation and biopolymer processing

Professor Peter Halley's research group is investigating two major areas:

- biofluids characterisation; and
- biopolymer processing.

Biofluids characterisation incorporates novel material and flow characterisation (rheology) for a variety of projects, including:

- design of texture-modified foods for aged care;
- novel techniques for predicting swallowing; and
- novel coatings for tablets and films.

The group has strong interactions with the chemical engineering, pharmacy, biochemistry, food science and speech pathology disciplines, and links with various hospitals.

The research into biopolymer processing focuses on understanding and optimising the processability of a wide range of biopolymers, including starch; lignin; polyhydroxyalkanoates (PHA); polylactic acid (PLA); and biopolymer nanocomposites, comprising starch, polyurethane and polyester nanocomposites. The work aims to develop smart, functional biopolymer systems for biomedical, drug delivery and high-value industrial applications.

The group has successfully:

- initiated three new projects investigating water resistant starch, texture modified foods and PHA polymers from waste;
- published and patented work on biopolymers and degradable polymers; and
- commercialised new degradable polymer products.

The group has research projects in:

- novel texture modified foods for aged care;
- water resistant starch polymers for smart food packaging applications;
- PHA polymers from waste streams;
- novel starch/ionic liquid nanomaterials;
- rheology of TPU nanocomposites; and
- supercritical $CO_2$ processing of starch nanocomposites.

**Key publications in the past five years:**


Halley PJ, Dorgan JR. (2011) Next-generation biopolymers: Advanced functionality and improved sustainability. *MRS Bulletin* 36(9), 687-693.

Liu WC, Halley PJ, Gilbert RG. (2010) Mechanism of degradation of starch, a highly branched polymer, during extrusion. *Macromolecules* 43(6), 2855-2864.

Halley PJ, George G. (2009) *Chemorheology; from fundamentals to reactive processing,* Cambridge University Press, Cambridge, UK.

Zhao RX, Torley P, Halley PJ. (2008) Emerging biodegradable materials: starch- and protein-based bio-nanocomposites. *Journal of Materials Science* 43(9), 3058-3071.

Chaléat CM, Halley PJ, Truss RW. (2008) Properties of a plasticised starch blend. Part 1: Influence of moisture content on fracture properties. *Carbohydrate Polymers* 71(4), 535-543.


**Awards and prizes:**

2011 CRC Polymers Chairman's Commercialisation Award

# Targeting the skin for needle-free, minimally-invasive vaccine delivery and diagnostics for disease

Professor Mark Kendall's research group focuses on physical methods for delivering biomolecules and stimuli to key immune response-inducing cells located in the skin; and extracting important biomolecules for diagnostics purposes.

The ultimate goal of the research is to dramatically improve the cost and efficiency of vaccination and treatment of major diseases such as malaria and influenza.

To achieve this goal, the group is:

- developing needle-free gene and drug delivery and extraction technologies to and from the skin;
- investigating micro-nanoprojection array patch (Nanopatch) technology;
- measuring the key biological and mechanical properties of skin; and
- assessing clinical application.

The multidisciplinary research spans biomedical engineering (fluid mechanics; micro-nanofabrication; solid mechanics), diagnostics (multi-photon microscopy), dermatology and vaccinology.

Professor Kendall's group has research projects covering:

- micro-nanoprojection patches for minimally-invasive, targeted delivery of genes and drugs to skin cells;
- micro-nanoprojection patches for targeted gene and drug delivery to the skin and improved DNA vaccines;
- micro-nanoprojection patches for improved sampling in diagnosis of disease;
- multi-photon microscopy for in-vivo imaging following delivery of drugs and vaccines to skin;
- MPM non-invasive imaging of biological interactions following drug delivery with micro-nanoprojection patches;
- measurement of mechanical properties in skin at the cellular and subcellular scale; and
- development of medical devices for clinical use.

Based on the research group's outstanding science and innovation, Professor Kendall co-founded Vaxxas Pty Ltd with $15 million of investment to progress the Nanopatch through clinical testing and to develop it as a medical device for widespread use. It is the most funding raised for an Australian biotechnology or medical devices company.

**Key publications in the past five years:**


Crichton ML, Donose BC, Chen X, Raphael A, Huang H, Kendall MAF. (2011) The viscoelastic, hyperelastic and scale-dependent behaviour of freshly excised individual skin layers. *Biomaterials* 32(20), 4670-4681.

Chen X, Fernando GJP, Raphael AP, Yukiko SR, Fairmaid EJ, Primero CA, Frazer IH, Brown LE, Kendall MAF. (2011) Rapid kinetics to peak serum antibodies is achieved following influenza vaccination by dry-coated densely packed microprojections to skin. *Journal of Controlled Release,* doi: 10.1016/j.jconrel.2011.10.026.

Chen X, Fernando GJP, Crichton ML, Flaim C, Yukiko SR, Fairmaid EJ, Corbett HJ, Primiero CA, Ansaldo AB, Frazer IH, Brown LE, Kendall MAF. (2011) Improving the reach of vaccines to low-resource regions, with a needle-free vaccine delivery device and long-term thermostabilisation. *Journal of Controlled Release* 152(3), 349-355.

Chen X, Corbett HJ, Yukiko SR, Raphael A, Fernando GJP, Fairmaid EJ, Prow TW, Brown LE, Kendall MAF. (2010) Site-selectively coated, densely-packed microprojection array patches for targeted delivery of vaccines to skin. *Advanced Functional Materials* 21(3), 464-473.

Corrie S, Fernando GJP, Crichton ML, Brunck MEG, Anderson CP, Kendall MAF. (2010) Surface-modified microprojection arrays for intradermal biomarker capture, with low non-specific protein binding. *Lab on a Chip* 10, 2655-2658.

Corbett HJ, Fernando GJP, Chen X, Frazer IH, Kendall MAF. (2010) Skin vaccination against cervical cancer associated human papillomavirus with a novel micro-projection array in a mouse model, *PloS One* 5(10), e13460.


## PROFESSOR MARK KENDALL

ARC FUTURE FELLOW AND GROUP LEADER


Prow TP, Chen X, Prow NA, Fernando GJP, Tan CSE, Raphael AP, Chang D, Ruutu MP, Jenkins DWK, Pyke A, Crichton ML, Raphaelli K, Goh LYH, Frazer IH, Roberts MS, Gardner J, Khromykh AA, Suhrbier A, Hall RA, Kendall MAF. (2010) Nanopatch-Targeted Skin Vaccination against West Nile Virus and Chikungunya Virus in Mice. *Small* 6(16), 1776-1784 (front cover).

Fernando GJP, Chen X, Prow TW, Crichton ML, Fairmaid EJ, Roberts MS, Frazer IH, Brown LE, Kendall MAF. (2010) Potent Immunity to Low Doses of Influenza Vaccine by Probabilistic Guided Micro-Targeted Skin Delivery in a Mouse Model. *PLoS ONE* 5(4), e10266. doi:10.1371/journal.pone.0010266.

Crichton ML, Ansaldo A, Chen X, Prow TW, Fernando GJP, Kendall MAF. (2010) The effect of strain rate on the precision of penetration of short densely-packed microprojection array patches coated with vaccine. *Biomaterials* 31(16), 4562-4572.


**Awards and prizes:**

*The Australian* Innovation Challenge 2011 winner

Australian Museum Eureka Prize winner 2011, Research by an interdisciplinary team

Queensland Clinical Trial Network and Merck's 2010 Translational Research Excellence Commercialisation Award

# PROFESSOR MAX LU

UQ SENIOR DEPUTY VICE-CHANCELLOR AND AIBN GROUP LEADER

## Functional nanomaterials

Professor Max Lu is the Foundation Director and current Research Director of the Australian Research Council Centre of Excellence for Functional Nanomaterials. He is also Senior Deputy Vice-Chancellor at UQ.

Professor Lu and his group are researching the synthesis and molecular engineering of nanomaterials such as inorganic nanoparticles, carbons, nanoporous materials and membranes.

The group is developing many innovative applications of these materials for clean energy and environmental technologies; and biomedical fields.

Specifically, Professor Lu's group has research projects in:

- visible light photocatalysts for solar and hydrogen energy generation and storage;
- nanoparticles and mesoporous carriers for drug and vaccine delivery;
- nanostructured materials for high density supercapacitors and batteries; and
- efficient catalysts and processes for renewable energy.

**Key publications in the past five years:**


Liu J, Yang HQ, Kleitz F, Chen ZG, Yang TY, Strounina E, Lu GQ, Qiao SZ. (2012) Yolk-Shell Hybrid Materials with a Periodic Mesoporous Organosilica Shell: Ideal Nanoreactors for Selective Alcohol Oxidation. *Advanced Functional Materials* 22(3), 591-599.

Gu Z, Rolfe BE, Thomas AC, Campbell JH, Lu GQ, Xu ZP. (2011) Cellular trafficking of low molecular weight heparin incorporated in layered double hydroxide nanoparticles in rat vascular smooth muscle cells. *Biomaterials* 32(29), 7234-7240. Doi: 10.1016/j.biomaterials.2011.05.083

Liu J, Qiao SZ, Liu H, Chen J, Orpe A, Zhao DY, Lu GQ, Lu. (2011) Extension of the Stober Method to the preparation of Monodisperse Resorcinol-Formaldehyde Resin Polymer and Carbon Spheres. *Angewandte Chemie-International Edition* 50(26), 5947-5951. Doi: 10.1002/anie.201102011.

Mukherji A, Marschall R, Tanksale A, Sun CH, Smith SC, Lu GQ, Wang LZ. (2011) N-Doped CsTaWO(6) as a New Photocatalyst for Hydrogen Production from Water Splitting Under Solar Irradiation. *Advanced Functional Materials* 21(1), 126-132. Doi: 10.1002/adfm.201000591

Li Z, Cheng LN, Sun Q, Zhu ZH, Riley MJ, Aljada M, Cheng ZX, Wang XL, Hanson GR, Qiao SZ, Smith SC, Lu GQ. (2010) Diluted Magnetic Semiconductor Nanowires Prepared by the Solution-Liquid-Solid Method. *Angewandte Chemie-International Edition* 49(15), 2777-2781.

Li ZY, Zhu GS, Lu GQ, Qiu SL, Yao XD. (2010) Ammonia Borane Confined by a Metal-Organic Framework for Chemical Hydrogen Storage: Enhancing Kinetics and Eliminating Ammonia. *Journal of the American Chemical Society* 132(5), 1490-1491.

Liu G, Niu P, Sun CH, Smith SC, Chen ZG, Lu GQ, Cheng HM. (2010) Unique Electronic Structure Induced High Photoreactivity of Sulphur-Doped Graphitic C3N4.*Journal of the American Chemical Society* 132(33), 11642-11648.

Liu J, Qiao SZ, Hartono SB, Lu GQ. (2010) Monodisperse Yolk-Shell Nanoparticles with a Hierarchical Porous Structure for Delivery Vehicles and Nanoreactors. *Angewandte Chemie-International Edition* 49(29), 4981-4985.

Chen ZG, Cheng LN, Xu HY, Liu JZ, Zou J, Sekiguchi T, Lu GQ, Cheng HM.(2010) ZnS Branched Architectures as Optoelectronic Devices and Field Emitters. *Advanced Materials* 22(21), 2376-2380.

Yang HG, Liu G, Qiao SZ, Sun CH, Jin YG, Smith SC, Zou J, Cheng HM, Lu GQ.(2009) Solvothermal Synthesis and Photoreactivity of Anatase TiO2 Nanosheets with Dominant {001} Facets. *Journal of the American Chemical Society* 131(11), 4078-4083.

Hulicova-Jurcakova D, Puziy AM, Poddubnaya OI, Suarez-Garcia F, Tascon JMD, Lu GQ. (2009) Highly Stable Performance of Supercapacitors from Phosphorus-Enriched Carbons. *Journal of the American Chemical Society* 131(14), 5026-5027.

Yang HG, Sun CH, Qiao SZ, Zou J, Liu G, Smith SC, Cheng HM, Lu GQ. (2008) Anatase TiO2 single crystals with a large percentage of reactive facets. *Nature* 453(7195), 638-641.

Wang DW, Li F, Liu M, Lu GQ, Cheng HM. (2008) 3D aperiodic hierarchical porous graphitic carbon material for high-rate electrochemical capacitive energy storage. *Angewandte Chemie-International Edition* 47(2), 373-376.


**Awards and prizes:**

China International Science and Technology Cooperation Award, 2011

# Research and development of biologic medicines

The principal theme of Associate Professor Stephen Mahler's research is the discovery and development of biologic medicines.

His research activities include a balanced mix of basic and applied research. As a biotechnologist, he has specialised in applied immunology, proteomics and bioengineering.

Associate Professor Mahler's research includes isolating monoclonal antibodies from large immunoglobulin gene libraries using high throughput selection techniques against selected targets. The targets are associated with cancer, infectious disease and graft versus host disease.

He is also developing antibody fragments and bispecific antibodies for targeting drug delivery vehicles to tumour sites. New antibodies are being isolated against tumour targets using AIBN's immunoglobulin gene libraries. The antibodies are linked to the delivery vehicles, carrying a payload of cytotoxic drugs.

The research is part of a collaboration with EnGeneIC, a Sydney-based company that has developed the novel minicell for drug delivery.

**Key publications in the past five years:**


Mahler SM. (2011) Biologics and biosimilars: emerging technologies driving global opportunity. *J Chem Technol and Biotechnol* 86(7), 893-894.

Pile KD, Graham GG, Mahler SM, Day RO. (2011) Disease-modifying antirheumatic drugs. In *Principles of immunopharmacology (third ed.).* Nijkamp FP, Parnham MJ (Ed.), (pp. 585-619) Basel, Switzerland: Springer.

Munro TP, Mahler SM, Huang EP, Chin DY, Gray PP. (2011) Bridging the gap: Facilities and technologies for development of early stage therapeutic mAb candidates. *mAbs* 3(5), 440-452.

Falconer RJ, Jackson-Matthews D, Mahler SM. (2011) Analytical strategies for assessing comparability of biosimilars. *J Chem Technol and Biotechnol* 86(7), 915-922.

Jones ML, Seldon T, Smede M, Linville A, Chin DY, Barnard R, Mahler SM, Munster D, Hart D, Gray PP, Munro TP. (2010) A method for rapid, ligation-independent reformatting of recombinant monoclonal antibodies. *Journal of Immunological Methods* 354, 85-90.

Matigian N, Abrahamsen G, Sutharsan R, Cook A, Nouwens A, Bellette B, Vitale A, An J, Anderson M, Beckhouse B, Cecil R, Chalk A. Cochrane J, Fan Y, Féron F, McCurdy R, McGrath J, Perry C, Raju J,


# ASSOCIATE PROFESSOR STEPHEN MAHLER


Ravishankar S, Silburn P, Sutherland G, Mahler SM, Mellick G, Wood S, Sue C, Wells C, Mackay-Sim A. (2010) Disease-specific, neurosphere-derived cells as models for brain disorders. *Disease Models and Mechanisms* 3, 785-798.

De Leon EJ, Yuan FF, Pearson H, Marquis C, Mahler SM. (2009) Evidence of heterogeneity in the antibody response against the platelet antigen 3a; recognition of an 11-mer peptide carrying the HPA-3a polymorphic determinant. *Vox Sanguinis* 96, 252-255,

Wang XS, Shao B, Heinecke J, Mahler SM, Stocker R. (2009) Detection of methionine sulfoxide-containing, oxidized apolipoprotein AI in HDL and plasma by ELISA. *J Lipid Research* 50, 586-594.

Marcal H, Wanandy NS, Sanguanchaipaiwong V, Woolnough CE, Lauto A, Mahler SM, Fosterz LJR. (2008) BioPEGylation of polyhydroxyalkanoates: Influence on properties and satellite stem cell cycle. *Biomacromolecules* 9, 2719-2726.

Vari F, Munster DJ, Hsu JL, Rossetti TR, Mahler SM, Gray PP, Turtle, CJ, Prue RL, Hart DNJ. (2008) Practical blood dendritic cell vaccination for immunotherapy of multiple myeloma. *British J Haematology* 143, 374-377.

# PROFESSOR DARREN MARTIN

GROUP LEADER

## Polymer nanocomposites and nanotoxicology

Professor Darren Martin's research focuses on processing and structure-property performance of novel polymeric biomaterials; renewable-based polymers and nanocomposites; and the toxicology of engineered nanoparticles. These interests overlap significantly, with initiatives in progress to investigate the physical and biological performance of polyurethane nanocomposites for biomedical and industrial applications.

Professor Martin is also conducting research linking a better understanding of the molecular and cellular mechanisms associated with nanoparticle toxicology with measurements of industrial exposure and bio-distribution. Professor Martin aims to shift the strong underlying science and engineering taking place in these projects towards consumer products, or medical device component applications. For example, his research group is working on new flexible nanocomposite materials for Cochlear implants and various high-performance engineering applications.

Professor Martin is the Chief Scientific Officer of start-up company TenasiTech, which is commercialising the polyurethane nanocomposite technology.

The Martin research group has projects in:

- thermoplastic polyurethane nano-composites, through TenasiTech Pty Ltd, Cochlear Ltd and Aortech Pty Ltd;
- the toxicology of engineered nano-particles, through ARC and NHMRC funded projects; and
- renewable polymers and composites based on resin from spinifex native grasses – an ARC-funded project.

**Key publications in the past five years:**


Butler MK, Prow TW, Guo YN, Lin LL, Webb RI, Martin DJ. (2011) High pressure freezing/freeze substitution and TEM for the characterisation of metal oxide nanoparticles within sunscreens. *Nanomedicine* (accepted in press December 2011).

Minchin RF, Martin DJ. (2010) Minireview: Nanoparticles for molecular imaging – an overview. *Endocrinology* 151(2), 474-481.

Musumeci AW, Schiller TL, Xu ZP, Minchin RF, Martin DJ, Smith SV. (2010) Synthesis and characterisation of dual radiolabeled layered double hydroxide nanoparticles for use in in vitro and in vivo nanotoxicology studies. *Journal of Physical Chemistry C* 114(2), 734-740.

Musumeci AW, Gosztola D, Schiller TL, Dimitrijevic NM, Mujica V, Martin DJ. (2009) SERS of semiconducting nanoparticles (TiO2 hybrid composites). *JACS Communication* 131(17), 6040-6041.

Smart S, Cassady A, Lu GQ, Martin D. (2006) The biocompatibility of carbon nanotubes: a review. *Carbon* 44, 1034-1047 (Special issue on toxicology of carbon nanomaterials).


# PROFESSOR ANTON MIDDELBERG

QUEENSLAND SMART FUTURES PREMIER'S FELLOW,
DEPUTY DIRECTOR AND GROUP LEADER

## Biomolecular engineering

Professor Anton Middelberg and his research group focuses on the design and processing of engineered proteins and peptides to develop new functional products and new manufacturing methods.

The work brings together bioengineering and nanotechnology, with application in vaccines and biopharmaceuticals and green processing.

Professor Middelberg and his group address global opportunities such as:

- developing new vaccine technologies that change the way we combat infectious and chronic diseases, including influenza and arthritis;
- understanding how biopharmaceuticals behave in solution and manufacturing processes, to devise new processes to recover products from complex suspensions; and
- using bio-inspired approaches to deliver new manufactured materials, such as customised surfactants, self-assembling peptides and nanostructured materials, from sustainable resources.

Professor Middelberg's research combines knowledge from chemical engineering and the physical and life sciences.

The group has research projects in:

- protein and nanoparticle technology for new vaccines;
- the aggregation of virus-like particle vaccines;
- vaccine nano-emulsions for dendritic cell targeting;
- recovery and modification of biopharmaceuticals;
- design and bioprocessing of sustainable biosurfactants including pepfactants; and
- nanomaterial manufacture through biomolecular templating.

**Key publications in the past five years:**


Middelberg APJ, Rivera-Hernandez T, Wibowo N, Lua LHL, Fan YY, Magor G, Chang C, Chuan YP, Good MF, Batzloff MR. (2011) A microbial platform for rapid and low-cost virus-like particle and capsomere vaccines. *Vaccine* 29(41), 7154-7162.

Middelberg APJ, Dimitijev-Dwyer M. (2011) A designed biosurfactant protein for switchable foam control. *ChemPhysChem*, 12(8), 1426-1429.

Zhao CX, He LZ, Qiao SZ, Middelberg APJ. (2011) Nanoparticle synthesis in microreactors. *Chem Eng Sci* 66(7), 1463-1479.

Liew MWO, Rajendran A, Middelberg APJ. (2010) Microbial production of virus-like particle vaccine protein at gram-per-litre levels. *J Biotechnol* 150(2), 224-231.

Ding Y, Chuan YP, He L, Middelberg APJ. (2010) Modelling the competition between aggregation and self-assembly during virus-like particle processing. *Biotechnol Bioeng* 107(3), 550-560. (front cover)


**Awards, prizes and appointments:**

Awarded 2010 Queensland Smart Futures Premier's Fellow.

Editor-in-Chief, *Chemical Engineering Science*

# PROFESSOR MICHAEL MONTEIRO

ARC FUTURE FELLOW
AND GROUP LEADER

## Designer polymer nanoreactors for use in biomedical applications and environmentally friendly organic reactions

Professor Michael Monteiro's research focuses on synthesing complex polymer architectures.

These tailor-made polymer architectures have the capacity to self-assemble into nanostructures such as rods, vesicles, spheres or donuts. The nanostructure confers important characteristics that can be applied in drug delivery and tissue regeneration.

For example, a new, self-adjuvanting vaccine has been created through the self-assembly of a dendrimer consisting of epitopes covalently bound to a polymeric core. Incorporating certain polymers into the structures is useful for siRNA delivery.

Professor Monteiro and his research group have also demonstrated that highly dense nanoparticles can denature specific serum proteins, which induces the activation of certain biochemical pathways.

Professor Monteiro's research group has designed custom-made polymer architectures for use as nanoreactors. The group has developed a completely new way of conducting polymerisations in water by creating the desired nanoenvironment using custom made nanoreactors.

Increased demand for environmentally-friendly and economically-competitive polymeric materials for use in coatings, biomedical and electronic industries has driven this new water-based methodology.

The methodology will expand the range of structures available to materials scientists.

The group has projects in the areas of:

- nanoreactors for polymer and organic reactions in water;
- customised nanostructures for drug and vaccine delivery; and
- nanotoxicology of designer nanostructures.

**Key publications in the past 12 months:**


Bell CA, Bernhardt PV, Monteiro MJ. (2011) A rapid electrochemical method for determining rate coefficients for copper-catalysed polymerisations. *Journal of the American Chemical Society* 133(31), 11944-11947.

Bell CA, Jia ZF, Kulis J, Monteiro MJ. (2011) Modulating Two Copper(I)-Catalysed Orthogonal "Click" Reactions for the One-Pot Synthesis of Highly Branched Polymer Architectures at 25 degrees C. *Macromolecules* 44(12), 4814-4827.

Deng ZJ, Liang MT, Monteiro M, Toth I, Minchin RF. (2011) Nanoparticle-induced unfolding of fibrinogen promotes Mac-1 receptor activation and inflammation. *Nature Nanotechnology* 6(1), 39-44.

Jia ZF, Bell CA, Monteiro MJ. (2011) Directing the pathway of orthogonal 'click' reactions by modulating copper-catalytic activity. *Chemical Communications* 47(14), 4165-4167.

Jia ZF, Bell CA, Monteiro MJ. (2011) Rapid and highly efficient functionalisation of polymer bromide end-groups by SET-NRC. *Macromolecules* 44(7), 1747-1751.

Kessel S, Urbani CN, Monteiro MJ. (2011) Mechanically Driven Reorganisation of Thermoresponsive Diblock Copolymer Assemblies in Water. *Angewandte Chemie-International Edition* 50(35), 8082-8085.

Konkolewicz D, Monteiro MJ, Perrier S. (2011) Dendritic and Hyperbranched Polymers from Macromolecular Units: Elegant Approaches to the Synthesis of Functional Polymers. *Macromolecules* 44(18), 7067-7087.

Lin IC, Liang M, Liu TY, Monteiro MJ, Toth I. (2011) Cellular transport pathways of polymer-coated gold nanoparticles *Nanomedicine* 8(1), 8-11.

Lin IC, Liang MT, Liu TY, Ziora ZM, Monteiro MJ, Toth I. (2011) Interaction of Densely Polymer-Coated Gold Nanoparticles with Epithelial Caco-2 Monolayers. *Biomacromolecules* 12(4), 1339-1348.

Truong NP, Jia ZF, Burges M, McMillan NAJ, Monteiro MJ. (2011) Self-catalyzed degradation of linear cationic poly(2-dimethylaminoethyl acrylate) in water *Biomacromolecules* 15(5), 1876-1882.

Truong NP, Jia ZF, Burgess M, Payne L, McMillan NAJ, Monteiro MJ. (2011) Self-Catalysed Degradable Cationic Polymer for Release of DNA. *Biomacromolecules* 12(10), 3540-3548.

Zaman M, Skwarczynski M, Malcolm JM, Urbani CN, Jia ZF, Batzloff MR, Good MF, Monteiro MJ, Toth I. (2011) Self-adjuvanting polyacrylic nanoparticulate delivery system for group A streptococcus (GAS) vaccine. *Nanomedicine-Nanotechnology Biology and Medicine* 7(2), 168-173.

# Biologic medicines and stem cell bioengineering

Dr Trent Munro's research includes biologics (protein-based therapeutics) and translation aspects of stem cell biology.

Dr Munro and his team have key strengths in the discovery and production of therapeutic monoclonal antibodies. These complex molecules are technically challenging and expensive to produce. Dr Munro aims to develop more efficient bio-manufacturing platforms for producing these antibodies.

His research has an additional focus on developing bioengineered surfaces to allow large-scale culture of stem cells for applications in regenerative medicine. The research sits at the interface of biology and engineering and aims to produce targeted and next-generation therapies.

The team and key collaborators cover a range of disciplines, including biotechnology, biomaterials, protein biochemistry, cell biology, molecular biology and stem cell biology.

Dr Munro's recent achievements include:

- winning the UQ Trailblazer Competition and Sanofi Avensis Vision award for better health;
- leading a team responsible for producing an emergency stockpile of a potential treatment for Hendra virus for Queensland Health; and
- obtaining ARC Linkage and ARC Discovery funding.

Active research projects include:

- biologic bullets for beating bacterial infection;
- high-throughput approaches to biopharmaceutical cell line development;
- creating engineered polymers for stem cells;
- using bi-specific antibodies for targeted drug delivery; and
- engineering mammalian cells for efficient biologics production.

**Key publications in the past five years:**


Pilbrough W, Munro TP, Gray P. (2009) Intraclonal protein expression heterogeneity in recombinant CHO cells. *PLoS One* 4(12), e8432.

Jones ML, Seldon T, Smede M, Linville A, Chin DY, Barnard R, Mahler SM, Munster D, Hart D, Gray PP, Munro TP. (2010) A method for rapid, ligation-independent reformatting of recombinant monoclonal antibodies. *J Immunol Methods* 354(1-2), 85-90.

Prowse AB, Doran MR, Cooper-White JJ, Chong F, Munro TP, Fitzpatrick J, Chung TL, Haylock DN, Gray PP, Wolvetang EJ. (2010) Long-term culture of human embryonic stem cells on recombinant vitronectin in ascorbate free media. *Biomaterials* 31(32), 8281-8288.

Prowse AB, Chong F, Gray PP, Munro TP. (2011) Stem cell integrins: implications for ex-vivo culture and cellular therapies. *Stem Cell Res* 6(1), 1-12.

Codamo J, Munro TP, Hughes BS, Song M, Gray PP. (2011) Enhanced CHO cell-based transient gene expression with the epi-CHO expression system. *Mol Biotechnol* 48(2), 109-115.


## DR TRENT MUNRO

ASSOCIATE GROUP LEADER

# Systems and synthetic biology

Systems biology provides the means of answering intricate questions about complex biological systems. The questions considered by Professor Lars Nielsen's research group are very diverse, but generally inspired by some practical applications. For example:

How do we efficiently convert stem cells into white and red blood cells for use in anti-bacterial treatment?

Why does transgenic sugarcane produce plastic efficiently in one type of leaf cells, but not the other?

How do we efficiently engineer *E. coli* and yeast to produce fuels and chemicals from sucrose?

Given the number and diversity of mutations in any given tumour type, what are the common signalling phenotypes responsible for malignancy?

The common challenge for all those problems lies in formulating the question in such a way that it will yield a meaningful answer when using the appropriate mathematical, statistical and analytical tools. A key focus of Professor Nielsen's group is to develop the engineering frameworks and tools required to meet that challenge.

The understanding gained can be used to synthesise better systems and processes.

In addition to various in-house model systems, Professor Nielsen's group works closely with domestic and international companies and academic groups exploring the potential of the novel strategies developed.

The group has research projects in the areas of:

- developing biological replacements for materials currently produced from petrochemical feedstocks;
- producing plastics in sugar cane;
- expanding neutrophils from stem cells for therapeutic purposes;
- modelling and analysing mammalian cell metabolism using genome scale models and metabolomics; and
- modelling signalling and transcription regulation networks in animal cells.

**Key publications in the past five years:**


Chen W, Marcellin E, Hung J, Nielsen LK. (2009) Hyaluronan molecular weight is controlled by UDP-N- acetylglucosamine concentration in *Streptococcus zooepidemicus*. *J Biol Chem* 284, 18007-18014.

Quek L-E, Dietmair S, Krömer JO, Nielsen LK. (2010) Metabolic flux analysis in mammalian cell culture. *Metabolic Engineering* 12, 161-171.

de Oliveira Dal'molin CG, Quek LE, Palfreyman RW, Brumbley SM, Nielsen LK. (2010) AraGEM - a Genome-Scale Reconstruction of the Primary Metabolic Network in Arabidopsis thaliana. *Plant Physiol* 152, 579–589.

Timmins NE, Athanasas S, Günther M, Buntine P, Nielsen LK. (2011) Ultra high yield manufacture of red blood cells from hematopoietic stem cells. *Tissue Engineering, Part C* 17, 1131-1137.

Archer CT, Kim JF, Jeong H, Park JH, Vickers CE, Lee SY, Nielsen LK. (2011) The genome sequence of E coli W (ATCC 9637): comparative genome analysis and an improved genome-scale reconstruction of E coli. *BMC Genomics* 12, 9.



PROFESSOR LARS NIELSEN

GROUP LEADER

# Systems biology approach to the production of baculovirus biopesticides and animal vaccines

Dr Steven Reid's research group has a process patent on a procedure for producing baculoviruses using fermentation.

The lead product is a baculovirus targeting the *Helicoverpa* pest species. Globally, $US3.2 billion a year is spent on traditional chemical pesticides to control this pest.

A baculovirus product manufactured by Dr Reid's group and formulated by Bioflexus, under the trade name Heliocide, has been registered for use on Australian crops to combat heliothis caterpillars, more widely known as the cotton bollworm. Dr Reid's group is undertaking further research to increase fermentation yields.

The group is collaborating with AIBN Professor Lars Nielsen to use a systems biology approach using transciptomic and metabolomic techniques in an effort to understand how the virus interacts with host cells in culture. The group anticipates further increases in yield, making it cost effective in broader markets, both nationally and internationally.

Recent commercialisation of human and veterinary vaccines using insect cell technology has broadened the interest of the group's systems biology approach to improve insect cell-based manufacturing systems. That has led to potential collaboration with Pfizer Animal Health to assess vaccine candidates.

Specific research projects include:

- establishing the transcriptome of the key insect cell lines currently used for manufacturing, to form the basis of the transcriptomic studies;
- developing HPLC/GC-MS techniques for quantifying intracellular metabolite levels for cells in culture, to enable the metabolomic studies; and
- developing techniques to modify virus and insect cell genomes, to aid manipulation of gene targets suggested by the systems biology studies as useful for improving yields.

## DR STEVEN REID

**Key publications in the past five years:**


Roberts GS, Yu S, Zeng Q, Chan LCL, Anderson W, Colby AH, Grinstaff MW, Reid S, Vogel R. (2012) Tunable pores for measuring concentrations of synthetic and biological nanoparticle dispersions. *Biosensors and Bioelectronics* 31(1), 17-25.

Pedrini MRS, Reid S, Nielsen LK, Chan LCL. (2011) Kinetic characterisation of the group II helicoverpa armigera nucleopolyhedrovirus propagated in suspension cell cultures: Implications for development of a biopesticides production process. *Biotechnology Progress* 27(3), 614-624.

Nguyen Q, Qi YM, Wu Y, Chan LCL, Nielsen LK, Reid S. (2011) In vitro production of Helicoverpa baculovirus biopesticides: Automated selection of insect cell clones for manufacturing and systems biology studies. *Journal of Virological Methods* 175(2), 197-205.

Chan L, Reid S, Nielsen LK. (2010) The kinetics of virus production from cell culture. In *Wiley Encyclopedia of Industrial Biotechnology.* Flickinger MC (Ed.), (pp. 1-24), Hoboken, NJ, US.

# Development of polymers for nanomedicine

Dr Kristofer Thurecht develops polymers for a range of applications, from nanomedicine to degradable plastics.

He focuses on understanding the fundamental physical chemistry of systems, such as developing biocompatible delivery vehicles that facilitate diagnosis and treatment of disease.

Dr Thurecht's work is intrinsically inter-disciplinary, covering polymer physical chemistry, synthetic polymer chemistry, pharmacy and formulation science, biomaterials, molecular imaging and drug delivery.

Achievements for 2011 include:

- developing molecular imaging agents for in vivo diagnosis using multiple imaging modalities, funded by the Australian Research Council and the Prostate Cancer Foundation of Australia;
- publication of research findings in high-impact, high-ranking journals and review material in the form of book chapters;
- maintaining links and collaboration with Eli Lilly (10th largest pharmaceutical company worldwide) through an ARC linkage grant; and
- awarding of an ARC Future Fellowship.

Active research projects include:

- developing polymeric theranostics for directly imaging drug delivery and efficacy of treatment;
- multi-modal imaging using polymers;
- supercritical $CO_2$ as a solvent for polymer synthesis, processing and modification;
- biodegradable polymers for drug delivery; and
- polymeric ionic liquids as novel polyelectrolytes.

**Key publications in the past five years:**


Munnemann K, Kolzer M, Blakey I, Whittaker AK, Thurecht KJ. (2012) Hyperbranched polymers for molecular imaging: designing polymers for parahydrogen induced polarisation (PHIP). *Chemical Communications* 48(10), 1583-1585.

Thurecht KJ, Blakey I, Peng H, Squires O, Hsu S, Alexander C, Whittaker AK. (2010) Functional Hyperbranched Polymers: Towards Targeted in vivo $^{19}$F Magnetic Resonance Imaging using Designed Macromolecules. *Journal of the American Chemical Society* 132(15), 5336-5337.

Heath F, Saeed AO, Pennadam SS, Thurecht KJ, Alexander C. (2010) 'Isothermal' phase transitions and supramolecular architecture changes in thermoresponsive polymers via acid-labile side-chains. *Polymer Chemistry* 1(8), 1252-1262.

Zheng Y, Turner W, Zong M, Irvine DJ, Howdle SM, Thurecht KJ. (2011) Biodegradable Core-Shell Materials via RAFT and ROP: Characterisation and Comparison of Hyperbranched and Microgel Particles. *Macromolecules* 44(6), 1347-1354.

Thurecht KJ, Villarroya S. (2010) Biocatalytic Polymerization in Exotic Solvents, in Biocatalytic Polymerisation (1st edition). Loos K. (Ed.) (pp 323-348). Weinheim, Germany: Wiley-VCH.


## DR KRISTOFER THURECHT

ARC FUTURE FELLOW AND ASSOCIATE GROUP LEADER

# PROFESSOR MATT TRAU

DEPUTY DIRECTOR AND
GROUP LEADER

## Nanotechnology, biomarkers and molecular diagnostics

The use of biomarkers (molecules that indicate the onset and status of disease) is emerging as one of the most promising strategies for disease management. In nearly all forms of cancer, early diagnosis can lead to a cure at a fraction of the cost of currently ineffective treatments for late-stage disease. It is predicted that the development of new biomarker diagnostic technologies will simultaneously improve survival rates and quality of life, while significantly reducing health care costs.

At AIBN's Centre for Biomarker Research and Development, Professor Matt Trau and his research group are focused on several projects:

- nano-scaled biosensors for epigenetic readout in breast cancer;
- novel nano-devices for protein capture in diagnostics;
- single molecule readouts within elastic nanopores; and
- nanotechnology devices for capturing circulating tumour cells.

The development of nanoscaled biosensors is highly multidisciplinary, bringing together scientists from areas such as nanotechnology, molecular biology, biochemistry, pathology, medicine and bioinformatics. This cross-disciplinary research includes the National Breast Cancer Foundation-funded National Collaborative Grant which Professor Trau leads (*Novel strategies for prediction and control of advanced breast cancer via nanoscaled epigenetic-based sensors*).

The research involves close interactions with the Peter MacCallum Cancer Centre; the Garvan Institute; the Australian/New Zealand Breast Cancer Clinical Trials Group; the Fred Hutchinson Cancer Research Centre; the Seattle Biomedical Research Institute; the Benaroya Research Institute, the University of Washington; and Nanomics BioSystems Pty Ltd.

The single molecule readout area of research focuses on understanding tunable elastic nanopore sensors being developed with New Zealand's Izon Science Ltd. The sensors are used for monitoring particle-particle and particle-biomolecule interactions, and for quantitative sizing of colloidal dispersions.

**Key publications in the past 12 months:**


Kozak D, Anderson W, Grevett M, Trau M. (2012) Modelling Elastic Pore Sensors for Quantitative Single Particle Sizing, *Journal Physical Chemistry C.* In press Doi: 10.1021/jp211845t (front cover/feature article).

Shiddiky MJA, Rauf S, Kithvaa PH, Trau M. (2012) Graphene/quantum dot bionanoconjugates as signal amplifiers in stripping voltammetric detection of EpCAM biomarkers. *Biosensors and Bioelectronics* 35(1), 251-257.

Connolly AR, Trau M. (2011) Rapid DNA detection by beacon-assisted detection amplification. *Nature Protocols* 6(6), 772-778.

Corrie SR, Sova P, Feng Q, Blair T, Kiviat NB, Trau M. (2011) Bisulfite-free analysis of 5MeC-binding proteins and locus-specific methylation density using a microparticle-based flow cytometry assay. *Analyst* 136, 688-691. (front cover/feature article).

Kozak D, Anderson W, Vogel R, Trau M. (2011) Advances in resistive pulse sensors: Devices bridging the void between molecular and microscopic detection. *Nano Today* 6(5), 531-545.

Hirani R, Connolly AR, Putral L, Dobrovic A, Trau M. (2011) Sensitive Quantification of Somatic Mutations Using Molecular Inversion Probes. *Analytical Chemistry* 83(21), 8215-8221.

Kozak D, Kithva P, Bax J, Surawski PPT, Monteiro MJ, Trau M. (2011) Development of encoded particle-polymer arrays for the accelerated screening of antifouling layers. *Chemical Communications* 47(34), 9687-9689.

Palanisamy R, Connolly AR, Trau M. (2011) Epiallele Quantification Using Molecular Inversion Probes. *Analytical Chemistry* 83(7), 2631-2637.

Kozak D, Chen A, Bax J and Trau M, (2011) Protein Resistant Dextran and Dextran-PEG Copolymer Films for Improving Molecular Diagnostic Performance. *Biofouling* 27(5), 497-503.

Vogel R, Willmott G, Kozak D, Roberts GS, Anderson W, Groenewegen L, Glossop B, Barnett A, Turner A, Trau M. (2011) Quantitative sizing of nano/microparticles with a tunable elastomeric pore sensor. *Analytical Chemistry* 83(9), 3499-3506.

Xue Y, O'Mara ML, Surawski PPT, Trau M, Mark AE. (2011) Effect of Poly(ethylene glycol) (PEG) Spacers on the Conformational Properties of Small Peptides: A Molecular Dynamics Study. *Langmuir* 27(1), 296-303.

# PROFESSOR AJAYAN VINU

ARC FUTURE FELLOW
AND GROUP LEADER

## Multifunctional nanoporous materials for a clean environment and energy

Professor Ajayan Vinu and his research group are working on the innovation, design and preparation of highly-ordered nanoporous materials such as carbons, polymers and semiconductors. That includes phosphides, nitrides and metal oxides that can be used in catalysis, capture and photo electrochemical conversion of greenhouse gas and for energy storage and conversion for fuel cells, solar cells and batteries.

Professor Vinu discovered various novel nanoporous materials, including nanoporous carbon nitrides; nanoporous boron nitride and boron carbon nitrides; carbon nanocage; carbon nanocoops; highly acidic nanoporous metallosilicates; and nanoporous fullerenes, which have generated 16 patents. He also contributed significantly to the synthesis and pore size control of nanoporous materials using the self assembly process – or the hard templating approach – and their applications in energy and the environment.

His main project at AIBN is focused on developing nanoporous semiconductors that will be incorporated into stable, cost-effective photoelectrochemical semiconductor devices, for the conversion of $CO_2$ into fuels using water and sunlight. The novel technology will not only reduce $CO_2$ levels but also provide a source of clean energy. The project extends Professor Vinu's pioneering work on the synthesis of nanoporous carbon nitride materials with extremely high surface area, large pore volume and tunable pore diameters that can be functionalised with semiconductor nanoparticles. Such materials will be used as templates for preparing multifunctional, low-cost, highly ordered nanoporous semiconductors (including nitrides and phosphides) that can be used for fabricating fuel cells, solar cells and batteries.

The group has research projects in:

- conducting and semiconducting materials with highly ordered porous structure;
- fabrication of hydrogen and $CO_2$ storage materials;
- aqueous photoelectrochemical reduction of $CO_2$ into a clean fuel using functionalised nanoporous semiconductors;
- fabrication of electrode materials with excellent textural characteristics and metal, metal oxide and organic functional groups for supercapacitor and Li-ion battery applications;
- design of anode and cathode materials for polymer electrolyte membrane and direct methanol fuel cells;
- fine chemical synthesis using acidic, basic and redox functionalised nanoporous materials; and
- nanoporous biomolecules for sensing glucose and some selective toxic molecules.

### Key publications in the past five years:


Kim J, Anand C, Siddulunaidu T, You J, Aldeyab SS, Kim E, Vinu A. (2012) A Green Catalytic Polymerisation of Anthracene using High Iron Containing SBA-15 Reactor via Friedel-Crafts Alkylation. *Angewandte Chemie* 51, 2859-2863.

Datta KKR, Subba Reddy BV, Ariga K, Vinu A. (2010) Gold Nanoparticles Embedded in Nanoporous Carbon Nitride Stabiliser for Highly Efficient Three Component Coupling Reaction. *Angewandte Chemie Intl Ed* 49, 5961-5965.

Ji Q, Honma I, Paek S-M, Akada M, Hill JP, Vinu A, Ariga K. (2010) Layer-by-Layer Films of Graphene and Ionic Liquids for Highly Selective Gas Sensing. *Angewandte Chemie Intl Ed* 49, 9737-9739.

Jin X, Balasubramanian VV, Selvan ST, Sawant DP, Chari MA, Lu GQ, Vinu A. (2009) Highly Ordered Mesoporous Carbon Nitride Nanoparticles with a High Nitrogen Content: a Novel Metal-free Basic Catalyst.*Angewandte Chemie Intl Ed* 48(42), 7884-7887.

Alam S, Anand C, Ariga K, Mori T, Vinu A. (2009) Unusual Magnetic Properties of Size-Controlled Iron Oxide Nanoparticles Grown in a Nanoporous Matrix with Tunable Pores. *Angewandte Chemie Intl Ed* 48(40), 7358-7361.

Ji Q, Yoon SB, Hill J, Vinu A, Yu J-S, Ariga K. (2009) Layer-by-Layer Films of Dual-Pore Carbon Capsules with Designable Selectivity of Gas Adsorption. *Journal of the American Chemical Society* 131, 4220-4221.

Ariga K, Vinu A, Ji Q, Ohmori O, Hill J, Acharya S, Koike J, Shiratori S. (2008) A Layered Mesoporous Carbon Sensor Based on Nanopore-Filling Cooperative Adsorption in the Liquid Phase. *Angewandte Chemie Intl Ed* 47, 7254-7257.

Vinu A. (2008) Two dimensional Hexagonally Ordered Mesoporous Carbon Nitrides with Tunable Pore Diameter, Surface Area and Nitrogen Content. *Advanced Functional Materials* 18, 816-827. (Cover image).

Srinivasu P, Alam S, Balasubramanian VV, Velmathi S, Sawant DP, Bohlmann W, Mirajkar SP, Ariga K, Halligudi SB, Vinu A. (2008) Novel Three Dimensional Cubic Fm3m Mesoporous Aluminosilicates with Tailored Cage Type Pore Structure and High Aluminum Content. *Advanced Functional Materials* 18, 640-651. (Cover image).

Ji Q, Miyahara M, Hill JP, Acharya S, Vinu A, Yoon SB, Yu J-S, Sakamoto K, Ariga K. (2008) Stimuli-free Auto-Modulated Materials Release from Mesoporous Nano-compartment Films. *Journal of the American Chemical Society* 130, 2376-2377. (Highlighted in *Nature Materials*).


### Awards and prizes:

Wilhelm Friedrich Bessel Award (2010); Future Fellowship Award (2010); Indian Society of Chemists and Biologists Award for Excellence (2010); Catalysis Society of India award (2010).

# Cellular differentiation and activation

Associate Professor Christine Wells heads a research group that uses genomic technologies to understand the genetic and environmental factors that lead to disease susceptibility. The group is interested in:

- innate immune function and susceptibility to infectious disease; and
- stem cell differentiation.

The innate immune system provides the first line of defence against infection. Infectious diseases remain the leading cause of death worldwide. Many infectious agents have been implicated in the onset of cancers, tissue death and organ failure; and, in some cases, are responsible for exacerbating chronic diseases. To mount effective preventative programs, such as vaccinations, or provide appropriate diagnosis and point of care, researchers need to understand why some people are susceptible to infection, when others resolve infection without medical intervention.

The Wells group's research is aimed at:

- identifying the networks of genes marshalled to fight infections;
- modelling the interactions of the immune system with the environment; and
- developing markers for improved diagnosis and treatment of susceptible individuals.

The group's most recent success with this project has been identifying the C-type lectin Mincle, which has a critical role in immune responses to fungal diseases, including thrush, and has been implicated in mycobacterial infections such as TB. The group is characterising the regulation and function of Mincle in human health.

Stem cell biology promises new strategies for regenerative medicine. The Wells group recognises there is a wealth of stem cell data that is effectively hidden in public databases, but which could bring important information on stem cell behaviours if collated and interrogated in a systematic manner. The Stemformatics web portal is aimed at collating the data and enabling stem cell researchers to investigate the gene signatures that correlate with stem cell function.

The project is funded through the Australian Stem Cell Centre as a collaboration between the Wells group at AIBN; the Hilton group at The Walter and Eliza Hall Institute; and the Grimmond group at UQ's Institute for Molecular Bioscience.

Stemformatics.org currently:

- hosts expertly curated public gene expression data from exemplar stem cell datasets;
- facilitates simple gene searches across mouse and human stem cell datasets;
- presents the data in high-quality images; and
- provides transparent links to the original source and facilitates access to the primary data.

The Wells group is multidisciplinary, with expertise in cell biology and signalling, genomics, transcriptomics and bioinformatics. It has collaborations with microbiology labs, clinicians and immunology groups through the Australian Infectious Disease Research Centre at UQ; and is a participant in the international FANTOM (Functional Annotation of the Mammalian Genome) and the Functional Glycomics consortia. The group works closely with John Quackenbush and his group at the Dana-Farber Cancer Institute in Boston, Massachusetts; and the biostatistics group at the Harvard School of Public Health, in Boston.

The group has research projects in:

- genome biology to identify key genes determining macrophage differentiation and activation;
- genomics, bioinformatics and cell biology to investigate the transcriptional analysis of monocytes infected with an exemplar pathogen series;
- genomic and cell biology to understand the epigenetic events that modify immune cell differentiation; and
- developing new computational approaches for predictive models of cell fate.

### Key publications in the past five years:


Mar J, Wells CA, Quackenbush J. (2011) Defining an Informativeness Metric for Clustering Gene Expression Data. *Bioinformatics.* Feb 16 (Epub ahead of print).

Mar J, Matigian N, Quackenbush J, Wells CA. (2011) attract: A method for identifying core pathways that underlie cell state. *PLoS ONE* 6(10), e25445.

Mar JC, Mackay-Sim A, Matigian N, Miotto A, Mellick G, Sue C, Silburn P, McGrath J, Quackenbush J, Wells CA. (2011) Variance of gene expression identifies altered network constraints in neurological disease. *PLoS Genetics* 7(8):e100220.

FANTOM4 consortium including Wells CA. (2009) The transcriptional network that controls growth arrest and differentiation in a human myeloid leukemia cell line. *Nature Genetics* 41(5), 553-562.

Wells CA, Salvage-Jones J, Li X, Hitchens K, Butcher S, Murray R, Beckhouse A, Lo Y, Cobbold C, Ma B, Orr S, Stewart L, Lebus D, Sobieszczuk P, Hume D, Stow J, Blanchard H, Ashman B. (2008) The macrophage inducible c-type lectin, Mincle, is an essential component of the innate immune response to *Candida albicans*. *Journal of Immunology* 180(11), 7404-7413.


# ASSOCIATE PROFESSOR CHRISTINE WELLS

GROUP LEADER

### Awards and prizes:

2010 Women in Technology Research Excellence Award

# PROFESSOR ANDREW WHITTAKER

ARC PROFESSORIAL FELLOW AND GROUP LEADER

## Polymer chemistry

Professor Andrew Whittaker and his research group are working to develop novel polymeric materials for application in:

- biomaterials for diagnosis and treatment of disease;
- photolithography for the manufacture of integrated circuits; and
- molecular imaging agents for disease identification using nuclear magnetic resonance imaging.

This research is underpinned by extensive expertise in polymer synthetic chemistry, polymer physical chemistry, interactions with biological systems and magnetic resonance technology.

The group's biomaterials research is targeting various applications, including polymers for use as tissue implants; improving drug delivery; and aiding medical diagnosis. This is in addition to projects shedding light on drug delivery, the fundamentals of hydrogel polymer networks, surface modification and biosensors.

Using immersion and ultra-violet immersion lithography, the group is also investigating challenges facing the microelectronics industry as it struggles to incorporate nanometre-sized features on integrated circuits.

Research projects include:

- polymers for 193 nm immersion lithography;
- polymers for EUV lithography;
- block copolymers for healing line edge roughness;
- polymers for artificial vitreous;
- artificial blood vessels;
- dental bone repair;
- molecular imaging agents;
- hybrid imaging agents;
- ultrasound contrast agents;
- diffusion in hydrogels;
- novel hydrogel networks; and
- spinal cord repair.

**Key publications in the past five years:**


Tan I, Flanagan BM, Halley PJ, Whittaker AK, Gidley MJ. (2007) A Method for Estimating the Nature and Relative Proportions of Amorphous, Single and Double-Helical Components in Starch Granules by 13C CP/MAS NMR. *Biomacromolecules* 8(3), 885-891.

Blakey I, George GA, Hill DJT, Liu H, Rasoul F, Rintoul L, Zimmerman P, Whittaker AK. (2007) Mechanism of 157 nm Photodegradation of Poly[4,5-difluoro-2,2- bis(trifluoromethyl)-1,3-dioxole-co-tetrafluoroethylene] (Teflon AF). *Macromolecules* 40(25), 8954-8961.

Peng H, Xiao Y, Mao X, Chen L, Crawford R, Whittaker AK. (2008) Amphiphilic Triblock Copolymers of Methoxy-poly(ethylene glycol)-b-poly(L-lactide)-b-poly(L-lysine) for Enhancement of Osteoblast Attachment and Growth. *Biomacromolecules* 10(1), 95-104.

Peng H, Blakey I, Dargaville B, Rasoul F, Rose S, Whittaker AK. (2009) Synthesis and Evaluation of Partly Fluorinated Block Copolymers as MRI Imaging Agents. *Biomacromolecules* 10(2), 374-381.

Mao X, Peng H, Ling J, Friis T, Whittaker AK, Crawford R, Xiao Y. (2009) Enhanced human bone marrow stromal cell affinity for modified poly(-lactide) surfaces by the upregulation of adhesion molecular genes. *Biomaterials* 30(36), 6903-6911.

Thurecht KJ, Blakey I, Peng H, Squires O, Hsu S, Alexander C, Whittaker A K. (2010) Functional Hyperbranched Polymers: Toward Targeted in Vivo $^{19}$F Magnetic Resonance Imaging Using Designed Macromolecules. *Journal of the American Chemical Society* 132(15), 5336-5337.

Blakey I, Thurecht KJ, Whittaker AK. (2010) High-pressure real-time 129Xe NMR: monitoring of surfactant conformation during the self-assembly of reverse micelles in supercritical carbon dioxide. *Chemical Communications* (Cambridge, UK) 46(16), 2850-2852.

Paterson SM, Brown DH, Chirila TV, Keen I, Whittaker AK, Baker MV. (2010) The synthesis of water-soluble PHEMA via ARGET ATRP in protic media. *Journal of Polymer Science* (Part A: Polymer Chemistry) 48(18), 4084-4092.

Lawrie KJ, Blakey I, Blinco JP, Cheng HH, Gronheid R, Jack KS, Pollentier I, Leeson MJ, Younkin TR, Whittaker AK. (2011) Chain scission resists for extreme ultraviolet lithography based on high performance polysulfone-containing polymers. *J Mater Chem* 21, 5629-5637.

Blakey I, Yu A, Howdle SM, Whittaker AK, Thurecht KJ. (2011) Controlled polymerisation of lactide using an organo-catalyst in supercritical carbon dioxide. *Green Chemistry* 13(8), 2032-2037.

Sun H, Lee HH, Blakey I, Dargaville B, Chirila TV, Whittaker AK, Smith SC. (2011) Multiple Hydrogen-Bonded Complexes Based on 2-Ureido-4[1H]-pyrimidinone: A Theoretical Study. *Journal of Physical Chemistry B* 115(38), 11053-11062.

Dargaville BL, Vaquette C, Peng H, Rasoul F, Chau YQ, Cooper-White JJ, Campbell JH, Whittaker AK. (2011) Cross-Linked Poly(trimethylene carbonate-co-L-lactide) as a Biodegradable, Elastomeric Scaffold for Vascular Engineering Applications. *Biomacromolecules* 12(11), 3856-3869.

Muennemann K, Koelzer M, Blakey I, Whittaker AK, Thurecht KJ. (2012) Hyperbranched polymers for molecular imaging: designing polymers for parahydrogen induced polarisation (PHIP). *Chemical Communications* (Cambridge, United Kingdom) 48(10), 1583-1585.

# Human pluripotent stem cells for regenerative medicine

Associate Professor Ernst Wolvetang's research is focused on the development of human pluripotent stem cell-based therapies and disease models.

Because human pluripotent stem cells can be cultured indefinitely and can generate every cell type of the human body, they are the cell type of choice for stem cell based regenerative medicine – and as a discovery platform for the understanding of the molecular basis of human disease and development.

The ability to reprogram adult cells into pluripotent cells, so called induced pluripotent cells (iPS cells), that are essentially equivalent to embryonic stem cells has removed the ethical concerns attached to this type of stem cell research. It also allows the generation of patient specific stem cells that will not suffer from rejection. Generating iPS cells allows the creation of unique disease models previously not available to researchers.

Activities in the Wolvetang research group concentrate on the two main areas of:

- elucidating the role of specific signalling pathways and the microenvironment in controlling the behaviour of human pluripotent cells to enable safer, more efficient stem cell expansion and differentiation; and
- generating species and patient specific iPS to understand the molecular basis of disease and enable cellular therapy.

Specific projects in these areas include:

- developing novel cell reprogramming technologies;
- generating Down Syndrome iPS cells to understand Alzheimers disease;
- understanding the epigenetic effects of culture conditions;
- elucidating BMP-SMAD signalling in human stem cells;
- metabolomic analysis of human embryonic stem cells; and
- developing smart surfaces for stem cell expansion and differentiation.

By combining cutting-edge molecular analysis and cell biology tools, the group will gain an in-depth understanding of the molecular machinery controlling human pluripotent stem cells and consequently be able to unlock the potential of those cells for application in regenerative medicine and drug development.

**Key publications in the past five years:**


Witworth DJ, Ovchinnikov DA, Wolvetang EJ. (2012) Generation and Characterization of LIF-dependent Canine Induced Pluripotent Stem Cells from Adult Dermal Fibroblasts. *Stem Cells Dev* Feb 15. (Epub ahead of print).

Chen YS, Pelekanos RA, Ellis RL, Horne R, Wolvetang EJ, Fisk NM. (2011) Small Molecule Mesengenic Induction of Human Induced Pluripotent Stem Cells to Generate Mesenchymal Stem/Stromal Cells. *Stem cells Translational Medicine* 1, 83-95.

Vitale AM, Wolvetang EJ, Mackay-Sim A. (2011) Induced pluripotent cells: a new technology to study human diseases. *The International Journal of Biochemistry and Cell Biology* 43(6), 843-846.

Tra T, Gong L, Kao LP, Li XL, Grandela C, Devenish RJ, Prescott M, Wolvetang E. (shared senior authors). (2011) Autophagy in human embryonic stem cells. *PLoS One* 6(11), e27485.

Chung TL, Turner JP, Thaker NY, Kolle G, Cooper-White JJ, Grimmond SM, Pera MF, Wolvetang EJ. (2010) Ascorbate promotes epigenetic activation of CD30 in human embryonic stem cells. *Stem Cells* 28(10), 1782-1793.

Prowse A, Doran M, Cooper-White JJ, Chong F, Munro T, Fitzpatrick J, Chung TL, Haylock DN, Gray PP, Wolvetang EJ. (2010) Long-term culture of human embryonic stem cells on recombinant vitronectin in ascorbate free media. *Biomaterials* 31(32), 8281-8288.

Chung TL, Brena RM, Kolle G, Grimmond SM, Berman BP, Laird PW, Pera MF, Wolvetang EJ. (2010) Vitamin C promotes widespread yet specific DNA demethylation of the epigenome in human embryonic stem cells. *Stem Cells* 28(10), 1848-1855.

Chung TL, Thaker N, Wolvetang EJ. (2010) Genetic and epigenetic instability of human pluripotent stem cells. *The Open Stem Cell Journal* 3, 52-61.

Hannan N, Jamshidi P, Pera MF, Wolvetang EJ. (2009) BMP -11 and Myostatin Maintain Human Embryonic Stem Cells in Feeder Free Cultures. *Cloning and Stem Cells* 11(3), 427-435.

Prowse ABJ, Wilson J, Osborne GW, Gray PP, Wolvetang EJ. (2009) Multiplexed staining of live human embryonic stem cells for flow cytometric analysis of pluripotency markers. *Stem Cells and Development* 18(8), 1135-1140.

Hannan NRF, Wolvetang EJ. (2008) Adipocyte differentiation in human embryonic stem cells transduced with Oct4 shRNA lentivirus. *Stem Cells and Development* 18(4), 653-660.

Grandela C, Pera MF, Wolvetang EJ. (2007) p53 is required for etoposide-induced apoptosis of human embryonic stem cells. *Stem Cell Research* 1(2), 116-128.


# ASSOCIATE PROFESSOR ERNST WOLVETANG

GROUP LEADER

# ASSOCIATE PROFESSOR ZHI PING (GORDON) XU

ARC AUSTRALIAN RESEARCH FELLOW AND ASSOCIATE GROUP LEADER

## Clay nanomaterials for biomedical applications in drug delivery and vaccines

Associate Professor Gordon Xu's research focuses on the controlled preparation of anionic clay (for example, layered double hydroxide, LDH) nanomaterials and bioapplications in delivering medicines, genes, proteins and vaccines.

Associate Professor Xu and his team are developing a fundamental understanding of the interactions of clay-drug nanoparticles with proteins in serum and target cells/tissues – and subsequent biological effects. That understanding enables the design and synthesis of improved materials for a range of applications, including anti-restenotic drug delivery, gene delivery, protein delivery and vaccine adjuvants.

The team and key collaborators cover a range of disciplines, including nanomaterials science and technology, colloidal chemistry, surface chemistry, computational chemistry, cellular and molecular biology, biomedicine, pharmacy and neuroscience.

Associate Professor Xu's achievements for 2011 include:

- being awarded an ARC Discovery Project on nanoparticle skin penetration;
- publishing research findings in high-impact, high-ranking journals;
- applying for a provisional patent on micronutrient foliar fertilisers; and
- maintaining strong links with the agriculture industry, such as with Incitec Pivot Ltd and AgriChem.

Active research projects include:

- protein adsorption on LDH nanoparticles and desorption;
- molecular dynamic simulation on protein folding on the LDH nanoparticle surface;
- drug/gene delivery using stabilised LDH nanoparticles in animal model;
- LDH-based nanoadjuvants for antigen;
- preparation and modification of quantum dots for molecular imaging;
- $SiO_2$-dot-coated LDHs and their bioapplications; and
- liposome-LDH nanohybrids for gene delivery.

**Key publications in the past five years:**


Zhu Y, Li Z, Chen M, Cooper H, Lu GQ, Xu ZP. (2012) Synthesis of Robust Sandwich-Like SiO2@CdTe@SiO2 Fluorescent Nanoparticles for Cellular Imaging. *Chem Mater* 24, 421-423.

Gu Z, Rolfe BE, Thomas AC, Campbell JH, Lu GQ, Xu ZP. (2011) Cellular trafficking of low molecular weight heparin carried with layered double hydroxide nanoparticles in rat vascular smooth muscle cells. *Biomaterials* 32, 7234-7240.

Wong YY, Markham K, Xu ZP, Chen M, Lu GQ, Bartlett PF, Cooper HM. (2010) Efficient delivery of siRNA to cortical neurons using layered double hydroxide nanoparticles. *Biomaterials* 31, 8770-8779.

Gu Z, Rolfe BE, Xu ZP, Thomas AC, Campbell JH, Lu GQ. (2010) Enhanced effect of low molecular weight heparin carried by layered double hydroxide nanoparticles on rat vascular smooth muscle cells. *Biomaterials* 31, 5455-5462.

Ladewig K, Niebert M, Xu ZP, Gray P, Lu GQ. (2010) Efficient siRNA delivery to mammalian cells using layered double hydroxide nanoparticles. *Biomaterials* 31, 1821-1829.

Xu ZP, Niebert M, Porazik K, Walker TL, Cooper HM, Middelberg APJ, Gray PP, Bartlett PF, Lu GQ. (2008) Subcellular Compartment Targeting of Layered Double Hydroxide Nanoparticles. *J Control Release* 130, 86-94.

Gu Z, Thomas AC, Xu ZP, Campbell J, Lu GQ. (2008) In vitro Sustained Release of Low Molecular Weight Heparin from MgAl-Layered Double Hydroxide Nanohybrids. *Chem Mater* 20, 3715-3722.

Xu ZP, Kurniawan ND, Bartlett PF, Lu GQ. (2007) Enhancement of relaxivities of Gd-DTPA complex via intercalation into layered double hydroxide nanoparticles. *Chem Eur J* 13, 2824-2830.

Liu S, Liu L, Xu ZP, Yu A, Lu GQ, da Costa JCD. (2007) Bioceramic macrocapsules for cell immunoisolation. *Angew Chem Int Ed,* 3062-3065.

Yu JJ, Wang XP, Tao YX, Hao ZP, Xu ZP, Lu GQ. (2007) Novel Multi-functional Mixed Oxide Catalysts for Effective $NO_x$ Capture, Decomposition and Reduction. *Advanced Functional Materials* 17, 3598-3606.


## Nanomaterials for biotechnology, energy and environmental protection

# PROFESSOR CHENGZHONG (MICHAEL) YU

ARC FUTURE FELLOW AND GROUP LEADER

Professor Chengzhong (Michael) Yu and his research group have an excellent track record of research and innovation in nanoporous and nano-materials with various compositions, adjustable structures and tailored functions for biotechnology, clean energy and environment protection.

His group also focuses on investigating cancer carcinogenesis to identify potential therapeutic targets and use nanotechnology to develop novel cancer diagnosis and therapies.

Research projects in the group include:

- a robust nanomaterial platform for advanced delivery;
- nanoporous materials for bio-catalysis, bio-separation and bio-analysis;
- biomaterials for bone repair and dental applications; and
- advanced nanomaterials for sustainable environment and energy applications.

**Key publications in the past five years:**


Qian K, Gu WY, Yuan P, Liu F, Wang YH, Monteiro M, Yu CZ. (2012) Enrichment and Detection of Peptides from Biological Systems Using Designed Periodic Mesoporous Organosilica Microspheres. *Small* 8, 231-236.

Gu W, Yeo E, McMillan N, Yu CZ. (2011) Silencing Oncogene Expression in Cervical Cancer Stem-like Cells Inhibits Their Cell Growth and Self-renewal Ability. *Cancer Gene Therapy* 18, 897-905.

Yang J, Zhou L, Zhao LZ, Zhang HW, Yin JN, Wei GF, Qian K, Wang YH, Yu CZ. (2011) A Designed Nanoporous Material for Phosphate Removal with High Efficiency. *J Mater Chem* 21(8), 2489-2494.

Zhu J, Tang JW, Zhao LZ, Zhou XF, Wang YH, Yu CZ. (2010) Ultra-small, Well-Dispersed, Hollow Siliceous Spheres with Enhanced Endocytosis Properties. *Small* 6(2), 276-282.

Zhou L, Yang LC, Yuan P, Zou J, Wu YP, Yu CZ. (2010) Alpha-$MoO_3$ Nanobelts: A High Performance Cathode Material for Lithium Ion Batteries. *J Phys Chem C* 114, 21868-21872.

# GRANTS

| Type | Scheme | Lead AIBN Investigator | Other Chief Investigators | Project Title | Duration | 2011 income |
|---|---|---|---|---|---|---|
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Michael Monteiro | A/Prof Nigel McMillan | Engineered polymer nanoparticles: a potent weapon against cancer | 2009-2011 | $130,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Dr Simon Corrie | Prof Mark Kendall, Prof Christopher Anderson | Non-invasive diagnosis using micropatches that sample biomarkers from skin | 2009-2011 | $120,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Kirill Alexandrov | | Novel approaches for structural and functional analysis of the protein complex COG, a tether that controls intra-Golgi trafficking | 2009-2011 | $180,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Michael Monteiro | Prof Virgil Percec | Designer nanoreactors: an environmentally friendly solution for polymer synthesis | 2009-2011 | $150,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Andrew Whittaker | Dr Kevin Jack, Dr Hui Peng | Designed delivery novel hydrogels for drug delivery from precisely-structured networks | 2009-2011 | $130,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Dr Shizhang Qiao | Prof Duong Do, Dr Greg Birkett | Synthesis of unique mesoporous graphitic carbons and their application to fundamental problems in adsorption science | 2009-2013 | $40,715 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Anton Middelberg | | Sustainable processes for next-generation surface coatings and core-shell nanoparticles based on biomolecular templating | 2010-2012 | $150,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Mark Kendall | Prof Ian Frazer, Prof Michael Roberts, Prof Davide Ambrosi | Improving immune response to vaccines by selective targeting of epithelial regions with the Nanopatch | 2010-2012 | $280,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Dr Jian Liu | | Nanostructured degradable polymer for drug delivery | 2010-2012 | $80,182 |
| Australian Competitive Grant Income | ARC Discovery Projects | A/Prof Idriss Blakey | Dr Kristofer Thurecht, Peter Fredericks, Cameron Alexander, | Multimodal biomedical imaging probes: development of advanced polymer nanocomposite devices for oncology | 2010-2012 | $90,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Justin Cooper-White | Prof Nicholas Fisk, Dr Lizbeth Grondahl, A/Prof Ernst Wolvetang | Scalable, high throughput microfluidic platforms for tissue specific biomaterials development and tissue genesis | 2010-2012 | $130,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Dr Shizhang Qiao | Dr Yonggang Jin, Prof Mietek Jaroniec | Multifunctional porous nanospheres engineered composite membranes for hydrogen and methanol fuel cells | 2010-2012 | $85,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Sean Smith | Dr Hong Zhang, Prof Walter Thiel | Function, mechanism and dynamics in fluorescent proteins: a computational investigation | 2010-2011 | $80,882 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Chengzhong Yu | Dr Xiangdong Yao | Practical hydrogen storage for fuel cells electrical vehicles by confined ammonia borane system | 2010-2012 | $130,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Chengzhong Yu | Prof Max Lu, Dr Xinguo Jiang, Dr Jian Lu | Designer nano-carriers for targeted hydrophobic anticancer drug delivery with enhanced bioavailability | 2011-2013 | $140,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Prof Justin Cooper-White | | Elucidating surface-mediated permissive cues for cellular differentiation | 2011-2014 | $130,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | Dr Chunxia Zhao | | Engineered nanoporous materials and composites having hierarchical structures by emulsion templating | 2011-2014 | $125,000 |
| Australian Competitive Grant Income | ARC Discovery Projects | A/Professor Aijun Du | Prof Sean Smith, Prof Stefano Sanvito | Exploring electronic functionality in low-dimensional carbon and boron-nitride nanomaterials via advanced theoretical modelling | 2011-2014 | $150,000 |
| Australian Competitive Grant Income | ARC Future Fellowships | Prof Michael Monteiro | | Transformer 3D nanostructures: stimuli responsive polymers | 2009-2013 | $445,600 |

| Type | Scheme | Lead AIBN Investigator | Other Chief Investigators | Project Title | Duration | 2011 income |
|---|---|---|---|---|---|---|
| Australian Competitive Grant Income | ARC Future Fellowships | Prof Chengzhong Yu | | Novel synthesis and bio-applications of functional macroporous ordered siliceous foams | 2010-2014 | $394,440 |
| Australian Competitive Grant Income | ARC Future Fellowships | Dr Annette Dexter | | Designed peptides as functional surfactants | 2010-2013 | $343,200 |
| Australian Competitive Grant Income | ARC Future Fellowships | Prof Mark Kendall | | Optimising the body's immune response with a Nanopatch that delivers biomolecules to the skin | 2010-2014 | $445,600 |
| Australian Competitive Grant Income | ARC Future Fellowships | Prof Ajayan Vinu | | Design of novel nanoporous semiconductor materials for clean environment and energy | 2011-2015 | $229,958 |
| Australian Competitive Grant Income | ARC Future Fellowships | A/Prof Idriss Blakey | | Smart magnetic resonance imaging (MRI) contrast agents: from early detection to assessment of drug delivery mechanisms | 2011-2014 | $176,234 |
| Australian Competitive Grant Income | ARC Future Fellowships | Dr Kristofer Thurecht | | Traceable theranostics: tools for visualising drug delivery and therapeutic benefit in vivo | 2011-2015 | $85,527 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Max Lu | Dr Shizhang Qiao, Dr Brenton Peters, Dr Michael Kennedy | Porous silica-based nanocapsules for targeted and controlled release of biocides | 2008-2011 | $222,416 |
| Australian Competitive Grant Income | ARC Linkage Projects | Dr Zhi Ping (Gordon) Xu | Prof Anh Nguyen, Dr Longbin Huang | Tailoring nano-crystal suspensions for extended ion supply to hydrophobic and hydrophilic leaf surfaces | 2009-2012 | $120,535 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Andrew Whittaker | Dr Idriss Blakey, Dr Kevin Jack, Prof John Drennan, Dr Todd Ross Younkin | Advanced lithographic solutions using block copolymers: integrating self assembly and lithography | 2009-2011 | $551,541 |
| Australian Competitive Grant Income | ARC Linkage Projects | Dr Steve Reid | Prof Lars Nielsen | In-vitro production of baculovirus biopesticides – a systems biology approach | 2009-2012 | $500,000 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Justin Cooper-White | Prof Gail Anderson, Dr Tanja Eindorf, Prof Peter Ghosh, A/Prof Stan Gronthos, Prof Andrew Zannettino | Intelligent scaffolds and methods for repair of osteochondral defects | 2009-2012 | $29,000 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Peter Halley | Prof Bhesh Bhandari, Dr Julie Cichero, Dr Leigh Ward, Dr Timothy Nicholson | A novel rheological and chewing and swallowing model for the smart design of texture modified foods for increased aged health | 2009-2012 | $120,000 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Max Lu | Prof Victor Rudolph, Dr Guo Xiong Wang | Nano- and micro-scale engineering of MoS2-based catalyst for conversion of syngas to ethanol | 2010-2013 | $187,500 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Andrew Whittaker | Prof Maree Smith, Dr Bruce Wyse, Dr Kristofer Thurecht | Novel polymeric microparticles for slow-release intrathecal delivery of analgesics | 2010-2013 | $32,000 |
| Australian Competitive Grant Income | ARC Linkage Projects | A/Prof Stephen Mahler | Prof Maree Smith, Dr Bruce Wyse, Dr Trent Woodruff, Prof Paul Marie Gerard Curmi, Dr Dean Naylor, Dr Richard Brown | Development of chaperonin 10-based second generation biopharmaceuticals for treatment of inflammatory diseases | 2010-2013 | $105,000 |
| Australian Competitive Grant Income | ARC Linkage Projects | Prof Lars Nielsen | Dr Stevens Brumbley, Dr Kristi Snell | Redirecting carbon flow through mesophyll and bundle sheath cells of sugarcane to produce poly-3-hydroxybutyrate | 2010-2014 | $575,000 |
| Australian Competitive Grant Income | Australian Institute of Nuclear Science and Engineering | A/Prof Idriss Blakey | Dr Zul Merican, Dr Suzanne Smith | Calibration of surface enhanced raman spectroscopy (SERS) with radiolabelling for quantification for ligands on gold nanoparticles | 2011 | $12,408 |
| Australian Competitive Grant Income | Australian Institute of Nuclear Science and Engineering | Dr Lizhong He | | The physical states of pharmaceutical proteins and self-assembled peptides (AINSE Research Fellowship) | 2008-2011 | $165,982 |

| Type | Scheme | Lead AIBN Investigator | Other Chief Investigators | Project Title | Duration | 2011 income |
|---|---|---|---|---|---|---|
| Australian Competitive Grant Income | Australian Institute of Nuclear Science and Engineering | Dr Kristofer Thurecht | A/Prof Idryss Blakey, Dr Suzanne Smith | Development of PET/MRI multimodal biomedical imaging agents | 2011 | $21,472 |
| Australian Competitive Grant Income | Australian Institute of Nuclear Science and Engineering | Dr Lizhong He | Dr Elliot Gilbert | Structure-function relation in polymer-protein conjugates for enhanced drug design | 2011-2012 | $14,300 |
| Australian Competitive Grant Income | NHMRC Program Grant | Prof Kirill Alexandrov | Prof Robert Parton | Molecular and functional characterisation of cell surface microdomains | 2008-2012 | $935,766 |
| Australian Competitive Grant Income | NHMRC Project Grant | Prof Julie Campbell | Dr Anita Thomas, Dr Zhiping Xu, Prof Max Lu | Antibody-directed delivery of anti-restenotic agents using inorganic nanoparticles | 2009-2011 | $78,563 |
| Australian Competitive Grant Income | NHMRC Project Grant | Prof Kirill Alexandrov | Dr Daniel Abankwa | Understanding changes in the mammalian prenylome induced by statins and prenyltransferase inhibitors | 2009-2011 | $181,250 |
| Australian Competitive Grant Income | NHMRC Project Grant | Prof Mark Kendall | Dr Germain Fernando, Prof Ian Frazer, Dr Dexiang Chen, Prof Lorena Brown | Nanopatch immunisation against pandemic influenza: improved immune responses at a reduced dose. | 2009-2011 | $122,813 |
| Australian Competitive Grant Income | NHMRC Project Grant | Prof Justin Cooper-White | Prof Dietmar Hutmacher, Dr Michael Doran, Dr Garry Brooke, Prof Julie Campbell | Taking the limp out of cartilage repair | 2010-2012 | $144,375 |
| Australian Competitive Grant Income | NHMRC Project Grant | A/Prof Christine Wells | Dr Robert Ashman, Prof Vicky Avery, Prof Sean Grimmond | Genomic characterisation of novel inflammatory regulators in a mouse model of disseminated Candidiasis | 2011-2012 | $133,415 |
| Australian Competitive Grant Income | NHMRC Training (Postdoctoral) Fellowship | Dr Bei Cheng | | NHMRC Australia-China Exchange: How does oestrogen affect blood vessels | 2009-2011 | $70,571 |
| Australian Competitive Grant Income | NHMRC Career Development Award | A/Prof Christine Wells | | NHMRC Career Development Award: Identification of novel repressors of inflammation | 2011 | $154,152 |
| Australian Competitive Grant Income | Queensland University of Technology (ARC Discovery Project administered by QUT) | Prof Darren Martin | Prof Lidia Morawska, Dr Thor Bostrom, Dr Congrong He | Detection, characteristics and dynamics of airborne engineered nanoparticles for human exposure assessment | 2011-2013 | $16,500 |
| Australian Competitive Grant Income | University of Melbourne (ARC Special Research Initiative administered by the University of Melbourne) | Prof Peter Gray | Prof Melissa Little, Prof Justin Cooper-White, Prof Sean Grimmond, A/Prof Ernst Wolvetang, Prof Lars Nielsen, Prof Perry Bartlett, A/Prof Christine Wells, Prof Martin Pera, Prof Trevor Kilpatrick, Prof David Gardner, Prof Doug Hilton, Prof Nadia Rosenthal, Prof Andrew Elefanty, Prof Ed Stanley, A/Prof Tiziano Barberi, Prof Richard Harvey, Prof Robert Graham, Prof Warren Alexander, Dr Andrew Laslett, Dr Susie Nilsson, A/Prof David Haylock | Stem Cells Australia | 2011-2018 | $1,010,625 |
| Australian Competitive Grant Income | Wesley Research Institute Limited (NHMRC Project Grant administered by Wesley Research Institute) | Dr Barbara Rolfe | Prof Julie Campbell, Prof David Johnson, Dr Ming Wei | Macrophages: A therapeutic target in peritoneal dialysis-induced fibrosis? | 2011-2013 | $105,122 |
| National and International Grant Income | Australian Stem Cell Centre | Dr Nick Timmins | Prof Michael Atkinson, Dr Garry Brooke | Development of a scalable, automated, closed system device for manufacturing clinical grade mesenchymal stem cells | 2009-2011 | $55,000 |
| National and International Grant Income | Australian Stem Cell Centre | A/ Prof Ernst Wolvetang | | Novel methods of reprogramming (ASCC Collaborative Stream 2, Module 1) | 2009-2011 | $155,114 |
| National and International Grant Income | Australian Stem Cell Centre | A/ Prof Ernst Wolvetang | | Safe and efficient expansion ofgGenetically stable hESC (ASCC Collaborative Stream 1 – Module 6) | 2009-2011 | $187,509 |

| Type | Scheme | Lead AIBN Investigator | Other Chief Investigators | Project Title | Duration | 2011 income |
|---|---|---|---|---|---|---|
| National and International Grant Income | Australian Stem Cell Centre | Prof Lars Nielsen | | Production of neutrophils (ASCC Collaborative Stream 1 – Module 4) | 2009-2011 | $259,266 |
| National and International Grant Income | Australian Stem Cell Centre | Prof Peter Gray | Prof Justin Cooper-White, A/ Prof Ernst Wolvetang | AIBN BioReactor Program (ASCC Collaborative Stream 1 – Module 2) | 2009-2011 | $404,106 |
| National and International Grant Income | Australian Stem Cell Centre | A/ Prof Ernst Wolvetang | Prof Nicholas Fisk, Dr Liza-Jane Raggatt | Primitive iPS-derived MSC for bone repair (ASCC Collaborative Stream 2 – Module 7) | 2010-2011 | $145,767 |
| National and International Grant Income | Bill & Melinda Gates Foundation | Dr Krassen Dimitrov | | Nano-dumbbells for single-molecule diagnostics from saliva | 2010-2011 | $108,175 |
| National and International Grant Income | Cancer Australia | Prof Matt Trau | A/Professor Melissa Brown, Dr Glenn Francis, Dr Kymberley Vickery, Dr Bronwyn Battersby | Nanoscaled biosensors: reading epigenetic signatures to improve breast cancer detection and treatment | 2008-2011 | $88,000 |
| National and International Grant Income | CRC for Polymers | Prof Peter Halley | Prof Mike Gidley, A/Prof Rowan Truss, A/Prof Darren Martin, Dr Fengwei Xie, Mr Luke Matthew, Mr Grant Edwards, Mr Stephen Coombs, Mr Robert Shanks | Degradable packaging materials derived from renewable resources | 2005-2012 | $211,959 |
| National and International Grant Income | Defence Materials Technology Centre | Prof Peter Halley | Mr Matthew Dargusch, Prof Graeme George, A/Prof Martin Veidt | Aircraft prognostic tools to reduce corrosion impacts (DMTC) | 2008-2015 | $213,997 |
| National and International Grant Income | Department of Education, Employment and Workplace Relations – Endeavour Research Fellowships | Dr Ranvir Singh Gill | | Identification of novel plastid targetting sequences for genetic engineering of sugarcane | 2011 | $23,500 |
| National and International Grant Income | Department of Innovation, Industry, Science and Research – ISL Australia-China Special Fund | Prof John Drennan | Prof Jin Zou | Synthesis, characterisation, and applications of novel porous materials with complicated structures | 2010-2011 | $54,780 |
| National and International Grant Income | Fondation Jerome Lejeune | A/Prof Ernst Wolvetang | Prof David Ma | Use of induced pluripotent stem cells to define genetic factors involved in abnormal myeloproliferation and leukaemia in Down syndrome patients | 2011-2014 | $33,413 |
| National and International Grant Income | Go8 Australia – Germany Joint Research Co-operation Scheme | Prof Sean Smith | Dr Harendra Parekh | Complexation and cellular uptake of genes with novel peptide-based dendrimers: a fundamental joint study involving synthesis, optical single-molecule spectroscopy and simulations | 2010-2011 | $10,518 |
| National and International Grant Income | Griffith University | A/Prof Christine Wells | | Australian Stem Cell Portal – ASCC strategic development initiative 2 | 2011 | $297,000 |
| National and International Grant Income | James Cook University | Dr Andrew Prowse | | Differentiation of human embryonic stem cells to endothelial cells | 2011-2012 | $5,500 |
| National and International Grant Income | Murdoch University | Prof Michael Monteiro | Prof Peter Gray, Dr Trent Munro, A/Prof Lianzhou Wang | Highly productive and selective bio-organic hybrid membrane water filters – National Centre of Excellence in Desalination | 2011-2013 | $145,616 |
| National and International Grant Income | National Breast Cancer Foundation | Prof Matt Trau | Prof John Forbes, Prof Susan Clark, Prof Melissa Brown, A/Prof Glenn Francis, Prof Alexander Dobrovic, Prof Rodney Scott, Dr Bronwyn J Battersby, Dr Kymberley Vickery | Novel strategies for prediction and control of advanced breast cancer via nanoscaled epigenetic-based biosensors | 2008-2013 | $1,650,000 |
| National and International Grant Income | QLD Department of Primary Industries & Fisheries | Prof Max Lu | Dr Shizhang Qiao | Platform technology for nanoparticle based non-injectible delivery of veterinary vaccines | 2008-2011 | $38,500 |
| National and International Grant Income | Queensland Government | Prof Peter Gray | | National Collaborative Research Infra-structure Strategy (NCRIS) – Capability area 5.5 biotechnology products | 2007-2011 | $213,950 |

| Type | Scheme | Lead AIBN Investigator | Other Chief Investigators | Project Title | Duration | 2011 income |
|---|---|---|---|---|---|---|
| National and International Grant Income | Queensland Government | Prof Lars Nielsen | | National Collaborative Research Infrastructure Strategy (NCRIS) – Capability area 5.1 evolving bio-molecular platforms and informatics (sub-capability – metabolomics) | 2007-2011 | $55,000 |
| National and International Grant Income | Queensland Government Smart Futures Fellowships | Dr Zhen Li | | Smart Futures Fellowship: Multifunctional magnetic nanomatrials: robust contrast agents for detection and treatment of cancers | 2009-2012 | $44,000 |
| National and International Grant Income | Queensland Government Smart Futures Fellowships | Dr Chenghua Sun | | Smart Futures Fellowship: Computer-aided synthesis of high-performance titanium dioxide for solar cells and photocatalysts | 2009-2012 | $44,000 |
| National and International Grant Income | Queensland Government Smart Futures Fellowships | Dr Claudia Vickers | | Smart Futures Fellowship: Engineering sucrose-based industrial isoprenoid production in yeast cells | 2010-2014 | $55,000 |
| National and International Grant Income | Queensland Government Smart Futures Fellowships | Dr Chamindie Punyadeera | | Smart Futures Fellowship: Saving hearts with a simple saliva test | 2010-2013 | $110,000 |
| National and International Grant Income | Queensland Government Smart Futures Fellowships | Dr Simon Corrie | | Smart Futures Fellowship: Micropatches for non-invasive disease diagnostics | 2009-2012 | $44,000 |
| National and International Grant Income | Queensland Government Smart Futures Premiers Fellowships | Prof Anton Middelberg | | Delivering smarter vaccines faster through nanotechnology | 2010-2015 | $250,000 |
| National and International Grant Income | Queensland Government Smart Futures Partnerships-Alliances Facilitation Program | Prof Lars Nielsen | Prof Peter Gray, Mr Jason Fletcher | Queensland bio jet fuel initiative | 2009-2011 | $110,000 |
| National and International Grant Income | Queensland Government Smart Futures Partnerships-Alliances Facilitation Program | Prof Peter Gray | Prof Lars Nielsen, Mr Jason Fletcher | Process modelling applicable to biofuels | 2009-2011 | $55,000 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Andrew Whittaker | Dr Firas Rasoul, Dr Anne Symons, Dr Craig Hawker, Prof Karen Wooley, Prof Julie Campbell, Prof Traian Chirila, Prof David Haddleton, A/Prof Stephen Rose, Prof Steven Howdle | International biomaterials research alliance | 2007-2011 | $64,623 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Max Lu | Professor Sean Smith, Professor John Zhu, A/Prof Lianzhou Wiang, A/Prof Joe Diniz Da Costa, | Queensland-China alliance in nanomaterials for clean energy technologies (QCANCET) | 2008-2012 | $804,375 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Lars Nielsen | Prof Sang Yup Lee | Korea-Australia bio-product alliance | 2008-2012 | $580,671 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Mark Kendall | Prof Ian Frazer, Prof Michael Roberts | International needle-free vaccination alliance (INVax) | 2009-2012 | $636,783 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Dr Krassen Dimitrov | Prof Karl Bohringer, Prof Patrick Stayton | Molecular diagnostics for tropical disease | 2009-2011 | $27,625 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Andrew Whittaker | Dr Firas Rasoul, A/Prof John Forsythe, Dr Eve Tsai, Prof Ian Brereton, Dr David Nisbet, Prof George Simon, Dr Bronwin Dargaville | Spinal chord repair | 2010-2013 | $756,631 |

| Type | Scheme | Lead AIBN Investigator | Other Chief Investigators | Project Title | Duration | 2011 income |
|---|---|---|---|---|---|---|
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Anton Middelberg | Prof Sun Yan | Vaccine now - beating infectious disease with rapid response technology | 2010-2013 | $528,000 |
| National and International Grant Income | Queensland Government Smart State National and International Research Alliances Program | Prof Lars Nielsen | Prof Peter P Gray, Mr Brad Wheatley, Dr Claudia E Vickers, Prof Rocky De Nys, A/Prof Ben Hankamer, Dr Ralf Dietzgen, Prof Peter M Gresshoff, Dr Neil Renninger | Queensland sustainable aviation fuel initiative | 2010-2013 | $1,430,000 |
| National and International Grant Income | Queensland Government Smart State Research Facilities Fund | Prof Peter Gray | Prof Lars Nielsen, Prof Justin Cooper-White, Prof Peter Halley, Prof Max Lu, Prof Anton Middelberg, Prof Andrew Whittaker, Prof Michael Monteiro, Prof Matt Trau, Dr Steve Reid, Prof Jonathan Golledge, Dr Stuart Hazell | Bionano-products development facility | 2007-2011 | $2,721,057 |
| National and International Grant Income | Rural Industries Research & Development Corporation | Dr Akshat Tanksale | Dr Jorge Beltramini | Conversion of lignocellulosic biomass to dimethyl ether (BioDMR) | 2010-2013 | $27,500 |
| National and International Grant Income | Rural Industries Research & Development Corporation | Prof Justin Cooper-White | A/Prof Paul Mills | Modulation of gap junction expression in healing equine tendon | 2007-2011 | $11,000 |
| National and International Grant Income | Seattle Biomedical Research Institute | Prof Matt Trau | Prof Gerard Cangelosi | Accelerated molecular probe pipeline | 2009-2011 | $65,361 |
| National and International Grant Income | University of Sydney | A/Prof Darren Martin | | Linked centre and services (source of funds: NCRIS) | 2009-2012 | $55,550 |
| National and International Grant Income | Department of Innovation, Industry, Science and Research (DIISR) | Prof Justin Cooper White | | NCRIS Fabrication Facility | 2007-2011 | 1,400,000 |
| National and International Grant Income | Department of Innovation, Industry, Science and Research (DIISR) | Prof Peter Gray | | NCRIS Biotech Products Facility | 2007-2011 | 700,000 |
| National and International Grant Income | Department of Innovation, Industry, Science and Research (DIISR) | Prof Lars Nielsen | | NCRIS Metabolomics Facility | 2007-2011 | 121,500 |
| Contract Research and other Industry Income | Uniquest Pty Ltd | A/Prof Stephen Mahler | | Bioproton phytase enzymes | 2010-2011 | $181,500 |
| Contract Research and other Industry Income | Uniquest Pty Ltd | Prof Mark Kendall | | Nanopatch - delivery device | 2011-2012 | $925,456 |
| Contract Research and other Industry Income | Uniquest Pty Ltd | Dr David Chin | | Recombinant antibody manufacture | 2011-2012 | $314,471 |
| Contract Research and other Industry Income | Incitec Pivot Limited, Southern Cross Operations | Dr Zhi Ping (Gordon) Xu | Dr Longbin Huang, A/ProfRowan W Truss | Preparation of cross-linking starch-based nanocomposite films and characterisation of water adsorption and mechanical strength | 2010-2011 | $36,667 |
| Contract Research and other Industry Income | Australian Coal Research Limited | Dr Krassen Dimitrov | Laurie Gibson | Application of nano particles to fine coal float sink test | 2011-2013 | $35,200 |
| Other | Research Donation Generic | Prof Anton Middleberg | | Australia-Vietnam Engineered Vaccines Alliance (AVEVA) | 2011-2013 | $59,559 |

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# AIBN SEMINARS 2011

4 February: **Professor Xinhe Bao**, Dalian Institute of Chemical Physics, the Chinese Academy of Sciences, China
**Title:** Catalysis with nano-structured carbon materials

9 February: **Professor Harm-Anton Klok**, Ecole Polytechnique Fédérale de Lausanne, Institut des Matériaux and Institut des Sciences et Ingénierie Chimiques, Laboratoire des Polymères, Lausanne, Switzerland
**Title:** Precision synthesis of diagnostic and sensory polymer brushes

9 February: **Professor Xinhe Bao**, Dalian Institute of Chemical Physics, the Chinese Academy of Sciences, China
**Title:** Interface confinement and catalysis with oxide systems

10 March: **Professor Ajayan Vinu**, International Center for Materials Nanoarchitectronics, World Premier International Research Center, NIMS, Japan
**Title:** Advanced functional nanoporous non-siliceous materials with multiple functions

17 March: **Professor Warren D (Skip) Heston**, Cleveland Clinic Lerner College of Medicine of Case Western Reserve University, US
**Title:** Prostate specific membrane antigen: a target for imaging and therapy for prostate cancer and tumor vasculature

24 March: **Dr Ian Nisbet**, Industrial Affiliates Program Coordinator, AIBN
**Title:** Experiences in the commercialisation of technology and how the industrial affiliates program fits in AIBN commercialisation activities

31 March: **Professor Christine Wells**, Group Leader, AIBN
**Title:** Expression and expressivity: Why biological variation is no longer a dirty little secret

7 April: **Professor Cameron Alexander**, University of Nottingham, UK
**Title:** Polymer switches and biological responses

8 April: **Professor Giorgio Carta**, Biomolecular Interaction Center Fellow, University of Canterbury, New Zealand; Department of Chemical Engineering, University of Virginia, Charlottesville, Virginia, US
**Title:** Can we remove the downstream processing bottleneck in biopharmaceutical production?

14 April: **Professor Robin Mortimer AO**, Executive Director, Office of Health and Medical Research, Queensland Health, Brisbane, Australia
**Title:** Vision for translational research in Queensland

14 April: **Dr Lisa White**, Tissue Engineering Group, Centre for Biomolecular Sciences, University of Nottingham, UK
**Title:** Supercritical CO2 foamed scaffolds for tissue engineering

21 April: **Professor Peter M Gresshoff**, Director, ARC Centre of Excellence, Integrative Legume Research, The University of Queensland, Australia
**Title:** Molecular characterisation, growth and improvement of the tree legume Pongamia pinnata, a next-generation bioenergy feedstock

12 May: **Professor Jeff Gorman**, Head, QIMR Protein Discovery Centre, Queensland Institute of Medical Research, Brisbane, Australia
**Title:** Regulation of type I-dependent and independent antiviral responses by respiratory syncytial virus non-structural protein 1

18 May: **Professor Mark Biggs**, School of Chemical Engineering, University of Adelaide, Australia
**Title:** Towards the rational de novo design of solid-binding peptides for advanced functional and nanoscale materials and systems

19 May: **Professor Andras Nagy**, Senior Scientist, Samuel Lunenfeld Research Institute, Mount Sinai Hospital; Professor, Department of Molecular Genetics and Institute of Medical Science, University of Toronto; Investigator, McEwen Centre for Regenerative Medicine, Toronto, Canada
**Title:** Stem cells: is the hype getting normalised?

26 May: **Professor John Drennan**, Group Leader, AIBN; Director, Centre for Microscopy and Microanalysis, The University of Queensland, Australia
**Title:** It might not be nanotechnology or bioengineering but it's rocket science

23 June: **Dr Karine Mardon**, NIF Facility Fellow, Centre for Advanced Imaging, The University of Queensland, Australia
**Title:** Micro PET/CT scanner

7 July: **Professor Andreas Schmid**, Laboratory of Chemical Biotechnology, TU Dortmund University, Germany
**Title:** Catalytic biofilms

28 July: **Dr Jessica Mar**, Department of Systems and Computational Biology, Albert Einstein College of Medicine, New York, US
**Title:** Modelling cell fate transitions and a variance-based approach to studying human disease

9 August: **David Rooney**, UQ Business School, The University of Queensland, Australia
**Title:** Science leadership

11 August: **Professor Nadia Rosenthal**, Director, Australian Regenerative Medicine Institute, Monash University, Victoria, Australia
**Title:** Enhancing mammalian regeneration

12 August: **Professor Molly Stevens**, Department of Materials and Institute for Biomedical Engineering, Imperial College London, UK
**Title:** Bio-inspired nanomaterials for regenerative medicine and sensing

15 August: **Professor Bert Meijer**, Institute for Complex Molecular Systems, Laboratory of Macromolecular and Organic Chemistry; Laboratory of Chemical Biology, Eindhoven University of Technology, the Netherlands
**Title:** Supramolecular biomaterials: a modular approach to bioactivity

18 August: **Dr Sally Louise Gras**, Chemical and Biomolecular Engineering, University of Melbourne, Victoria, Australia
**Title:** Functional peptide materials

25 August: **Dr Mireille Lahoud**, Senior Research Officer, Division of Immunology, Walter and Eliza Hall Institute of Medical Research, Victoria, Australia
**Title:** The dendritic cell danger receptor Clec9A: characterisation and immunomodulatory potential

1 September: **Dr Geoff Garrett AO**, Queensland Chief Scientist
**Title:** Leading clever people through change

8 September: **Professor Ulrich Wiesner**, Spencer T Olin Professor of Engineering, Department of Materials Science and Engineering, Cornell University, New York, US
**Title:** Functional nanomaterials

15 September: **Dr Richard Clark**, ARC Future Fellow, School of Biomedical Sciences, The University of Queensland, Australia
**Title:** Understanding the structure/activity relationships of the iron regulatory peptide hepcidin

22 September: **Associate Professor Sebastian Perrier**, Director, Key Centre for Polymers and Colloids, School of Chemistry, University of Sydney, New South Wales, Australia
Title: Using molecular engineering to build nanostructured materials

13 October: **Dr Pamela Pollock**, Senior Research Fellow, Faculty of Science and Technology, Queensland University of Technology, Australia
**Title:** FGFR2 mutations in endometrial cancer: prognostic and therapeutic implications

20 October: **Associate Professor Freddy Kleitz**, Department of Chemistry, Université Laval, Québec, Canada
**Title:** Functional mesoporous materials: from material synthesis to application perspectives

27 October: **Professor Rod Boswell**, Research School of Physical Sciences and Engineering, Australian National University, Australian Capital Territory, Australia
**Title:** Tailoring crystalline structure in N-doped TiO2 thin films: application to photocatalytic and biological reactions

28 October: **Dr Bradley Ladewig**, Department of Chemical Engineering, Monash University, Victoria, Australia
**Title:** Metal organic framework composite membranes for gas separation

3 November: **Professor Debra J Bernhardt**, Director, Queensland Micro and Nanotechnology Centre; Professor, School of Biomolecular and Physical Sciences, Griffith University, Queensland, Australia
**Title:** Fluctuations and transport in nanoscale systems

17 November: **Dr Hans P Kocher**, Executive Director, Integrated Biologics Profiling, Novartis Pharma AG, Basel, Switzerland
**Title:** Developability assessment and expression of therapeutic antibody candidates

22 November: **David Shaw**, Additives Europe Technical Manager, Rockwood Additives Ltd, Cheshire, UK
**Title:** Functional clay: their properties, use and manufacture

24 November: **Associate Professor Andrew Dove**, Department of Chemistry, University of Warwick, Coventry, UK
**Title:** Functionalisation and self-assembly of degradable polymers

24 November: **Professor Alan M Bond**, RL Martin Distinguished Professor of Chemistry, Monash University, Melbourne, Victoria, Australia
**Title:** Broadening electrochemical horizons: advances in chemical knowledge achieved by use of modern electrochemical techniques

24 November: **Professor Linjie Zhi**, Institute of Chemistry, Chinese Academy of Science, China
**Title:** Chemical approaches towards well-defined grapheme-based nanomaterials for energy applications

28 November: **Professor Tanya Monro**, ARC Federation Fellow; Director, Institute for Photonics and Advanced Sensing, University of Adelaide, Australia
**Title:** Creating new tools for measurement: emerging optical fibre sensors

12 December: **Professor Dr Rachel O'Reilly**, Department of Chemistry, University of Warwick, Coventry, UK
**Title:** Polymer nanostructures: synthesis, characterisation and application

14 December: **Dr Hilary Burch**, Research Assistant, AIBN
**Title:** Navigating the world of scientific publishing: hints and tips from an insider

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## Our history

- AIBN was established by The University of Queensland Senate in December 2002.
- Construction of a custom-designed 15,689sq m AIBN research facility started in November 2004.
- First AIBN Group Leaders appointed in 2005.
- The $73.6 million AIBN research facility was completed in August 2006.
- Then Queensland Premier Peter Beattie opened the facility on October 23, 2006.

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