

# Bioengineering for a Healthy Future

**Capability Portfolio** 

UNSW, Your Research Partner of Choice





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# FROM THE PRESIDENT AND VICE-CHANCELLOR

A core part of our mission at UNSW is to make an impact beyond our campus gates. We seek to transform lives through advancing knowledge and understanding, by generating debate and by driving economic and social progress.

Universities like UNSW have enormous potential to transform the communities of which we are part and change people's lives for the better.

One of the most direct ways a university can change lives – indeed save lives – is through health and medical research. Bioengineering for a Healthy Future outlines our expertise and activities in health and bioengineering, making a compelling case for governments and industry to partner with us on a wide range of ground-breaking projects.

This document highlights the full breadth of our university's capabilities across connected healthcare, bionics, bioengineered materials and technologies, biomolecular innovations, and medical imaging analytics – all of which are areas of enormous potential.

The medical technology sector, especially, is set to be a key driver of the Australian economy in the future. As it grows, so too will the impact on millions of people worldwide who will benefit from innovative clinical practices, treatments and devices.

At UNSW, we continuously seek to increase our level of collaboration across the country and across sectors, chasing the best outcomes for the communities we serve.

As you read this Capability Portfolio, I encourage you to consider how we might work together towards our common goals and a healthy future for people in Australia and worldwide.

Professor lan Jacobs President and Vice-Chancellor, UNSW



# FROM THE DEPUTY VICE CHANCELLOR ENTERPRISE

The UNSW Division of Enterprise is responsible for facilitating engagement between our academics and partners from industry, government and the community. In the last four years we have doubled our partner engagement delivering high impact and high quality outcomes through contract and collaborative research, consulting, short courses and executive education.

Our expertise in biomedical engineering research has a critical role to play in finding new solutions to biological, medical and healthcare problems. Through the development of health technologies and advances in diagnostics and therapies we work towards improving the treatment and quality of life for Australians with life-threatening or debilitating diseases and conditions.

UNSW is committed to engaging with our partners to deliver social progress and economic prosperity, generating impact, mutual benefit and value. In support of this mission, through collaboration and innovation the Division of Enterprise aims to bring together the greatest minds within global industry, policy, academia and our community and build a culture of knowledge exchange. Furthermore, we host Australia's most successful entrepreneurship and start up programs.

Our dedication to establishing the critical elements of an innovation ecosystem underpins the development and potential impact of our oncampus precincts in future industries, health and clinical translation. With the release of this Capability Portfolio we invite our partners, both prospective and current from industry, government and the community, to explore just some of the expertise we hold within and look forward to exploring opportunities for collaboration, innovation and impact.

Professor Brian Boyle Deputy Vice-Chancellor, Enterprise, UNSW

# CONNECTED HEALTHCARE



## Signal, Information and Machine Intelligence Lab

#### More information

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Working at the crossroads of health and technology to apply signal processing and machine learning algorithms to data, such as speech and bio-signals, to assist healthcare providers and improve the quality of patients' lives.

#### Competitive advantage

Expertise in:

Impact

- Non-intrusive health monitoring via audio signals
- Disordered speech monitoring
- Behavioural analyses
- Biomedical signal processing
- Machine learning and pattern classification
- Analyses of EEG, ECG, heart rate, respiratory rate, skin conductance
- Voice biometrics

With the use of machine learning and artificial intelligence, data such as speech and bio-signals – which contain tremendous amounts of information about health and wellbeing – can be used to determine if patients are at risk of health problems, provide feedback on the effectiveness of therapy and to interpret and help to regulate stress levels.

#### Successful outcomes

- Validated automated speech therapy system for children with apraxia of speech in clinical trials
- Prediction, detection and monitoring of a number of conditions and emotional states
- Fluorescence lifetime imaging endoscope
- Bayesian frameworks for incorporating uncertainty into machine intelligence for prediction and recognition of ambiguous, subjective and perceptual attributes such as emotional state
- · Characterisation and recognition of speaker attributes in voice biometric systems
- Smartphone applications to monitor mental states and speech disorders
- Longitudinal validation of biofeedback games for stress self-regulation

#### **Capabilities and facilities**

- High performance computing capabilities for large scale signal and information analysis, and training machine learning models
- Large library of code, scripts and databases of speech and other signals
- Soundproofed, light-controlled studio facility for recording speech and behavioural signals

- Charité Universitätsmedizin, Berlin, Tex Germany Col
- Texas A&M Diagnostic Sciences, College Station, USA
- · Hamad Hospital, Qatar

# Making a Smart Assessment of Mental State

More information

**Professor Julien Epps** School of Electrical Engineering and Telecommunications

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Automatically detecting mental state and depression by using voice screening and monitoring to make a non-invasive, cheap, smartphone-based assessment.

#### **Competitive advantage**

- State-of-the-art speech-based assessment of depression via smartphone
- · World leaders in automatic voice analysis

#### Impact

- Smartphone-based solutions will reach millions of patients worldwide, and allow collection of big data
- The technology also covers call-centre type solutions e.g. for automatically detecting suicidality in telephone calls

#### Successful outcomes

- Early trials currently being conducted by ARC Linkage partner SondeHealth, with large pharmaceutical companies
- Provisional patent currently being filed
- Extended team (via ARC Linkage Project) has a quick path to market and are experts in app-based mental health interventions

#### **Capabilities and facilities**

Access to what is probably the largest depressed-speech database
 in the world

- SondeHealth
- Black Dog Institute



Associate Professor Blanca Gallego Luxan Centre for Big Data Research in Health

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Digitalisation of healthcare gives a unique opportunity to leverage information to help patients and clinicians choose the best care pathways. The design, development and evaluation of technology that uses large repositories of routinely collected data, supports the making of safe and optimal clinical decisions for individual patients.

#### **Competitive advantage**

- Working at the intersection of medicine and computing, bringing together doctors, pharmacists, mathematicians, software engineers and computer scientists
- State-of-the-art technologies and the use of large clinical practice datasets
- · Fully validated solutions and technology that is cost-effective and safe
- Ability to understand clinical decision making and the challenges in translating machine learning techniques into clinical practice

#### Impact

- Reduction of unnecessary hospitalisations and ICU admissions through timely and accurate identification of patients at risk
- Personalised, safer and more effective healthcare delivery through identification of what works best, and for which patients

#### Successful outcomes

- A 'watch list' tool to automatically populate list of patients at high risk of deterioration to prevent unnecessary ICU admissions
- Tool to standardise the names of the structures delineated in radiotherapy plans to enable big data analyses in cancer care
- A suite of algorithms to estimate heterogeneity of treatment effects from large routinely collected datasets

#### **Capabilities and facilities**

- A secure, customisable cloud computing infrastructure certified in accordance with the Privacy Security Assurance Framework, which allows the use of high-computing resources on sensitive or confidential data
- Access to big medical data from Australia, UK and US
- Expertise on state-of-the-art computational statistics including deep learning, interpretable machine learning and causal inference algorithms

- Prince of Wales Hospital, Sydney
- Stanford UniversityThe University of Oxford
- St Vincent's Hospital, Sydney
   The University
- Northern Sydney Cancer Centre
- · e-Health NSW



**Professor Louisa Jorm** Centre for Big Data Research in Health

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Applying advanced analytics to big data-including the millions of records generated routinely by health services, clinical data captured at the point-of-care, and data generated by the population at large through technologies such as wearable devices and social media-in order to enhance health and wellbeing.

#### Competitive advantage

Internationally recognised expertise across the following capability areas:

- Data science, data analytics, biostatistics, epidemiology and bioinformatics
- Ethical, legal and policy frameworks relevant to using health big data
- · Secure management, sharing, curation and stewardship of health big data
- Developing and delivering training in health data analytics
- · Communicating complex research findings through multiple modalities, including data visualisation, technical reports, plain-English briefings, multimedia products and social media

#### Impact

Bringing together researchers, consumers, clinicians, industry and government to frame relevant research questions, generate research designs that apply to real-world contexts, and commit to implementing the research and its findings.

#### Successful outcomes

- · Analysis of Healthdirect telephone helpline records, to identify whether people followed advice and the outcomes
- Analysis of In-Vitro Fertilisation (IVF) treatment data to determine chances of success
- · Analysis of data for NSW children showing a later school start has clear developmental benefits

#### **Capabilities and facilities**

E-Research Institutional Cloud Architecture (ERICA) secure cloud-based platform for research using sensitive microdata.

- Australian Commission on Safety and Quality in Health Care
- Australian Government Department of Health
- Department of Veteran's Affairs
- Healthdirect Australia
- Australian Institute of Health and Welfare

- NSW Ministry of Health
- · Department of Health and Human Services Victoria
- New Zealand Ministry of Health
- NPS MedicineWise
- Prospection Pty Ltd
  - Janssen Pty Ltd



**Dr Nadeem Kaakoush** Microbiome Interactions Group School of Medical Sciences

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Specialising in microbiome data analytics for biomarker discovery focused on chronic inflammatory diseases of the digestive tract, and gastrointestinal cancers in particular.

#### **Competitive advantage**

- Expertise in deep profiling of the human microbiome documented in high impact outputs
- Documented capacity to perform multi-omics strategies
- Long-term experience with the handling and extraction of a range of clinical samples

#### Impact

Profiling the human microbiome – now causally linked to a range of diseases that fall within the broad themes of cancer, infectious disease, non-communicable diseases and mental health – using next generation sequencing and big data analytics.

#### Successful outcomes

- Identified microbial signatures associated with therapeutic efficacy of faecal microbiota transplantation in ulcerative colitis
- Identified novel associations between the oesophageal microbiome and the progression of the oesophageal adenocarcinoma cascade

#### **Capabilities and facilities**

- Experience in study design, patient recruitment and sample collection for optimal downstream analysis
- Handling and extraction of clinical samples of diverse origins
- Access to next-generation sequencing facilities and computing infrastructure to handle big data
- Established data analysis pipelines for signature discovery

#### Our partners

Extensive list of clinical collaborators and historic data sharing relationships with industry partners.

# Managing Chronic Disease and Wellness Using Telehealth Technologies

#### More information

Scientia Professor Nigel Lovell Graduate School of Biomedical Engineering

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Integrating various telehealth technologies to better support those suffering from chronic disease, provide continuity of care from the hospital to the home and promote preventive health and wellness strategies.

#### Competitive advantage

- · Access to patient clinics and study groups
- Active presence in the Randwick Health Zone, including close involvement in the design of a Virtual Care Centre planned for the new Prince of Wales Hospital (POWH)
- Engagement of clinicians and stakeholders to promote user-centric systems design
- Decades of experience in medical device regulatory approvals (TGA/FDA/CE) and development of health-authority-compliant software architectures

#### Impact

- Reduce hospital readmissions and patient mortality by 40%
- Reduce complications caused by non-adherence to prescribed medications

#### Successful outcomes

- Systems piloted in clinical trials at POWH in the cardiac rehabilitation setting
- Expanded to a clinical trial throughout NSW hospitals for reducing hospital readmissions in the case of cardiovascular disease

#### **Capabilities and facilities**

- · Algorithms for health risk stratification
- Software lifecycle development processes
- Network laboratory of dedicated software developers currently engaged in a dozen health projects using common tools and architectures

- Neuroscience Research Australia (NeuRA)
- Numerous hospitals throughout Australia
- NSW Ministry of Health
- Agency for Clinical Innovation

# Cardiovascular Simulation and Device Development



#### More information

**Dr Socrates Dokos** Graduate School of Biomedical Engineering

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A close collaboration between clinicians and biomedical engineering enables patient specific planning for complex cardiac procedures, and simulation to improve device design and delivery.

#### Competitive advantage

- Closely link engineering and clinical team
- Well developed cardiovascular simulation focused on improving outcome
- Experience with multimodal cardiac imaging techniques

#### Impact

- Improved and accelerated device design
- Increased certainty of procedural planning for early stage device implementation
- Improved device sizing for complex procedures
- Clinician education/skills simulation

#### Successful outcomes

- Cardiovascular 3D printing for early-stage device development and testing
- Patient specific simulation for first-in-man and early stage cardiovascular device deployment
- · Complex surgical and cardiovascular intervention planning

- · Cardiac segmentation and analysis
- Cardiovascular simulation: COMSOL/Matlab
- 3D Printing

# Generating Real-World Evidence about Prescribed Medicines



#### More information

**Professor Sallie Pearson** Centre for Big Data Research in Health

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Leveraging population-based, routinely collected data to generate real-world evidence about prescribed medicines.

#### Competitive advantage

- Unique combination of skills, in the ethics, governance, analysis and interpretation of large-linked data
- Leader in high-quality, interdisciplinary health research using big data
- Training and capacity building in health big data analytics
- Long-standing and productive partnership with clinicians, policymakers and industry to facilitate the rapid translation of research findings into health improvements

#### Impact

Population data linkage is a powerful and cost-effective means of generating unbiased, long-term evidence about the use, risk and benefits of prescribed medicines and the impact of health interventions.

- Specialist skills in (pharmaco)epidemiology, biostatistics and health data science
- Deep understanding of relevant ethical, legal and policy frameworks
- High-level expertise in the secure management of big data
- Proficiency in developing and delivering training



Scientia Professor Carla Treloar Centre for Social Research in Health Social Policy Research Centre

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The work of the Centre for Social Research in Health (CSRH) attempts to fill the gap between the promise of biomedical technologies and their translation as impactful interventions in the real-world.

#### **Competitive advantage**

- CSRH has built a national and international reputation over nearly 30 years – in exploring the health and well being of populations, particularly those experiencing marginalisation
- Led the world in monitoring the uptake of HIV prevention and treatment technologies
- Expertise in the implementation and acceptability of new models of care, and investigations into under-use of new medicines
- Designed new prevention technologies and studied factors affecting acceptability of new biomedical technologies
- · Work closely with affected communities, clinicians and policy makers

#### Impact

The mission is to support efforts to maximise the return on investments in new technologies to promote health, and to keep a careful watch on practices or policies that may create or exacerbate inequalities.

#### Successful applications

The potential to explore the factors that can optimise the roll out and scale of new medicines and technologies from the perspectives of:

- End user (consumer)
- Health worker (including at the bedside, in the laboratory, in prevention and treatment)
- Stakeholder (industry, policy maker, funder)

- CSRH is a specialist research centre. Researchers are leaders in their fields, with a strong reputation in the academic community
- The Centre fosters the talents of the next generation of social science researchers through support for early career researchers and our postgraduate research program.

# **Artificial Intelligence** (AI)-Empowered Biomedicine

#### More information

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The AI-empowered biomedicine laboratory develops cutting-edge innovative AI and machine-learning methodologies to integrate and interpret large-scale molecular and clinical data to promote personalised medicine and precision therapy.

#### **Competitive advantage**

- · Multidisciplinary expertise and cross-faculty collaborations
- Developing advanced machine-learning methods and deep-learning models that leverage large omics data

#### Impact

- Improving translational genomics and personalised medicine
- · Facilitating tailored treatment and precision therapy
- · Reducing the cost and timeframe of drug development
- Reducing the risk of type 2 diabetes
- Developing downloadable/online toolkits reusable in different clinical settings

#### Successful outcomes

- · Discovery of circulating microRNA markers of colorectal cancer prognosis
- Identification of diagnostic non-coding RNAs in ovarian tumour microenvironment associated with metastasis
- Identification of exosomal microRNA biomarkers for non-invasive glioblastoma diagnosis
- ExomiR signatures of disease status in multiple sclerosis
- Network-based drug repositioning led to identification of less-toxic cancer treatment drugs
- Prediction of functional noncoding variants in human brain genome (in progress)
- · Comprehensive databases on mammalian cellular interactions
- Development of computational tools and software for biomarker discovery and drug repurposing

#### **Capabilities and facilities**

- High-Performance Computing (HPC) resources for model development
- Access to Australia's largest genomics facilities with state-of-the-art next-generation sequencing technologies
- Highly multidisciplinary research network enabling translation of the research outcomes

- Nutromics Pty Ltd
- BCAL Diagnostics
- Royal Prince Alfred Hospital

# **Expanded Perception and**

# Interaction Centre (EPICentre)

#### More information

Associate Professor Tomasz Bednarz Director EPICentre UNSW Art & Design

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A pioneering high-performance visualisation facility that forges new ground in integrated artistic, biomedical and scientific thinking to facilitate understanding of complex datasets and ultra-scale imagery.

#### **Competitive advantage**

- High-End Visualisation System (HEVS) removes barriers of entry for deploying visualisation applications to any platform
- · The most influential computer graphics and high-performance visualisation lab in Australia
- EPICentre hosts the highest resolution Virtual Reality (VR) system in the world

#### Impact

EPICentre promotes cross connection of visualisation with applied computational simulations, artificial intelligence (AI), and creativity in arts, science, design, engineering, medicine and education.

#### Successful applications

- Massive Networks and AI: visualisation and analytics of very large-scale graphs in immersive environments
- Microscope on Big Genomics Data: innovative fully interactive and ultra-highresolution navigation tool to browse and analyse gene expression levels from human cancer cells.
- Visual Analytics of Single Cell Microscopy Data: immersive visualisations integrating bio-images and derived quantitative data

#### **Capabilities and facilities**

- EPICylinder: 340-degree cylindrical screen, ~120 million pixels in 3D
- DomeLab: 6.4m Hemispherical Full-Dome 4K
- XR-Lab and CG-Lab: wide range of VR / AR / XR systems, motion tracking system
- Interactive 3x3 MultiTaction iWall
- Al-driven Visual Analytics, with creative and design-led approach to solving complex problems

#### Our partners

• CSIRO (Data61, CASS and IM&T); Children's Cancer Institute; NMI; NIST; Association for Computing Machinery (SIGGRAPH); Khronos Group; DSTG



Scientia Professor Dennis Del Favero Chair Professor of Digital Innovation Director iCinema Research Centre

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Undertaking immersive and interactive projects, through the use of next generation cyber/physical technologies, to re-imagine ways of creating, designing, learning and working.

#### Competitive advantage

- Multidisciplinary centre bridging key research areas across multiple faculties
- World-leading expertise in artificial intelligence, AR, VR, mobility and robotics
- Frontier 3D Cinematic, modelling, printing, scanning and robotic platforms
- Global network of cutting-edge research and industry partners

#### Impact

- Facilitating the use of next-generation immersive interactivity applications in contemporary art, cultural heritage, defence memorialisation, digital museology and mining simulation
- Contributing to Australia's international leadership in transformative aesthetic advances that translate cutting-edge visualisation research into industry application
- Enabling end-users to explore interactive modelling of fictional and real-world scenarios in real-time at cinematic 1:1 scale through full-body physical exploration, supported by artificial intelligence systems
- Providing innovative visualisation modalities greatly sought after in a world increasingly reliant on joint human and machine decision-making

#### **Successful applications**

- Construction Safety VR for Brookfield Multiplex, Sydney
- Cultural Heritage Installation for The Smithsonian, Washington
- Metro 3D Immersive Prototyping for WSP, Sydney
- Mine Training and Planning VR Systems for China Technology & Engineering Group, Fushun

- 360 degree full-body AR and VR Platform with 20M pixel resolution
- Wide range of Head Mounted Display systems
- Ultra-High-Definition 5K fixed and mobile 2D/3D scanning systems
- Advanced Robotic Interaction facilities
- Interface for seamless communication between physical and virtual worlds
- Key research areas across multiple faculties of Art and Design, Art and Social Sciences, Engineering, Science and NIDA

## 3D Visualisation Aesthetics Lab (3DVAL)



#### More information

Associate Professor John McGhee UNSW Art & Design

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Exploring the challenges of visual narratives and developing novel ways to navigate complexity using creative methodologies from the video game, 3D computer animation and Virtual Reality (VR) creative content industries.

#### Competitive advantage

- An award-winning cross-disciplinary research hub that explores arts-led approaches for visualising complex scientific and biomedical scan data
- Research team with diverse multimedia and scientific backgrounds, and considerable industry experience
- Proven ability to deploy design-led modes to the visualisation of complex scientific and biomedical data using 3D computer arts approaches, most recently VR Head Mounted Displays (HMD)

#### Impact

Award-winning visualisations with real-world applications, including disease comprehension and rehabilitation.

#### Successful applications

- VR Pain Management System provides effective distraction to hospital patients experiencing acute pain via a gamified exploration of virtual worlds. A collaboration with St. Vincent's Hospital and Samsung
- 'Journey to the Centre of the Cell' project, which recreates a breast cancer cell, was nominated in the Best VizSim Project category for visualisations that have real-world applications, and for the overall Golden Cube award as part of the International 2016 Unity awards in Los Angeles, USA
- 'A fantastic voyage-travel inside your brain and visualise your own stroke' was awarded the 2016 St Vincent's Hospital Innovation & Excellence Award for clinical health engagement, allowing patients to explore personalised vascular scans

#### **Capabilities and facilities**

- Wide range of VR / AR systems
- State-of-the-art 3D visualisation creative content studio
- 3D computer workstations
- Render farm systems

- St. Vincent's Hospital
- Garvan Institute for Medical Research
- ARC Centre of Excellence in Convergent Bio-Nano Science & Technology (CBNS)





**Professor Lynne Bilston** NeuRA (Neuroscience Research Australia)

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New therapies to activate muscles with high temporal and spatial control offer a novel therapeutic approach to a wide range of clinical conditions that include poor muscle activation as a key problem. One such approach is optogenetic muscle activation techniques, which use a light stimulus to activate muscle cells that have had light-sensitive ion channels expressed in them.

#### Competitive advantage

- First in the world optogenetic approach for Obstructive Sleep Apnoea (OSA)
- Unique direct muscle stimulation optogenetics approach that minimises systemic and off-target effects

#### Impact

Optical techniques offer an exciting, new, minimally invasive method for Obstructive Sleep Apnoea, and more broadly for skeletal muscle control. An optogenetic approach to OSA aims to be effective for all patients whilst being comfortable and tolerable.

#### Successful outcomes

- Optical stimulation of upper airway dilator muscle (genioglossus) in an animal model
- Stimulator proof-of-concept design

#### **Capabilities and facilities**

- Electrophysiology
- Optogenetic electrophysiology experiments
- Single motor unit recording
- Electronic/Industrial and Mechanical Design
- Rapid electronic and mechanical prototyping
- PCB/Schematic design
- 3D printing
- Midfield wireless powering for low power implantable stimulators

#### **Our partners**

• National University of Singapore

- Sleep & Respiratory Physiology

   Neurophysiological techniques to study human upper airway muscle activity function and airway mechanics during wakefulness and sleep
- Imaging
- Magnetic Resonance Elastography
- 2 Photon Microscopy
- Multi-Modal MR Imaging Techniques

# Advanced Flexible Surgical Robotics and Wearable Assistive Devices



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Flexible robotic systems for effective diagnosis and treatment of various cancers and cardiovascular diseases. Wearable devices can enhance the human sense of touch and can be applied to rehabilitation and healthcare sectors, entertainment and defence.

#### Competitive advantage

- World-leading technologies in soft robotics, wearable devices, and flexible surgical systems with multifunctionalities that can be applied widely in various applications
- Expertise in mechanical design, electronics, system modelling, functional materials and nonlinear control
- Experience in international patent protection

#### Impact

Improving the quality of human life with cutting edge technologies and using surgical robotics, soft robotics, and haptic systems to make early diagnosis and to treat cancers within the human gastro-intestinal tract, as well as the heart, lungs, and bladder.

#### Successful outcomes

- World's first flexible endoscopic robot for gastrointestinal cancer treatment
- World's first multifunctional muscles and microtubule sensors for haptics and robotic applications

#### **Capabilities and facilities**

Full-scale experimental equipment for real-time control and characterisation of robotics and mechanical systems.

#### **Our partners**

Strong collaboration networks in USA, Singapore, and Australia.

Structure-Property Relation in Biomaterials and Failure Characterisation of Materials used for Implants

#### More information

Dr Bernd Gludovatz School of Mechanical and Manufacturing Engineering

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Developing a better understanding of biological and nature-inspired materials; researching the impact of diseases like osteoporosis or diabetes on bone quality; and contributing to the design of advanced, damage-tolerant materials for use in prosthetic devices through characterisation, testing, and failure analysis over a wide range of naturally occurring environments.

#### Competitive advantage

- Mechanical performance characterisation in various environments both
   in-situ and ex-situ
- Simultaneous characterisation of failure evolution on multiple length scales
- Experience working on conventional implant materials and novel composites; e.g. high-entropy alloys, intermetallics and bio-inspired composites

#### Impact

- Understanding the origin of mechanical performance in biological materials
- Characterising the impact of diseases, including their treatments, on the structural reliability of biomaterials such as bone
- Developing improved material combinations for implants

#### Successful outcomes

- Understanding the development of bone structure and quality during skeletal growth
- Evaluation of diseases and drug treatments on the mechanical competence of bone
- Understanding the effect of testing conditions on the fracture resistance of human bone
- Small-scale testing of remineralised carious lesions in human teeth
- Damage-tolerance evaluation of biological materials for use in nature-inspired material design
- · Characterisation of causes of various implant failures

#### **Capabilities and facilities**

- · Alemnis in-situ nano-indenter with intrinsic displacement control
- Deben micro-tester for both in-situ and ex-situ observation of deformation
   and failure
- · Instron multi-axial testing frames with temperature and environment control

#### **Our partners**

Various companies requiring failure analysis of orthopaedic, cardiac and respiratory medical implant devices made from materials such as oxidised zirconium, pyrolytic carbon and nickel-titanium shape memory alloys



**Dr Heba Khamis** Graduate School of Biomedical Engineering

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Restoring missing sensory function following hand amputation is a challenge for prosthetic designers/engineers. This patented technology replicates the human sense of touch and could provide upper limb prosthetics of the future with a sense of friction and grip security, which is essential for dexterity.

#### **Competitive advantage**

- Patented soft sensor design can measure 3D localised force, 3D localised deflection, 3D localised vibration, torque, incipient slip (when parts of a surface slip while other parts remain stuck) and friction at the contact interface
- No other sensing technology can measure all of these parameters which are sensed by the human skin and play an essential role in enabling human dexterity
- Sensor technology could provide upper limb prosthetics of the future with a sense of touch
- The size, density, compliance, measurement range and sensitivity of the sensor can be customised
- The sensor is resistant to heat, shock, water and chemicals

#### Impact

Applications of the tactile sensing technology include hand prostheses, robotic surgery, robot-assisted rehabilitation – which improve control and dexterity through feedback mechanisms based on tactile information.

#### Successful outcomes

Successful participation in the CSIRO ON Accelerate 2019 start-up accelerator program for commercialisation.

#### **Capabilities and facilities**

- Electrical engineering (electronics design and signal processing)
- Software engineering (firmware and software design and programming)
- Machine learning
- Prototyping
- 3D printing
- Electronics
- Testing equipment including robotic arms and grippers and mechanical stages

#### **Our partners**

Funding from US Office of Naval Research Global.



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Scientia Professor Nigel Lovell Graduate School of Biomedical Engineering T: +61 2 9385 3922 | E: n.lovell@unsw.edu.au The development of the optrode array chip: a stepping stone towards the next generation of high-density, implantable brain/machine interface.

#### **Competitive advantage**

- Passively transducing the neural signals into the optical domain bypasses the problem of signal degradation and provides a scalable solution that could disrupt the way science thinks about brain/machine interfaces
- Unprecedented resolution, coverage and throughput
- Step-change in both clinical and research environments

#### Impact

The best approach to brain/machine interfaces suffers from serious limitations, in that their signal/noise degrades as the density of electrodes increases. An embeddable, conformal optics chip will provide a step-change in both clinical and research environments and enable the control of machines through the brain or the enhancement of human abilities.

#### Successful outcomes

- Short-term: multi-optrode arrays (250 connections)
- Mid-term: prosthesis control (5000-10,000 connections)
- Long-term: machine control (1 million connections)

#### **Capabilities and facilities**

- Access to exhaustive nano-fabrication facilities at the Australian National Fabrication Facility (ANFF)
- Full 3D finite-elements model of all opto-electronics aspects completed
- Research team comprising 5 senior academics and a number of doctoral students

- Zedelef Pty Ltd
- Preclinical testing facilities



Design of Application Specific Integrated Circuits (ASICs) and systems for biomedical implants.

#### Competitive advantage

• Expertise in research and development of integrated circuit and system designs over a wide range of Complementary Metal-Oxide-Semiconductor (CMOS) technologies for a broad range of applications with cross-disciplinary design constraints.

Particular expertise with implanted electronics design includes:

- Tailored functionality better performance, longer battery life
- Systems architecture
- Custom safety systems
- · Risk mitigation with coexisting function implementations

#### Impact

- Reduced-size implanted systems
- Better therapeutic outcomes
- Clinical research support

#### Successful outcomes

- Many patents filed with collaborators
- Bionic eye electronics

#### Capabilities and facilities

- Industry standard design software suite
- Comprehensive electronics testing facilities
- Expertise in integrated circuits and systems design

#### More information

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Scientia Professor Nigel H. Lovell Graduate School of Biomedical Engineering T: +61 2 9385 3922 | E: n.lovell@unsw.edu.au Pioneered the development of visual neuroprostheses (Bionic Eyes) in Australia. With half a dozen patents and several new disruptive neural interface technologies that make the device significantly more functional and novel than competitive technologies. A pre-clinical prototype has been developed.

#### **Competitive advantage**

- Multi-disciplinary team working at the interface of biology and engineering
- Extensive patent portfolio covering industrial and biomedical aspects of implantable bionics technology
- Design approaches and facilities that include Quality Management Systems following ISO13485 principles

#### Impact

- A Bionic Eye is currently the only approach to provide vision restoration in diseases such as retinitis pigmentosa
- Currently millions of people worldwide have retinal degeneration that could be treated by a Bionic Eye

#### **Successful applications**

- Preclinically tested prototype of 98-channel visual neuroprosthesis
- Neurostimulation microelectronics for stimulation and recording with wider
   uses in implantable and wearable devices

#### **Capabilities and facilities**

- Biomedical microfabrication facility
- A range of electrophysiology, animal surgery, and microscopy setups for biological assessment of technology
- Access to engineers and infrastructure at the Australian National Fabrication Facility

#### Our partners

• International collaborators in Asia, Europe and America



**Professor Laura Poole-Warren** Graduate School of Biomedical Engineering

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Research activities, primarily focused on Bionics, Biomaterials and Tissue Engineering, that involve a wide range of biomedical engineering activities including biomechanics, orthopaedics, laser micro-manufacturing, bioinstrumentation, electronic chip design, wireless sensor networks, advanced microscopy, neurophysiology, electrophysiology, and in vitro and in vivo experimentation.

#### Competitive advantage

- Design and development of novel neural interfacing materials for neural stimulation, and recording electrodes
- Advanced electrode coatings that use cells and photo-active nanomaterials, embedded within conducting polymers and conducting hydrogels, to provide physiological stimulation of excitable tissues at the individual cell level
- Electrode coatings tailored to improve electrical performance while reducing scarring and enabling enhanced device-tissue integration
- Understanding neuro-compatibility; compatibility of new materials with nervous tissues
- Development of 3D mixed cell cultures for evaluating neural responses to technology

#### Impact

- Novel electrode coatings significantly improve the performance and lifetime
   of bionic devices
- Enhanced ability to restore auditory and visual perception
- Improved deep brain stimulators to treat or manage conditions such as Parkinson's disease, Alzheimer's, anxiety and depression

#### Successful outcomes

• Patent (9299476)

- Materials fabrication, mechanical and electrical characterisation, primary cell culture, biomedical imaging, animal models
- Dedicated facilities for bionic device fabrication and characterisation



**Dr Michael Stevens** Graduate School of Biomedical Engineering

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Developing wearable technology for detecting falls in older people in order to reduce the risk of lying undiscovered for a long period. This wearable technology can be adapted into smart phones and smart watches, and forms part of a holistic approach to aged care.

#### Competitive advantage

- Wearable fall detector with 95% accuracy
- Lowest false alarm rate reported in literature
- Lightweight, comfortable and low cost
- Optimised battery life 4 years, no charging, no battery replacement

#### Impact

Approximately one-third of community dwelling residents aged over 65 experience at least one fall a year, with the chance of falling increasing with age. About half of all elderly people who fall without being seriously injured are unable to get up and this leads to further limitation of functional activities and physical outcomes such as muscle damage, dehydration, hypothermia, pneumonia and increased mortality.

#### Successful outcomes

Tested in the lab and in real life, with healthy volunteers.

#### **Capabilities and facilities**

- 45 prototypes ready for trials with older Australians
- The capability to adapt the algorithms for use with mobile phone technology
- Working to integrate the falls detector into a "smart-home" designed for older Australians

#### **Our partners**

Vitalcare Pty Ltd



Dr Michael Stevens Graduate School of Biomedical Engineering

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Developing algorithms to automatically adjust heart pumps to respond to changes in patient state.

#### Competitive advantage

- Realistic bench top testing rig that simulates a range of cardiovascular conditions
- Ability and skills to test LVADs, RVADs and Total Artificial Hearts
- · Able to apply automatic speed variation strategies to the devices

#### Impact

LVAD implants are growing exponentially, however they still rely on clinicians to adjust the pump speed. As a result, events like sneezing, coughing, exercise and postural changes will lead to hazardous events like ventricular suction or venous congestion, adding further complication. Automatic physiological control systems for LVADs can reduce the likelihood of these events.

#### Successful outcomes

Successfully tested in over 600 different simulated patient scenarios in-silico and in-vitro.

#### **Capabilities and facilities**

- Capability for testing and evaluating implantable heart pumps using simulation and bench top testing rigs
- Technology can be deployed with the right commercial partner
- Testing equipment can be utilised to independently verify LVAD performance

- BiVACOR
- St Vincents Hospital



**Professor Mari Velonaki** Creative Robotics Lab/National Facility for Human-Robot Interaction Research

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A cross-disciplinary research environment dedicated to understanding how humans can interact with three-dimensional robotic agents and responsive structures within the context of creative and social robotics.

#### Competitive advantage

- The Creative Robotics Lab is one of the first teams in the world to take an informed multi-disciplinary approach to human-computer and human-robot interface
- The National Facility for Human-Robot Interaction Research is a state-ofthe-art data collection facility for studying and evaluating Human-Machine Interaction across the disciplines of Robotics, Artificial Intelligence, Psychology, Rehabilitation Medicine and Interactive Arts
- Extensive experience co-designing with industry

#### Impact

- Creating an awareness of social robotics
- · Incorporating art, design and creativity as a key dimension in robotics
- Changing the way assistive devices technology can resolve situations with social stigma
- · Increasing safety to allowing people to stay at home longer

#### Successful applications

- In relation to robotics, one of the few groups in the world that has done cross cultural studies across socio economic groups and countries
- Work in Autism Therapies: Playful, therapeutic and educational interfaces that a child can learn with the Casper robot

#### **Capabilities and resources**

- National Facility for Human Robot Interaction Research
- Creative Robotics Lab
- Biggest data collection in the world on how humans interact with robotic technology
- Experts in autism, technology, people, culture and robot morphologies

- US Airforce
- Fuji Xerox Innovation Japan
- NICTA
- St Vincent's Kai and Rehabilitation Clinic

## Tactile Diagnostics and Encoding



#### More information

Associate Professor Richard Vickery School of Medical Sciences

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Creating technologies to build a human interface to artificial touch sensors that is non-invasive, robust, cost-effective, and safe. The technology could be applied to restore touch to amputees with a prosthetic hand or make early diagnosis of nerve damage resulting from chemotherapy or diabetes.

#### Competitive advantage

- Neural translation system uses trained artificial neurons based on nerve signal recordings from actual individual human tactile receptors encoding different aspects of object manipulation
- Enabling patients to experience touch without requiring extensive training or brain plasticity
- · Unique pulsatile mechanical stimulation approach
- Technology is non-invasive, which makes it cheaper, safer, easier to test and get approved, easier to upgrade and repair, and avoids patients needing to make a decision about the risk/benefit of surgery

#### Impact

- Early detection of chemotherapy-induced peripheral neuropathy (CIPN) provides opportunities for treatment modification before permanent life-long damage ensues
- Providing tactile feedback could significantly improve acceptance of prosthetic hands by users and therefore improve rehabilitation outcomes and the quality of life of amputees

#### Successful outcomes

- Successfully conveyed tactile sense and supported direction judgements in small-scale trial
- Early evidence from rat studies that chemotherapy-induced nerve damage in non-symptomatic animals can be detected

#### **Capabilities and facilities**

- · Skills in recording neural activity from humans performing tactile tasks
- A library of recordings of individual human touch neurons
- Brain recordings in rats responding to identical touch stimuli as presented in humans
- · Ability to create a library of virtual neurons to act as biomimetic translators
- Patented IP in independent control of intensity and frequency in touch perception
- · Non-invasive methods to create these touch perceptions

- The Prince of Wales Hospital
- Hyperbaric Health

- Translational Cancer
- Research Network

Wearable and Flexible Sensors with High Sensitivity and Stretchability for Human Health Monitoring

#### More information

**Professor Chun Wang** School of Mechanical and Manufacturing Engineering

A 70004

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Through rational material design and structural engineering, a range of wearable sensor systems—with high sensitivity, stretchability and durability to enable detection of subtle pressure/force changes associated with movement and health conditions—has been developed. These new sensors open the door to applications for monitoring the health of those with chronic diseases.

#### **Competitive advantage**

- High accuracy, quick to respond, robust and extremely durable
- · Highly flexible and stretchable-it can be stretched up to 100% strain
- Easy data collection process through electrical resistance
- · Low power consumption, in tens of microwatts
- Water resistance—encapsulated sensor is moisture proof and resistant to body fluids

#### Impact

- · Early prediction and diagnosis of illness prior to the onset of symptoms
- Affordable, customised, user friendly, robust and rapid, and equipment free

#### Successful outcomes

Demonstration of continuously monitoring physiological signals and human motion in a reliable, skin-conforming and non-intrusive manner.

#### **Capabilities and facilities**

- Mechanical test of sensor devices in terms of modulus and fatigue
- High accuracy measurements of electrical properties of sensor devices

- Sydney Children's Hospital
- Neuroscience Research Australia (NeuRA)
- 3F Medical, Shanghai, China
- Defence Innovations, Melbourne



Dr Leo Wu School of Mechanical and Manufacturing Engineering

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Intelligent snake-like robots are the next generation of surgical robots that will bring less invasive surgery and better outcomes to patients.

#### Competitive advantage

- Advanced expertise in robotic surgical instrumentation for minimally invasive surgery
- Innovative design and modelling of flexible snake-like robots
- Intelligent sensing to enable situational awareness
- Better design and implementation of human-robot interaction

#### Impact

- Less invasive surgery for patients through innovative design and fabrication
- More dexterity for the surgeon
- Larger accessibility through small incisions
- Safer operations with real-time sensing
- Easier surgical operations with better human-robot interaction

#### Successful outcomes

- Successful cadaveric trials in ear nose throat surgeries
- Successful cadaveric trials in orthopedic surgeries

#### **Capabilities and facilities**

- Capability of prototyping from scratch
- Advanced collaborative robotic arms
- · Advanced tracking systems
- Portable ultrasound system for surgical guidance

- St George Hospital
- Prince Charles Hospital
- Holy Spirit Northside Private Hospital

# BIOENGINEERED MATERIALS AND TECHNOLOGIES

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## Eye Infection and Contact Lenses

#### More information

**Dr Nicole Carnt** School of Optometry and Vision science

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Strategies for improved medical device compliance and patient involvement in research, and expertise in genomics, immunology, microbiology, image analysis and mathematical modelling to improve the diagnosis and management strategies for corneal infections.

#### Competitive advantage

- A consortium of interdisciplinary local and international researchers committed to providing better health for wearers of contact lens medical devices, and other individuals prone to corneal infection
- Strong strategic partnerships with regulators, industry, basic scientists, mathematicians, clinicians and patients
- Expertise in epidemiological genomics, immunology, microbiology, tissue imaging, mathematical modelling

#### Impact

- · Improved contact lens safety
- Understanding of patient genetic and immunological susceptibility and response to corneal infection

#### Successful outcomes

- Demonstrated that some contact lens wearers are genetically predisposed to corneal infection
- Identification of contact lens solution responsible for an outbreak of severe infection, leading to its subsequent withdrawal from market
- Co-design of "Patient Information" for severe infection with a consumer advocate
- · Champion of consumer-designed imaging for healthy contact lens wear

#### **Capabilities and facilities**

- · Proven patient recruitment and involvement in research
- Broad range of basic science, imaging and clinical data integration
- Translation of research into practice expertise

- Eye Department, Westmead Hospital
- Westmead Institute for Medical Research
- J&J VisionCare
- Alcon

- Cornea and Contact Lens Association
   of Australia
- British Contact Lens Association
- American Optometric Foundation and American Academy of Optometry
- Australian Standards and International Standards Organisation (ISO)
Colorimetric Sensors for In-Field Detection of Chemical and Biological Compounds



#### Developing nanosensors that can help to detect diseases and monitor the safety and quality of food, and the environment, better and faster. The presence of target analytes can be monitored through colorimetric changes easily visualised by the naked eye.

#### **Competitive advantage**

- Results that can be seen without the use of specialised equipment enables in-field qualitative and quantitative measurements
- Sensors can be modified or embedded onto any substrates with no restriction of surface geometry or topography, including paper, film, glass, and plastic

#### Impact

- Aiming to solve current challenges in industries by developing detection techniques that are fast, simple, cost-effective, portable, and allow on-the-spot measurements
- Nanosensors find many applications, ranging from early disease diagnostics to food and environmental monitoring

#### Successful outcomes

• Research reports demonstrating the capability of the technology can be provided upon request.

#### **Capabilities and facilities**

- · Access to nanoparticle synthesis and inkjet printing for sensors
- Access to the state-of-the art Mark Wainwright Analytical Centre for materials characterisation

#### More information

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Circularity and Co-Constitution between Law and the Biosciences

#### More information

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Examining the bio-legal implications and social-political impact of biotechnology: with advances in bioscience come entire new methods, paradigmatic shifts in human self-understanding or modes of production, for which law often does not yet have sufficient knowledge to regulate, support or prohibit. Yet the law creates the landscape in which that research is conducted.

#### **Competitive advantage**

Established the UNSW Law Initiative for Biolegality, focused on the co-constitution and circularity between law and the biosciences.

#### Impact

The aim of the UNSW Law Initiative for Biolegality is to set up a dialogue between bioscientists and legal scholars to examine the bio-legal implications and social-political impact of biotechnology in the 21st century.

#### Successful outcomes

- A new Book Series Biolegality / Palgrave MacMillan (ongoing)
- An edited book Personhood in the Age of Biolegality/ Palgrave MacMillan (2019)
- A monograph Biolegality: A Critical Intervention / Palgrave MacMillan (forthcoming 2020)

#### Capabilities and facilities

- Law
- Allens Hub for Technology, Law and Innovation
- The Kirby Institute
- All biosciences and biotechnological fields are represented but in particular reproductive technologies, neuroscience, personalised medicine, human and plant genetics, forensic sciences
- Topics are, among others, the legal status and implications of genetic engineering, human DNA, mitochondrial replacement technology, personalized medicine, CRISPR- Cas9, genetic population research, biosecurity, GMO, LMO, and the bio-legal politics of patenting, indigenous knowledge, property, nature and community

X-ray Induced Chemotherapy via Engineered Liposomes for Deep Cancer Therapy

#### Competitive advantage

- Safety nanocarrier delivery system
- FDA approved ingredients for liposome formulation
- · Cancer-targeting capability of the delivery system

particularly those located in deep tissue.

- · Synchronous action of chemo and low dose x-ray radiation
- · Minimal systemic toxicity of chemotherapy drug to healthy tissues

The number of new cancer cases each year is increasing and there is a shortage of new clinical approaches to fight it. A

targeted liposome drug delivery system, enabling X-ray induced

chemotherapy has been developed for the treatment of tumours,

• Adjuvant treatment of deep tumours

#### Impact

It is estimated that in 2020, there will be approximately 150,000 new cases of cancer diagnosed in Australia. This technology significantly enhances the therapeutic efficacy and reduces the systemic toxicity of the chemotherapeutic agents which are used in concurrent chemo and radiotherapy. This will offer a paradigm-shifting alternative for patients who are too fragile or have become resistant to chemotherapy.

#### Successful outcomes

The development of a targeted liposome drug delivery system, enabling X-ray induced chemotherapy (PCT/AU2018/000247). The anti-tumour effect produced by this innovation was used for tumour treatment in preclinical studies, particularly those located in deep tissue.

#### **Capabilities and facilities**

The lab has extensive facilities for the design and testing liposome drug delivery system.

#### **Our partners**

- Royal North Shore Hospital
- GenesisCare

#### More information

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**Dr Anna Guller** Graduate School of Biomedical Engineering

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Developing biomaterials for regenerative medicine, including: organ specific scaffolds for three dimensional cell culture in vitro; organ specific microcarrier for high throughput cell culture and secretome production; implantable biomaterials and drug and cell delivery systems; and materials for immunobiomodulation in situ.

#### Competitive advantage

The first group in the world to develop a low-cost methodology to produce organ-specific, low immunogenic and highly biocompatible tissue scaffolds.

#### Impact

- Improved healing in recalcitrant wounds
- Biologically accurate tumour models for drug development
   and nanomedicne
- Animal-free early drug testing in organ-specific and disease-specific microenvironments

#### Successful outcomes

The approach is in the early stages of clinical translation in the area of regenerative and veterinary medicine.

#### **Capabilities and facilities**

Customisable, scalable and affordable production of organ-specific biomaterials.

- Royal North Shore Hospital
- Garvan Institute
- Sechenov University Hospitals



Scientia Professor Justin Gooding School of Chemistry and the Australian Centre for NanoMedicine

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A suite of advanced sensors that can detect ultralow amounts of biomarkers and even count single molecules, has been developed. These sensors solve the challenge of being able to detect very rare species in biological samples such as blood and, through improving early detection, will improve survival rates.

#### **Competitive advantage**

- · World-leading capability in sensor development
- Expertise in understanding how sensors work in a biological milieu
- Strong foundation in surface chemistry, which is vital for such interfacial devices
- Strong track record in publication and commercialisation

#### Impact

The detection of very low amounts of a biomarker is key to the early diagnosis of disease, the cure for cancer, the rapid diagnosis of infections and identifying the infective agent.

#### Successful outcomes

- Involved in the commercialisation of a glucose sensor that sells in the millions each year
- Commercialised a 3D bioprinter which will revolutionise cancer research and has potential in personalised medicine

#### **Capabilities and facilities**

Extensive experience in surface characterisation, electron microscopy, fluorescence microscopy, including super-resolution microscopy, and nanofabrication

#### **Our partners**

Commercial in confidence

## Bioinspired Multifunctional Materials for Cell and Tissue Assembly

#### More information

Dr Kristopher Kilian

School of Chemistry; School of Materials Science and Engineering; Australian Institute for Nanomedicine

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Expertise in cell engineering and the design of multifunctional soft materials – including hydrogels, coatings, dynamic stimuli-responsive materials, and 3D patterning approaches – as well as precise control of microenvironment parameters, is used to create and maintain reproducible culture conditions to facilitate new avenues for cell manufacture.

#### Competitive advantage

- Novel synthetic materials with user-defined dynamics enable spatiotemporal control over cell assembly and activity
- Expertise in the precise control of chemistry and mechanics in vitro to homogenise cell state for the tuning of a desired population
- Skills at controlling and directing cell state in the laboratory facilitate 3D assembly into functional tissue-mimetic architectures

#### Impact

- Coatings and materials for reproducible manufacture of clinically useful cells from donor banks or patients
- Model systems comprised of 2D/3D spheroids and organoids for development and disease modelling, and for drug development

#### Successful outcomes

- Engineering melanoma heterogeneity in a microtumour array for testing combination therapies
- Multicellular heterotypic models of tissue microenvironments with 3D
   printed vasculature

#### **Capabilities and facilities**

- GeneTech-approved PC2 laboratory with lithographic, ink jet and direct-write printing
- Wet chemistry and molecular biology laboratories

- Mayo Clinic
- Cynata Therapeutics

Disruptive Tech for the Engineering and Manufacture of Materials and Devices with Smart Properties

#### More information

Inaugural Paul Trainor Chair, Professor Melissa L. Knothe Tate Graduate School of Biomedical Engineering

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Enabling the design and advanced manufacture of smart materials and devices using patented disruptive technologies that emulate the intrinsic mechanical gradients of natural tissues, like bones and trees.

#### Competitive advantage

- World-first patented technology to recursively weave textiles with mechanical gradients and patterns emulating nature's own
- Unique patent technology to engineer and manufacture composites comprising engineered textiles and smart matrix

#### Impact

- Addresses the current shortcomings of implantables including surgical meshes, stents and surgical reconstruction implants
- Enables novel drug delivery strategies for combination devices, dressings and implants

#### Successful outcomes

Preclinical testing underway for implants and wearables

#### **Capabilities and facilities**

Prototyping and tech innovation facility at partner start-up in NSW

- TissuTex Pty. Ltd., NSW Australia
- Food and Drug Administration, USA
- National Institutes of Health, USA
- · Cleveland Clinic, USA
- Case Western Reserve University, USA
- Stanford University School of Medicine and D School, USA
- University of Lund, Sweden
- Ludwig Maximilians University, Germany
- Christopher Columbus Foundation US Chamber of Commerce
- Wallace Coulter Foundation, USA
- AO Research and Development Institute, Switzerland

Antibacterial and Biofilm Resistant Resin-Based Dental Composites

#### More information

**Professor Jamie Kruzic** School of Mechanical and Manufacturing Engineering

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Development and testing of a number of antibacterial resin-based dental composites that resist biofilm formation – which leads to tooth decay – while simultaneously meeting the other material property requirements for use in specific dental treatments.

#### **Competitive advantage**

Expertise and facilities to develop and test antibacterial resin-based dental composites using various approaches tailored to specific dental treatments.

#### Impact

Longer lasting dental treatments and reduced societal and economic costs for dental care.

#### Successful outcomes

Focus to date has been on journal publications and patent applications. Presently looking for commercialisation partners.

#### **Capabilities and facilities**

Capabilities include the development of novel antimicrobial resin composites and facilities and expertise for testing various properties, including but not limited to:

- Minimum inhibitory concentration (MIC)
- Agar disk-diffusion test
- Crystal violet biofilm assay
- Biofilm assay for colony forming units
- · Live/dead bacterial assay for biofilm analysis
- · Custom developed biomechanical analyses of biofilm inhibition
- Cytotoxicity
- Genotoxicity
- Degree of conversion
- Flexural strength
- Fracture toughness

- National Institute of Dental and Craniofacial Research, USA
- Oregon Health and Science University, USA
- Sao Paulo Research Foundation, Brazil
- University Ibirapuera, Brazil
- · University of São Paulo, Brazil

# Development of Novel Antimicrobial Scaffolds

#### More information

**Professor Naresh Kumar** School of Chemistry

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Development of quorum-sensing inhibitors, antimicrobial peptides and mimics, and incorporating them into polymers and biomaterials with the aim of reducing device-related infections.

#### **Competitive advantage**

- Portfolio of antimicrobial and antibiofilm agents and scaffolds with novel
  mechanisms of action
- Antimicrobial coatings technologies with demonstrated in-vivo efficacy
   at preventing device-related infections
- Recognised international experts in the field of antimicrobial discovery
   and biomaterials
- Outstanding track record in the area of novel surface strategies for antimicrobial control, with multiple industry-supported and government funding in this area

#### Impact

Up to 65% of all hospital-acquired infections are caused by microbial colonisation of surfaces. This is a major health problem that can be prevented by new technologies which will save billions of dollars in healthcare costs and provide substantial economic benefits for industries.

#### Successful outcomes

- Completed Phase I/Phase III clinical trials for antimicrobial contact lenses
- Antimicrobial prototype devices for major biomedical companies including Cochlear

#### **Capabilities and facilities**

- World-class synthetic chemistry facilities including NMR and mass spectrometry, supported by a diverse range of imaging and surface characterisation facilities from the Mark Wainwright Analytical Centre
- Clinically relevant animal models for device-related infections

- Biosignal Ltd
- Cochlear Ltd
- Australian Biotechnologies Pty Ltd
- Intellectual Ventures (now Xinova)
- Allegra Orthopaedics

## Heat and Light Generating Magnetic or Photonic Nanoparticles

#### More information

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Custom designed magnetic or photonic nanoparticles can generate heat or light in a highly controllable, precise and efficient manner, across a wide range of length scales. When these nanoparticles are combined with drug carrying macromolecules or catalytic materials, heat or light triggered drug release can be achieved. The nanoparticles can also be used as a contrast agent or tracer for imaging (MRI, MPI) and sensing of biological systems. This technology is used in situations where spatial, temporal and dosage control is required in drug delivery, or where simultaneous drug delivery and medical imaging or sensing is required for effective treatment of disease or injuries.

#### **Competitive advantage**

- Precise control of heating rate and footprint in the nano or micro-length scale
- Spatial, temporal, and dose control of drug delivery
- Simultaneous high-resolution, high-sensitivity and real-time imaging
- Multiplex, high-sensitivity and real-time sensing
- Radiation-free and highly sensitive imaging modality
- Magnetic capture for sensing

#### Impact

More effective detection, diagnosis and treatment of disease, leading to improved prognosis for patients.

#### Successful outcomes

- · Gold coated magnetite nanoparticles for metal ion detection
- Needle shaped magnetite for spatial and temporal control of drug release
- · Magnetite stabilised liposome for drug delivery

#### **Capabilities and facilities**

- The laboratory houses the Nanotheric magneTherm, and Ambrell EASYHEAT
   magnetic induction heating system
- Nanotheric magneTherm enables magnetic fluid and nanoparticle to be tested in field strengths up to 20 kA/m (25 mT) and over a wide range of user-configurable frequencies
- The laboratory also houses a Horiba Fluoromax-3 Spectrofluorometer equipped with a class 3B NIR laser for the characterisation of photonic upconversion of nanoparticles

#### **Our partners**

· Lipotek



Associate Professor Megan Lord Graduate School of Biomedical Engineering

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A leading capability in the development of biomaterials functionalised with biological signalling molecules for blood vessel repair and regeneration, for therapeutic application.

#### Competitive advantage

Fundamental and multidisciplinary expertise in:

- Synthetic and natural biomaterials
- Blood vessel cell surface and extracellular matrix molecules
- Recombinant protein expression
- Biochemical, biophysical and cell-based functional assays
- In vivo models

#### Impact

• Developing next generation biomaterials that interface with the body to direct blood vessel and tissue repair

#### Successful outcomes

- IP portfolio in methods to produce signalling molecules
- Preclinical testing for novel vascular graft coating
- Preclinical testing for diabetic wound healing
- Coatings for prolonged platelet storage

#### **Capabilities and facilities**

• State-of-the-art preclinical biomaterial and biological molecule development and testing laboratories encompassing in vitro and in vivo analyses

- Synedgen Inc
- TriCol Biomedical
- Diabetes Australia
- Australian Red Cross Blood Service



**Dr Robert Nordon** Graduate School of Biomedical Engineering

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Lab-on-a-chip is a microdevice that controls chemical and biological processing using microfluidic integrated circuits. A laboratory process can be miniaturised, automated, and distributed to point-of-care. Alternatively, lab-on-a-chip can be automated and scaled-out using culture processes for delivery of cell and gene therapy.

#### Competitive advantage

- Integrating blood collection, separation, processing and analysis into plastic disposable devices
- Lower cost of goods by reducing reagent consumption, laboratory infrastructure and skilled labour inputs
- Internet connectivity

#### Impact

Increasing healthcare productivity through point-of-care diagnostics, early initiation of therapy, reduced cost-of-goods, and central coordination of resources and supply chains through the Internet-of-Things.

#### Successful outcomes

- Invention, licensing, commercialisation and clinical translation of a hollow fibre bioreactor for closed automation of cell manufacture
- Patent pending (US2017274196 (A1), 2014) on plastic microneedle patch for point-of-care blood diagnostics
- Provisional filing on scaling microfluidics to manufacture cells for cell and gene therapy

#### **Capabilities and facilities**

• Medical microdevice development from inception through to microfluidic design, fabrication, prototype evaluation, and clinical application

- Calimmune Australia Pty Ltd
- CSL

# Fibre Optic Dental Material Characterisation System (FODMCS)

#### More information

**Professor Gangadhara B Prusty** School of Mechanical and Manufacturing Engineering

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A novel fibre optic dental instrumentation system to provide true understanding of the curing behaviour of dental materials. This system could be also used as a dental restoration training platform for dental practitioners. This research program is aimed to contribute to the development of technology, education and training to achieve dental restorations of the highest quality.

#### **Competitive advantage**

- A unique system to provide new insights to dental composite properties such as shrinkage profile and its relationship with curing lamp and curing techniques
- A unique dental restoration training platform to study the impact of restoration techniques and materials properties on the quality and longevity of the restoration

#### Impact

- Greatly improve the quality of life of dental patients and the bench time of practitioners by knowing the composite-curing lamp-curing techniques correlation.
- Promote the use of dental composites among dental practitioners and dental patients alike.

#### Successful outcomes

Proof of concept demonstrated in lab, research ongoing towards prototype development.

#### **Capabilities and facilities**

Dental composite testing and characterisation facility; optical fibre sensor development and characterisation facilities.

- University of Wollongong
- SDI Ltd

# Bioinspired Materials and Regenerative Medicine

#### More information

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Functional biomaterials and bioengineered tissues will play a key role in replacing and regenerating injured and diseased tissue in our ageing population, have the potential to revolutionise drug, medical device and cosmetics testing, and enable the study of disease development and progression in human tissues rather than in animal models.

#### Competitive advantage

- · Functional biomaterials inspired by native tissue
- Fundamental understanding of tissue-biomaterial interactions for improved material engineering
- Biomaterial processing, fabrication and characterisation capabilities and expertise
- In vitro and in vivo functional models
- · Multidisciplinary expertise and strong collaborative links

#### Impact

- Novel functional biomaterials for the treatment of cardiovascular disease
   and wound healing
- In vitro human tissue models for use in drug, medical device and cosmetics testing, and for studying disease development and progression

#### Successful outcomes

- Novel biomaterials toward small diameter vascular grafts, cardiac patches and wound dressings (pre-clinical testing)
- Fundamental contributions to understanding of silk biomaterial processing into implantable biomaterials
- Fundamental contribution to the understanding of biomaterial and bioengineered tissue vascularisation and integration in the body
- Strategies toward material biofunctionalisation for enhanced biological outcomes

#### **Capabilities and facilities**

- Silk biomaterial processing and fabrication
- Biomaterial characterisation
- · In vitro cell based assays; in vivo safety and functional models
- Molecular biology and biochemistry assays

- Heart Research Institute
- Westmead Institute for Medical Research
- Department of Orthopaedic Surgery, Centre for Bioengineering & Nanomedicine, University of Otago Christchurch
- Department of Biomedical
- Engineering, Tufts University, Boston
- School of Dentistry, University of Leeds

# **BIOMOLECULAR INNOVATIONS**

Collaborative Translational Infectious Disease Research to Accelerate Integrated Health Care Solutions

#### More information

**Dr Tanya Applegate** Surveillance Evaluation and Research Program

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The Surveillance Evaluation and Research Program within Kirby Institute are world leaders in translational infectious disease research across the Asia-Pacific. With expertise in basic science, clinical and behavioural research, population-health, health economics and systems, modelling, biostatistics and epidemiology, this program conduct collaborative research to provide integrated health care solutions for all.

#### Competitive advantage

- Extensive experience in clinical trials, diagnostic and implementation research
- · Established clinical and surveillance networks across the Asia-Pacific
- Integrated framework for effective transdisciplinary infectious disease research
- Trusted and collaborative partnerships with community, decision makers, industry, academic, not-for-profit organisations, regulatory bodies, government and ministries of health
- Well characterised cohorts and linked data to model the scale, health-economic impact and real-world market potential of new biomedical technologies

#### Impact

- Sustainable scale-up of novel behavioural and biomedical interventions strategies
- · Transformational improvements in health outcomes of affected communities globally

#### Successful outcomes

Demonstration of impact of novel point-of-care diagnostic technologies for infections including chlamydia, gonorrhoea, human papilloma virus, hepatitis C virus and HIV infection among remote and marginalised communities

#### **Capabilities and facilities**

- Transdisciplinary field research
- · Rapid and sustainable integration of biomedical interventions into health systems
- Field evaluation and implementation research of novel diagnostics and biotechnology solutions, including at the point-of-care
- · Antimicrobial resistance research
- Health economics and modelling of target populations, roll-out strategies, market size, impact and uptake of technology
- Data linkage and analysis

- · Cepheid
- SpeeDx Pty Ltd

- Abbott Diagnostics
- Orasure Technologies
- Foundation for Innovative Diagnostics
   Hologic
- Atomo Diagnostics

# Bringing Hope to Those with Severe Corneal Disease

#### More information

**Professor Nick Di Girolamo** Ocular Disease Research Unit

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On a mission to restore sight in patients blinded from severe corneal disease.

#### **Competitive advantage**

- Identification of a new biomarker for severe corneal disease, which will become a point-of-care test to gauge disease severity and outcome of therapy
- Technology offers patients with blindness an opportunity to restore their sight and eye health
- An opportunity for clinicians to stage their patients in terms of disease severity and ascertain how their therapy has fared

#### Impact

Novel therapy and a new diagnostic biomarker will be offered to patients with severe corneal disease that cannot be treated with conventional medical or corneal graft therapy. The aim is to improve the therapy and the diagnostic test so that patients in developing nations will benefit.

#### Successful outcomes

- Phase 1 clinical trial on 16 patients with limbal stem cell deficiency completed. Mid-term follow-up should see a 63% success rate in terms of vision improvement
- In a mouse model of limbal stem cell deficiency, it has been shown that a novel biomarker has the capacity to detect pathological abnormalities well before gold-standard markers

#### **Capabilities and facilities**

Awarded funds from the Medical Research Future Fund (MRFF) Accelerator Research Stem Cell Program.

- NHMRC
- Stem Cells Australia
- ARC
- Ophthalmic Research Institute of Australia
- Catholic Archdiocese of Sydney



Dr Yann Gambin T: +61 (0) 435 595 009 | E: y.gambin@unsw.edu.au

Dr Emma Sierecki T: +61 (0) 435 595 009 | E: e.sierecki@unsw.edu.au

InteracTeam, EMBL Australia Node for Single Molecule Science

Development of a portable, simple and efficient solution (NanoBright) to perform single-molecule detection in 30 seconds, opening new opportunities for point-of-care diagnostics and the detection of pathogens in the field.

#### Competitive advantage

- A compact plug-and-play single molecule microscope made from a 3D
   printed scaffold
- Small (20 cm x 10 cm footprint), easy to use and can operate in broad daylight
- Performance is as good as high-end commercial microscopes

#### Impact

NanoBright enables the discovery and measurement of biomarkers at very low concentrations in complex samples. The reduced cost and ease of operation makes this the ideal platform to develop a range of assays for single molecule detection.

#### Successful outcomes

- Developed and used the Nanobright technology in laboratories for over 2 years
- Provided Nanobright to five academic research groups in Australia and Europe to detect rare species in complex biological samples at the single molecule level

#### **Capabilities and facilities**

- NanoBright is a compact confocal spectroscope; the "nanodrop" of single molecule detection. This device reads, in real time, the fluorescence from single proteins or single particles and enables quantification of number and size of the particles in the sample
- With 105 times greater sensitivity (compared to plate readers), sample preparation times can be drastically reduced as less amplification or incubation is required
- The NanoBright devices can be made to multiple specifications, compatible with fluorescent antibodies binding to specific bacteria, genetically encoded fluorophores commonly used in microscopy, DNA-binding dyes or molecules that react specifically to protein fibrils (amyloids)

- Aeris
- Novapharm
- Nanosonics

# Nerve Repair and Re-innervation via BaDGE® Naked DNA Therapeutics

#### More information

Scientia Professor Gary Housley Translational Neuroscience Facility, School of Medical Sciences T: +61 2 9385 1057 | E: g.housley@unsw.edu.au

#### Scientia Professor Nigel Lovell

Graduate School of Biomedical Engineering T: +61 2 9385 3922 | E: n.lovell@unsw.edu.au Bionic array Directed Gene Electrotransfer (BaDGE®) is a platform technology for targeted delivery of naked DNA. The first clinical application uses DNA encoding neurotrophins to drive regrowth of the auditory nerve.

#### **Competitive advantage**

- First-in-class DNA electro-transfer technology for targeted DNA payload delivery to a broad range of tissue targets. It is:
- Safe (naked DNA)
- Regulatory permissive (non-viral)
- Not limited by gene size packaging constraints
- The highest level of control of the delivery of genes to target tissues
- High efficiency gene augmentation therapeutics
- Multi-disciplinary team working at the interface of biology, engineering and clinical translation
- A patent portfolio covering all aspects of the BaDGE® platform

#### Impact

- BaDGE® is broadly transferrable to nerve/ brain injury and muscle re-innervation.
- Validated for nerve repair and directed nerve regrowth, CNS neuromodulation, control of muscle contraction
- Broad application potential based on this novel gene electrotransfer technology for discrete targeting of DNA therapeutics in tissues, brain injury, DNA vaccines, oncology, cardiovascular disease, hearing loss, and vision

#### Successful applications

- BaDGE® cochlear implant neurotrophin gene therapy clinical trial to regenerate the auditory nerve
- Licensing agreements with industry partners reflect due diligence on BaDGE® capabilities

#### **Capabilities and facilities**

- DNA therapeutics models, including cell, tissue and behavioural models, focusing on translational neuroscience applications, including nerve injury, brain injury, hearing and vision, pain, stroke, and traumatic brain injury
- Biomedical Engineering Faculty allows application-specific modelling, design and DNA delivery probe production

- National and international medical device companies
- DNA Therapeutics Licensees

### Biosensors and Ingestible Sensors



#### More information

**Professor Kourosh Kalantar-Zadeh** ARC Laureate Fellow and Director of the Centre for Advanced Solid and Liquid Electronics and Optics (CASLEO)

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Research in the fields of materials sciences, electronics, and transducers, especially work on two-dimensional semiconductors, ingestible sensors and liquid metals.

#### Competitive advantage

- Unique and award-winning knowledge in the development of biosensors for gut disorders
- · World renowned in the field of sensors
- Invention of an ingestible chemical sensor; a human gas sensing capsule
- Developed the concept of using plasmonic biosensors based on two dimensional systems
- Many years of experience in developing bio systems based on dielectrophoretic units

#### Impact and successful outcomes

- Successfully carried out projects for the development of medical devices and continued with investigating their performance and clinical outputs in the fields of gastroenterology for the measurements of biogases, metabolites, assessment of microbiome and diet impact
- Translational research: devices are now used in a number of industries and by reputed companies for gas and bio sensing as well as components of microfluidics
- Created the first biosensors using two dimensional materials other than graphene

#### **Capabilities and facilities**

Centre for Advanced Solid and Liquid Electronics and Optics (CASLEO)

- PC2 Lab
- Class 10000 fabrication lab
- · Optics lab
- High precision electronics lab
- · CASLEO specific wet chemistry lab

- Planet Innovation Ltd
- Atmo Biosciences Ltd
- Department of Agriculture, Australia
- Department of Industry, Innovation and Science, Australia

# NanoArmour for **Biopharmaceuticals**

#### More information

Dr Kang Liang Graduate School of Biomedical Engineering

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NanoArmour is a highly effective way to enhance the stability of fragile drugs without the need for cold storage. This technology can eliminate the need for cold-chain transportation and extend the shelf-life of protein/DNA drugs and vaccines, which will significantly enhance the bioavailability of drugs.

#### Competitive advantage

- Extensive experience in nanotechnology research, design and development of biocompatible, responsive and ultra-stable nanocoatings for biomolecules
- Competitive IP ownership in relevant technology

#### Impact

- Enables fragile drugs to be available when cold storage is not accessible, e.g. during war or in third world countries
- Enables fragile drugs to last longer, e.g. ultra-long shelf-life of protein/DNA drugs or vaccines

#### Successful outcomes

Successfully enhanced the stability of more than 50 proteins and DNA therapeutics to heat, UV, chemical and biological stressors.

#### **Capabilities and facilities**

- Experimental facilities to test the structural performance of nanocoating technology
- · The ability to protect almost any form of biomolecule
- The ability to be transferred to a biocompatible ionic form (e.g. Ca2+, Fe3+) immediately before administration

# Smart Paper Test Strips for POC Detection of Insulin, and Beyond

#### More information

**Dr Guozhen Liu** Graduate School of Biomedical Engineering

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Smart paper test strips that can accurately detect insulin in saliva at the point-of-care, offering a replacement for the current ELISA test.

#### **Competitive advantage**

This paper-based technology can accurately detect insulin to provide point-of-care monitoring for patients with pre-diabetes or diabetes. Advantages include:

- Saliva detection the technology is non-invasive
- Rapid response times of less than 10 min
- · Accurate comparable to the standard ELISA test
- Highly sensitive (0.03 ng/mL insulin sensitivity, 1 order more sensitive than ELISA)
- Cost-effective (less than \$1 per test strip)
- Stable at room temperature
- Point-of-care disposable strips
- Simple to use with an optical signal readable by eyes, or smart phone
- Smart paper strip has universal applications for early detection of chronic disease biomarkers
- Suitable for resource limited settings

#### Impact

- Simple detection of insulin in saliva
- · Improved ability to prevent and manage pre-diabetes or diabetes
- Smartphone-based signal readout will improve data collection and management of health data, enhancing capabilities to use big data for machine learning and Artificial Intelligence

#### Successful outcomes

- Provisional patent filed (2018904363)
- Start-up in development

#### **Capabilities and facilities**

Dedicated facilities for making paper based analytical devices.

# Curing Infectious Disease Through Bacterial Biofilm Control

#### More information

**Professor Michael Manefield** School of Chemical Engineering and School of Civil and Environmental Engineering

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Recognising the futility of developing next generation antibiotics without developing strategies to undermine the resilience of bacterial biofilms. The end goal of the research is to develop a means of destabilising bacterial biofilms and enable improved efficacy of traditional antibiotics.

#### **Competitive advantage**

- Expertise in microbial ecology, organic and surface chemistry, antimicrobial resistance, optometry and contact lens development
- State-of-the-art laboratories for biofilm-based assays
- World-class facilities for genomics, transcriptomics and proteomics
- Leadership in fundamental research on biofilms for over two decades

#### Impact

Antibiotics, highly effective at killing bacterial cells, have proven to be ineffective against cells entrained in a biofilm matrix—many infectious disease states involve multiple microorganisms (rather than a single culprit) bunkered in high cell density communities encased in a complex polymeric matrix. Developing a means of destabilising these biofilms will undermine the resistance to antibiotics and prevent unnecessary deaths from diseases that are currently curable.

#### Successful outcomes

Inspiring next generation pharmaceutical companies to target biofilm control

#### **Capabilities and facilities**

- · Synthetic chemistry and biofilm testing facilities
- Ramaciotti Centre for Genomics (genomics, transcriptomics)
- · Biomedical imaging facilities for biofilm characterisation
- Biomedical mass spectrometry facility for proteomics

- University of Copenhagen (Denmark)
- Nanyang Technological University (Singapore)
- Californian Institute of Technology (USA)

Validation of a Novel Non-Invasive High Throughput Screening Tool for Peripheral Neuropathy in Type 2 Diabetes

#### More information

**Dr Maria Markoulli** School of Optometry and Vision Science

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There is an unmet medical need for early diagnosis and monitoring of diabetic neuropathy, particularly in remote locations that do not have access to specialty care. Using the eye to monitor tear neuropeptides may allow early diagnosis and prevent complications.

#### **Competitive advantage**

Shown that in type 1 diabetes, measuring the release of tear film neuropeptides, specifically, substance P, from corneal nerve terminals may allow us to diagnose diabetic peripheral neuropathy. Plan is to determine whether this is also the case in type 2 diabetes.

#### Impact

Those with type 2 diabetes and neuropathy have an increased morbidity due to pain, foot ulceration and mortality. Identifying the conditions early and targeting them for more aggressive risk factor reduction may limit the progression of neuropathy and more severe consequences.

#### Successful outcomes

This project will translate to the development of a point-of-care assessment technique to assess the presence of diabetic peripheral neuropathy. This would involve the development of an instrument that can be used by non-specialists in remote communities and allow for referral on the basis of a positive outcome.

#### **Capabilities and facilities**

This work is part of a collaborative effort between the School of Optometry and Vision Science, the Prince of Wales Diabetes and Endocrinology Centre and the Prince of Wales Medical School.

- The Prince of Wales Diabetes and Endocrinology Centre
- The Prince of Wales Medical School

# **Biomarkers in Dry Eye Disease**

#### More information

Scientia Professor Fiona Stapleton School of Optometry and Vision Science E: f.stapleton@unsw.edu.au

Dr Blanka Golebiowski School of Optometry and Vision Science E: b.golebiowski@unsw.edu.au The 2017 global definition of dry eye disease – a common, yet poorly managed condition that is prevalent in up to 50% of Asian populations – highlights the importance of loss of tear film homeostasis and neurosensory abnormalities. This research program has developed and validated a suite of techniques and instruments which focus on these two key disease processes.

#### Competitive advantage

- Extensive and long-standing clinical and laboratory-based experience in dry eye disease
- · Comprehensive suite of technologies not available elsewhere in Australia
- Diverse and well-established database of potential study participants. Specialty clinics facilitate targeted patient recruitment (Dry Eye, Red Eye, Contact Lenses, Myopia Control)

#### Impact

Dry eye affects over 4 million Australian women. It is associated with reduced productivity at work, reduced subjective quality of life, equivalent to severe angina, and a significant and ongoing Medicare burden. Improved diagnostics, particularly those that target the key pathophysiological mechanisms, will enable more appropriate treatment and monitoring of the impact of treatment.

#### Successful outcomes

Established track record of clinical studies - Phase 1, first in man - Phase 4 trials.

#### **Capabilities and facilities**

- · Measuring sensitivity
- Subjective symptomatology
- In vivo confocal microscopy
- Tear neuropeptides and tear homeostasis

- Alcon
- Allergan
- Bausch + Lomb
- CooperVision
- Johnson and Johnson Vision Care
- Novartis
- Stiltec
- Menicon
- Azura Ophthalmics

### **Breath Analysis**



#### More information

**Professor Richard Stuetz** School of Civil and Environmental Engineering

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Breath analysis using Sorbent tubes and GC-MS/O technology to analyse Volatile Organic Compounds (VOCs) offers a non-intrusive alternative to traditional biopsies and blood tests.

#### Competitive advantage

Advantages include:

- Non-intrusive breath sampling as a suitable alternative for biopsies and blood tests
- Assessment of accuracy of the technology as it emerges
- Fast diagnosis opportunities that could take less than 40 minutes
- Simple use and application for patients and hospital staff

#### Impact

- Less intrusive sampling for patients
- Benchmarked methodology can be applied to further research

#### **Capabilities and facilities**

• Gas Chromatography-Mass Spectrometry/Olfactometry to characterise VOCs, which comprises a GC-MS (Agilent 6890GC/5973MSD) coupled to an ODP (Olfactory Detection Port, Gerstel)

- The Royal Hospital for Women
- Prince of Wales Clinical School



Dr Victoria Timchenko School of Mechanical and Manufacturing Engineering

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Efficient heat transfer is crucial for the thermal management of next generation medical devices. It is equally important in thermal therapies such as hyperthermia and cryotherapy as well as in thermally responsive nano carriers for drug delivery and diagnostics.

#### Competitive advantage

- Expertise in bio-heat transfer and nanoparticle transport
- Skills in the application of optically or magnetically heated nanoparticles for targeted destruction of tumours and infectious organisms
- Experience with enhancement of heat transfer and cooling in micro electronic devices

#### Impact

- Enhancing heating efficiency of nano structures for hyperthermia/ thermal ablation/drug delivery
- Development of plasmonic platform to accelerate reaction time in nucleic acid-based tests (digital Polymerase Chain Reaction (PCR))
- Providing effective solutions for thermal management/cooling of medical devices

#### Successful outcomes

Computational model for the temperature in multilayer superficial human tissues in the case of an external water-filtered infrared-A irradiation has been used to improve the efficiency of treatment of recurrent breast cancers.

#### **Capabilities and facilities**

- Expertise in multi-disciplinary numerical modelling of hyperthermia of tumours with embedded nanoparticles
- Access to high performance computational clusters and computational software

- Department of Radiation Oncology, Prince of Wales Hospital
- Sydnov PTY LTD (Developing highly sensitive DNA test platforms)



**Professor John Whitelock** School or Group: Bioengineered Molecules

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Using biomolecular engineering to manufacture proteins such as antibodies that may be useful in targeting cancer or building diagnostics for an early detection of inflammation. Once an antibody has been fully characterised and is taken for further development, the gene can be sequenced and humanised so that it does not cause allergic reactions in the body.

#### Competitive advantage

- Antibodies are species-specific in their binding and target specific antigens in the extracellular matrix. They have variable carbohydrate structures attached that affect binding
- Detailed knowledge of all of the possible different types of carbohydrates attached to antibodies; required by the Food and Drug Administration and Therapeutic Goods Administration before they can proceed to clinical trial
- In-house patented expression technology to express proteins in human cell systems

#### Impact

- Antibodies are a major component of many diagnostic kits in the marketplace and are used for immunotherapies and cell targeting
- Developed a human bioengineered form of heparin using biomolecular engineering technology to produce the drug under a laboratory environment that will be cleaner, safer and have better and more predictable activity in the clinic

#### Successful outcomes

Antibodies licensed non-exclusively to Merck Millipore and other companies for use as research reagents.

#### **Capabilities and facilities**

- The tissue culture and bioreactor facilities are available to engineer and manufacture antibodies in the laboratory
- State-of-the-art chemical analytical tools such as mass spectrometry and nuclear magnetic resonance together with more traditional biochemical and immunochemical methodology

- Merck Millipore
- Neuclone
- CSIRO

### Ramaciotti Centre for Genomics



**Professor Marc Wilkins** Ramaciotti Centre for Genomics

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The Ramaciotti Centre for Genomics is the largest genomics facility at any Australian University. It is comprehensively equipped with the latest generation of next-generation sequencing technology, with single-cell genomics platforms and with high throughput microarray systems. It is funded by the Australian Government as infrastructure of national significance.

#### **Competitive advantage**

- Genomics facility with 20 years' operational experience in virtually all areas
   of genomics
- Twenty full-time technical staff who process more than 20,000 samples by next-generation sequencing and more than 30,000 samples with other technologies, each year

#### Successful applications

- Human genome sequencing, exome sequencing and genotyping
- Rapid genome sequencing and assembly of viral, microbial and fungal pathogens
- Microbiome analysis of samples from humans, soil and water by 16S rRNA or metagenomics
- Short-read and long-read sequencing
- Analysis of gene expression by next-generation sequencing or microarray
- · Potential to analyse bioterrorism or biosecurity agents

#### **Capabilities and facilities**

- Capacity for end-to-end projects, including bioinformatics
- · Advanced quality systems and certified service provider
- Custom-built labs in new \$180M biosciences building
- High quality IT networks and systems

#### **Our Partners**

Researchers in industry, public-funded research agencies, medical research institutes and universities – more than 500 users per annum from more than 350 labs.

# MEDICAL IMAGING ANALYTICS

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**Professor Tracie Barber** School of Mechanical and Manufacturing Engineering

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An interdisciplinary approach in which engineering technologies and a combination of computational and dynamic techniques are used to solve real world clinical and industrial problems in the field of vascular flow.

#### **Competitive advantage**

- Close collaboration and established relationships with hospitals and local health organisations to ensure the work is relevant, solves the right problem, and is gaining useful results
- Cutting-edge research, driven by clinical issues and medical questions
- Global recognition in high-impact journals

#### Impact

The work is insightful and builds on fundamental findings in flow physics. It falls into three broad areas: dialysis vascular access, stenosis and stents, and medical imaging/ultrasound. Although new knowledge usually takes an average of 17 years to enter healthcare delivery, the high level of collaboration has been shown to deliver immediate impact.

#### Successful outcomes

- Findings have changed stent implantation practice amongst surgeons
- Developed a model using Computer Fluid Dynamic modelling and Matlab to reproduce ultrasound indices used in determining the health of the in-utero baby

#### **Capabilities and facilities**

- Obtaining reliable data and running models—primarily using ANSYS Fluent—on the local and off-site computing clusters
- Experimental laboratory with laser systems, including 3D laser doppler anemometry and planar, stereo and tomographic particle imaging velocimetry
- Use of two in-house designed pulsatile flow pumps
- In-house developed freehand ultrasound system allows the building of accurate, 3D representations of vasculature using only B-mode imaging

- The Royal Hospital for Women
- Prince of Wales Hospital
- Prince of Wales Private Hospital
- Concord Repatriation General Hospital
- Abbott Vascular Pty Ltd
- Medtronic Pty Ltd



**Professor Lynne Bilston** Neuroscience Research Australia (NeuRA)

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Developing and applying novel Magnetic Resonance Imaging and ultrasound imaging and analysis methods across a range of clinical disorders to quantify tissue mechanical properties, tissue deformation, and fluid flows. These methods are valuable in understanding disease mechanisms, and in providing information for diagnosis and monitoring of disease progression.

#### **Competitive advantage**

- First in the world large deformation MR elastography methods that can quantify the nonlinear viscoelastic mechanical properties of soft tissues in living humans
- World-leading anisotropic MR elastography methods with application to brain tissue and muscles
- Novel 'tagged' MRI methods for quantifying upper airway and skeletal muscle function
- Unique ultrasound methods to track upper airway muscle function
- New real-time fluid flow techniques for quantifying cerebrospinal fluid flow with respiration, to complement cardiac-gated fluid flow measurements

#### Impact

- MR elastrography studies showing impact in muscle degeneration in animal models and liver fibrosis in children
- Novel analysis of tongue muscle structure in sleep apnoea patients
- Real time CSF flow studies

#### Successful outcomes

- New insights into differential treatment outcomes in obstructive sleep apnoea
- Novel MR elastography techniques adopted for use in cancer research (EU2020), sleep apnoea, liver disease, and central nervous system disorders

#### **Capabilities and facilities**

- Research-dedicated state-of-the-art 3T MRI scanner (Philips Ingenia CX 3T)
- Multiple biomechanical imaging capabilities

- Philips Healthcare
- Inserm, France
- ETH Zurich

# Imaging killer immune cells targeting tumours



#### More information

Dr Maté Biro

EMBL Australia Group Leader Single Molecule Science, Cell Motility and Mechanobiology **T:** +61 2 9385 8020 | **E:** m.biro@unsw.edu.au Research and development of quantitative methods focused on understanding how cytotoxic immune cells can be harnessed for the treatment of solid malignancies. Specialise in revealing both the biological and mechanical processes that underpin the search, recognition and elimination phases of killer immune cell-mediated tumour rejection.

#### Competitive advantage

- Multidisciplinary team, instruments and methods incl. cell biology, immunology, physics, mathematics, engineering, computational modelling and simulations
- Quantitative analysis of precise cellular changes, movements, interactions and communications that enable immune cells to eliminate solid tumours

#### Impact

- Understanding how killer immune cells find and target solid tumours
- Testing of pharmaceuticals and protocols in quantitative assays
- · Co-development of novel methods and intellectual property

#### Successful outcomes

- Active collaboration with clinicians, researchers and industry who seek expertise in precise and quantitative investigations at the interface between cancer and immunology
- Developing widely adopted open source image analysis solutions
- Illuminating cellular phenomena that enhance tumour rejection and infiltration

#### **Capabilities and facilities**

- State-of-the-art microscopy suites and biomedical laboratories
- · Access to cutting-edge 3D live cell and intravital microscopes
- Advanced image analysis platforms
- · Computational simulation and modelling infrastructure
- Immunocompetent and immunocompromised animal models
- In vivo adoptive cell transfer models
- · Virus-based gene delivery and therapy
- Biophysical instrumentation

- · Children's Hospital at Westmead
- Royal Adelaide Hospital
- A\*STAR and Mechanobiology Institute, Singapore
- Noxopharm



SHARP Professor Ewa Goldys Deputy Director ARC Centre of Excellence for Nanoscale Biophotonics, Graduate School of Biomedical Engineering

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Developing novel methods of biomedical diagnostics using hyperspectral microscopy to characterise natural colour and morphology of cells and tissues in the body, to determine whether they carry the early hallmarks of disease. This can yield early screening systems for detecting ill but pre-symptomatic individuals.

#### Competitive advantage

- The method is non-invasive, rapid and easily deployable in the clinic
- The first team to extract detailed biochemical-level information from cells
   and tissues
- The method is highly sensitive and provides subtle insights into biological processes
- Awarded the Eureka Prize for Innovative Use of Technology

#### Impact

This method is expected to impact a broad range of disease conditions, including:

- · Improved therapies for regenerating cartilage injuries
- · Improved diagnostics of cancer of ocular surface
- Early diagnostics of kidney disease
- Applications in fertility and IVF industry
- Veterinary applications

#### Successful outcomes

- Early diagnostics of motor neurone diseases (clinical trial under way)
- Related start-up company is in its 5th year of operation

#### **Capabilities and facilities**

- High-content, high-throughput imaging
- Big data analytics
- Bioimaging, biosensing and data analytics

- Sydney Eye Hospital
- Fertility SA
- Royal North Shore Hospital
- Macquarie University Hospital
- Macquarie Neurology
- Regeneus Pty Ltd
- Quantitative Pty Ltd
- Prince of Wales Hospital



Associate Professor Lois Holloway Faculty of Medicine

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Using data analytics, machine learning and deep learning techniques across clinical and imaging datasets to provide the opportunity for establishing personalised medicine approaches to cancer treatment.

#### **Competitive advantage**

- Leading a strong collaboration of national and internationally linked hospital-based radiotherapy datasets
- Distributed learning to enable machine learning and advanced imaging analysis across the network of datasets
- Imaging datasets that are annotated during the routine course of radiotherapy including defined treatment regions and normal tissue structures, all in 3D

#### Impact

- Outcome models can provide additional clinical evidence where directly applicable clinical trial evidence is not available
- Variability in patient cohorts, treatment and outcome can be assessed in a streamlined fashion
- The impact of new technology that is unsuitable for a clinical trial, can be assessed

#### Successful outcomes

- · Validated published prediction models using this approach to accessing data
- Used imaging datasets available in this network to incorporate radiomics features into an outcome prediction model
- Develop autosegmentation algorithms using image datasets for use within a radiotherapy clinical environment

#### **Capabilities and facilities**

- An established network across both national and international radiotherapy clinics
- A developed platform for undertaking machine learning on distributed datasets, and for calculating and analysing radiomics features and assessing correlation with other clinical factors or outcomes

- NSW Local Health Districts
- Trans-Tasman Radiation
   Oncology Group
- Maastro clinic, Maastricht, The Netherlands
- Odense University Hospital Denmark
- Oslo University
- CSIRO
- Cancer Institute NSW

# **Bio-Imaging of the Eye** THE OWNER WHEN THE

#### More information

**Professor Michael Kalloniatis** Centre for Eye Health, School of Optometry and Vision Science

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Identifying and classifying the risk of progression in age-related macular degeneration (AMD) by applying pattern recognition to multi-modal images of the retina, changes in which can also be used to diagnose and analyse the progression of other retinal and optic nerve diseases.

#### **Competitive advantage**

- Uses different spectrally-derived retinal images or en-face optical coherence images to identify changes to, and different types of, drusen – fatty deposits which develop in the retina, associated with the early stages of AMD – as well as their location and size, to determine the risk of disease progression
- Accurate because it detects features not obvious to the naked eye, not
   subject to human biases, fatigue, inexperience, education etc
- Cost effective. It saves time for clinicians as there are fewer images to assess the technology produces one simple, composite image from multiple images and has the potential to automate comparisons in follow up visits
- Has the potential for immediate integration into current devices as it is
   accessible to existing, commercially available imaging technologies

#### Impact

Improving the diagnosis of retinal and optic nerve disease to assist clinical decision making.

#### Successful outcomes

- Patent filing: PCT/AU2019/050270
- Start-up in development

#### **Capabilities and facilities**

- The Centre for Eye Health (CFEH) provides clinical service to around 10,000 patients each year, more than 3,000 of whom have macular disease
- CFEH has clinical files of around 35,000 patients, many of whom have had multiple clinical visits over the 10-year existence of the Centre
- Dedicated research-focused staff with expertise in image analysis and a team of expert clinicians
Application of Clustering Methods to Analyse Clinical Topographic Data from the Anterior Eye

# More information

**Professor Michael Kalloniatis** Centre for Eye Health, School of Optometry and Vision Science

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The application of clustering and separability statistics on topographic data from the anterior eye assists in the classification of corneal disease or the identification of those at risk of angle-closure glaucoma. Imaging data from routinely available clinical instruments may be used and thus the method is transferable across existing imaging platforms.

#### Competitive advantage

This technology:

- Uses the application of clustering, followed by separability testing, to generate 'isocontours' of anterior topographic clinical data from routinely available clinical instruments. Advantages include:
- Identifying corneal changes and the risk for corneal disease progression
- Identifying anterior chamber morphology changes to identify and phenotype different types of glaucoma
- Instrument agnostic and includes advantages such as: being non-invasive, easy and quick to acquire, and readily interpretable
- Quick and easy to implement using techniques that currently exist in clinical practice and so will be highly accessible to clinicians
- Is accurate; it detects features that are not obvious to the naked eye and therefore not subject to human biases, fatigue, inexperience, education etc
- Is cost effective as it saves time. There are fewer images for clinicians to assess the technology produces one simple, composite image from multiple images and has the potential to automate comparisons in follow up visits

#### Impact

- · Simplifying the detection of corneal ectatic disease in at-risk individuals
- Assisting in screening and predicting development of corneal complications following corneal surgery, including commonly-performed refractive surgery
- Improving the characterisation of anterior eye morphology that makes an individual more susceptible to glaucoma
- Phenotyping different types of glaucoma to target and personalise a medical treatment approach

#### Successful outcomes

- · Patent filing: provisional patent in preparation
- Start-up in development

Preventing Injuries and Promoting Health, Safety and Mobility for Older People with Age-Related Eye Disease

# More information

Professor Lisa Keay School of Optometry and Vision Science and The George Institute for Global Health

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This public health research group has a demonstrated ability to assemble multi-disciplinary teams to address priority issues in injury prevention and eye health, innovate and build capacity in this sector.

#### Competitive advantage

- Large-scale interventional trials using new research methods—'in-vehicle' monitoring for road safety and accelerometers—to investigate activity in older people at risk of falls
- Established networks in the eye health sector and government to design studies which have the capacity to translate into policy and practice
- Expertise in community-based clinical trials of complex interventions

#### Impact

This program of research will address the two major causes of injuries (falls and road traffic injuries) which increase dramatically with older age and in visually impaired populations. This work will produce specific contributions to understanding the mechanisms of injury risk and will evaluate promising solutions to these issues, including the streamlining of cataract surgical services, targeted falls prevention and novel solutions for older driver safety.

#### Successful outcomes

- Research briefs from the NHMRC cohort study investigating cataract and falls risk have been tabled to the Australian Commission on Safety and Quality in Health Care Clinical Guidelines for Cataract committee
- Completed a comprehensive review of the licensing regime for older drivers. This is the foundation for further work investigating semi-autonomous vehicle technology and the driver-vehicle interface

#### **Capabilities and facilities**

- Health systems research
- Patient reported outcomes, economic evaluations, discrete choice modelling and co-design
- Experience with managing large datasets and processing data

- NSW Health Agency for Clinical Innovation
- Transport for NSW, Centre for Road Safety
- Western Sydney Local Health District
- South East Sydney Local Health District
- Mid North Coast Local Health District
- Northern Sydney Local Health District

- South-West Sydney Local Health District
- Guide Dogs NSW/ACT
- Optometrists Association
- Vision2020
- Glaucoma Australia
- NeuRA
  - The George Institute for Global Health

# Correlative Light and Electron Microscopy (CLEM) Based Analysis of Disease



### More information

Associate Professor Murray Killingsworth Faculty of Medicine

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Correlative light and electron microscopy (CLEM) is a synergistic microscopy approach for obtaining structure and function information from single cells and tissue samples. Correlation is obtained by overlay on ultrastructure of either biochemical information from other microscopy modalities such as immunocytochemistry, MRI or analytical platforms such as imaging mass spectrometry.

#### Competitive advantage

The Correlative Microscopy Facility, Ingham Institute is an Australian-first initiative for the application of correlative and 3D microscopy to cancer research.

#### Impact

Improving the efficiency of pathological testing protocols, enhanced understanding of disease pathogenesis and mechanisms at the sub-cellular level and improved treatments and interventions leading to practice policy change.

#### Successful outcomes

- Discovery of chronic inflammatory pathway in age-related macular degeneration
- Identification of new biomarkers in stroke endovascular thrombectomy blood clots

- Ingham Institute for Applied Medical Research
- NSW Health Pathology
- NSW Brain Clot Bank

Google Maps of the Body: Cross-Scale Connectomics for Cellular Epidemiology and Next-Gen Diagnostics

# More information

Inaugural Paul Trainor Chair Professor Melissa L. Knothe Tate Graduate School of Biomedical Engineering

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Incorporating novel imaging technologies with correlative approaches, image rendering and interaction capabilities using geospatial tools, as well as image analytics that incorporate machine learning, to understand cellular epidemiology of disease and develop novel next generation diagnostics.

#### Competitive advantage

World-leading technology to image and analyse subcellular to whole organ systems.

#### Impact

- Degenerative diseases show commonalities in the way they disrupt cellular and structural protein connectivities, from brain (dementia) to bone (osteoporosis) and joints (osteoarthritis)
- Connectomics approaches to understanding health and emergent disease throughout life provide a next generation approach to early diagnosis, cure and prevention of disease

#### Successful outcomes

- · First and currently the largest map of a human tissue/organ in the world
- First application of machine learning to assess the health of the world's largest tissue map

#### **Capabilities and facilities**

 Led the collaboration with Zeiss since the first prototype multi-beam scanning electron microscopes for rapid throughput defect assessment in semiconductor wafers were applied to human tissues

- Zeiss Microscopy
- TissuTex Pty. Ltd., NSW Australia
- Food and Drug Administration, National Institutes of Health, USA
- Hospital for Special Surgery New York, USA
- Cleveland Clinic, USA



### More information

Associate Professor Gary Liney Faculty of Medicine

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A unique integration of radiotherapy with real-time MRI-based image guidance that allows cancer and normal tissues to be seen directly during radiotherapy for the first time. Approximately 50% of cancer patients will benefit from such a system that will improve survival, prevent recurrence or relieve the symptoms of their cancer.

#### Competitive advantage

- One of only four engineering approaches in the world to this problem
- The Australian MRI-Linac is a unique 'in-line' system with the magnetic field parallel to the radiation beam. This results in different radiation dosimetry properties to perpendicular systems

#### Impact

- Early international studies suggest the real-time combination of image guidance and radiotherapy results in better survival for poor-outcome cancers
- The physiologic imaging capabilities of the MRI enable a virtual whole-tumour biopsy prior to and during each treatment, enabling real-time adaptive physiological targeting as a unique way to treat cancer

#### Successful outcomes

- First human images were obtained in March 2017
- First live MRI-Linac treatment in the southern hemisphere was performed using a rat brain tumour model In January 2019
- Planning for human studies underway

#### **Capabilities and facilities**

- The prototype magnet is a 1 Tesla split system designed to let the high energy X-ray beam travel through an open bore parallel to the magnetic field
- The research program is embedded into Liverpool Hospital and involves collaboration between numerous universities and scientific organisations
- Team history of scientific and technological advances in MRI and radiotherapy physics and engineering, as well as the clinical practice of MRI-Linac cancer radiotherapy
- Team record of research translation resulting in improvements in hardware, workflow, patient outcomes and policy

#### **Our partners**

The research program is embedded into the Ingham Institute working with Liverpool Hospital and involves collaboration between numerous universities and scientific organisations.



### More information

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Professor Arcot Sowmya School of Computer Science and Engineering T: +61 2 9385 6933 | E: a.sowmya@unsw.edu.au Advanced computational methods for automated biomedical image analysis, health informatics and downstream data analytics to improve the reliability and throughput of imaging-and multimodal data-based diagnostics and screening.

#### Competitive advantage

- Over 50 years' combined experience in automated biomedical image analysis
   and health informatics
- Multidisciplinary R&D in biomedical image computing, visual analytics and biomedical health informatics

#### Impact

- Early screening and faster, more accurate diagnosis of chronic diseases
- Facilitating the discovery of imaging biomarkers
- · Advancing the understanding of brain function in health and disorders
- Support for radiotherapy planning and distributed learning in medical settings
- High-throughput image analytics for drug screening

#### Successful outcomes

- · Software for atherosclerotic carotid plaque quantification
- · Automated vessel analysis for diagnosis of cardiovascular diseases
- Framework for quantitative analysis of ocular images
- Diffuse lung disease feature recognition and quantification
- Pattern recognition methods for digital histopathology
- Motion artefact removal in digital angiography
- CAD for diffuse lung disease pattern recognition
- 3-D image analysis for the improved treatment of arterio-venous malformations (AVMs)

#### **Capabilities and facilities**

- Machine and Deep learning
- GPU-based high-performance computing
- Imaging across the EM spectrum-radio waves to X-rays

- Harvard Medical School
- Technical University, Munich
- Geneva Neuroscience Center, University of Geneva
- Prince of Wales Hospital, Sydney
- Royal Women's Hospital, Sydney



### More information

**Professor Daniel Moses** Graduate School of Biomedical Engineering

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Research Imaging NSW (RINSW) is a new strategic initiative developed in partnership between UNSW, South East Sydney Local Health District and Neuroscience Research Australia to provide state-of-the-art MR imaging capabilities, and increase collaboration between leading academic, research and health care institutions.

#### **Competitive advantage**

- Siemens MAGNETOM Vida MRI
- RINSW has capabilities to assist in sequence design, testing and implementation onto the Vida system. An expert team of technical and scientific support staff comprised of Radiologists, Radiographers, MR Physicist and Siemens Clinical Scientist available for advice and training

#### Impact

Working towards extracting as much information as possible from patients' medical images and combining with other clinical and biological data to allow a personalised approach to treatment (personalised medicine).

#### Successful outcomes

Joint venture between SESLHD and UNSW in installing 3T MRI Human Imaging Facility on the Randwick Medical Precinct.

#### **Capabilities and facilities**

- Support for medical imaging projects
- In humans or animals
- In terms of clinical questions and modality use/optimisation
- With Medical Imaging Analytics (e.g. Radiomic analysis, Deep Learning)

- Medical Imaging Department on the Randwick Precinct (Prince of Wales Hospital/Sydney Children's Hospital, Royal Hospital for Women)
- Clinicians on the Randwick Campus and in the South East Sydney Local Health District

# Advanced Medical Image Analytics and Software Development Using Ultrasound

### More information

Professor Alec Welsh School of Women's & Children's Health, Faculty of Medicine

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A research group comprised of perinatal clinicians and biomedical engineers who conduct translational imaging research in a hospital setting. The multidisciplinary team allows development of novel ultrasound algorithms to image, evaluate and quantify structure and function (perfusion and impedance) of structures such as organs and tumours.

#### Competitive advantage

- Unique in having engineers and clinicians working side-by-side to optimise information from ultrasound. Co-location allows immediate addressing of clinical problems and research translation into clinical practice
- Deal directly with 'raw' ultrasound image data to write new algorithms for perfusion, vascular impedance, automation and evaluation of waveform data, camera-tracking-based stitching of 3D ultrasound and other tools
- The first team in Australia to introduce a research-dedicated ultrasound machine

#### Impact

THEFT.

- Novel technologies allow non-invasive evaluation of the foetus and neonate
- Developed tools for whole organ labelling (segmentation)
- The capacity to measure large organs or structures using 3D ultrasound
- · Novel Doppler assessment has been validated in an animal study

#### Successful outcomes

- Pilot studies indicate that perfusion technology is a potential predictive marker of pre-eclampsia
- Undertaking further clinical trials in foetal medicine, neonatology and gynaecology

#### **Capabilities and facilities**

- Numerous dedicated research ultrasound machines as well as a dedicated research imaging space adjacent to the rest of the research facility
- Dedicated computer hardware for convolutional neural network development (Nvidia RTX 2080 GPU)
- Research-dedicated ultrasound machine (Verasonics Vantage 256)

- GE Healthcare
- · Sydney South Eastern & Blue Mountains LHDs
- University of Michigan
- Randwick Hospital
- Nepean Hospital, Penrith

# Making the First Fracture the Last



### More information

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Any minimal trauma fracture (MTF) doubles the risk of future fractures. XRAIT uses natural language processing of radiology reports to allow risk stratification of patients by clinical services to reduce the social and economic impact of osteoporosis and ensure that their first fracture is their last.

#### Competitive advantage

- Natural Language Processing increases sensitivity and specificity by correctly identifying minimal trauma fracture in patients at increased risk of a second fracture
- XRAIT:
- Requires low computing power to read massive datasets and extract a clinically relevant output
- Has high sensitivity and specificity for fractures
- Is adaptive and can be calibrated for site specific variations in reporting
- Is a plug and play system that can be installed into diverse operating environments

#### Impact

More than 140,000 MTF are estimated to occur due to osteoporosis or osteopenia in people aged 50 years and older in Australia each year. Early identification and follow up of patients at risk of recurrent fracture will reduce the economic impact which, by 2022 is expected to reach \$3.84 billion.

#### Successful outcomes

- Showed a 6-fold increase in the numbers of fractures identified compared to manual case-based referrals to services designed to prevent the next fracture
- Installed across major teaching hospitals in SESLHD and in Concord and Royal North Shore Hospitals for evaluation and validation

#### **Capabilities and facilities**

- Close links to industry for underlying technology capacity on a contract basis
- NLP experts who can further develop the technology and concepts leading to enhanced versions and additions
- Support of eHealth to engage and develop the technology on a needs and facility-wide basis
- Committed clinical workforce and capacity to test clinical utility and
   effectiveness in real world settings

#### **Our partners**

- SPHERE MSK
- Pacific Knowledge Systems
   Surry Hills Sydney
- Macquarie Park, Sydney

NSW eHealth

NH&MRC

- SW Health Agency for Clinical Innovation
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# Optimising the Approach to Vascular Diagnosis and Treatment

### More information

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Advanced flow modelling and experimental analysis from medical images, virtualisation and simulation for structural and fluid dynamic investigation. This includes populational statistics and data-driven mapping for biomarker detection, improved diagnostics and treatment optimisation.

#### Competitive advantage

- Use-inspired research resulting in close collaboration with clinical professionals
- State-of-the-art capabilities in terms of bench-top testing with couple computational assessment

#### Impact

Using statistics, simulation and analytics to optimise the diagnosis and treatment approach in vascular care.

#### Successful outcomes

- Framework for a populational large-scale arterial shape and flow analysis
- Automated adverse vessel shape feature recognition tool
- Data analytics for two stent strategy forecasting
- Realistic replication of vessel tissue mechanics and shape using 3D printing
- Novel stent design proposal based on flow optimisation

#### **Capabilities and facilities**

- Multi-objective design optimisation
- PIV and LDA flow measurement systems with advanced pressure-flow control
- Microfluidic device fabrication facilities with PC1 lab
- A range of multi-material and compliance 3D printers
- Super-computer modelling with high end GPU and storage capability

- Prince of Wales Hospital
- Boston Scientific

# **CENTRES, INSTITUTES AND FACILITIES**

#### Mark Wainwright Analytical Centre (MWAC)

The Mark Wainwright Analytical Centre manages major instrumentation used by researchers for the study of the structure and composition of biological, chemical and physical materials. The facilities are housed in custom-built laboratories and are available for internal and external research groups, including government and industry partners. Instruments and associated support staff are grouped into units and facilities such as the Bioanalytical Mass Spectrometry Facility, The Electron Microscope Unit, The Nuclear Magnetic Resonance Facility, The Spectroscopy Laboratory and the UNSW Biorepository, which stores samples from healthy individuals and patients with cancer. MWAC features world-leading magnetic resonance facilities, including high-resolution solid-state NMR up to 700 MHz and X-band EPR. The Centre undertakes industry projects and specialist consulting work for external clients. Of particular note for bioengineering applications, MWAC also contains:

**Biomedical Imaging Facility (BMIF):** equipment and research support in core and advanced microscopy including: 2-photon and Intravital Microscopy, Biological/Soft Material Atomic Force Microscopy (AFM), Confocal Microscopy, Epifluorescence for live cell imaging, Fluorescence Correlation Spectroscopy (FCS), Fluorometer and Lifetime Spectroscopy, Spinning Disc Microscopy, Stimulated Emission Depletion (STED) Microscopy, Stochastic Optical Reconstruction Microscopy (STORM), Superresolution Fluorescence Microscopy including photo-activation localisation microscopy (PALM), Time-Resolved Single Molecule Imaging including Fluorescence Lifetime Imaging Microscopy (FLIM) and Total Internal Reflection Fluorescence (TIRF) Microscopy

**Biological Resources Imaging Facility (BRIL):** CT, PET, MRI and Ultrasound imaging set within a specified pathogen-free PC2 facility. Bioluminescence and fluorescence imaging, laser speckle and photoacoustic imaging are also available. Of particular note, the BioSpec Avance III 94/20 high field microimaging MRI system is one of the most powerful small-animal MRIs in Australia and is able to provide users with state-of-the-art small animal and sample imaging.

#### **Ramaciotti Centre for Genomics**

The Ramaciotti Centre for Genomics is the largest genomics facility at any Australian University. It is comprehensively equipped with the latest next-generation sequencing technology, single-cell genomics platforms and high-throughput microarray systems.

It is funded by the Australian Government as infrastructure of national significance and is accredited to ISO/IEC 17025 by the National Association of Testing Authorities (NATA).

- Areas of interest include analysis of:
- Genome and epigenome
- Gene expression and transcriptome
- Microbiome and metagenome
- Single cells
- Bioinformatics

#### **Cellular Genomics Futures Institute**

Single cell genomics is the next great revolution in medicine. The field leverages the massively parallel technologies that enabled large-scale human genome sequencing and makes it possible to see the entire genome in action at the quantum of individual cells. The Cellular Genomics Futures Institute is dedicated to inventing technologies to decode individual cell DNA, chromatin, RNA, and protein outputs that will be used for precise diagnosis and precision treatment of human disease.

#### Microbiome Research Centre (MRC)

The Microbiome Research Centre is the only centre in Australia dedicated to undertaking research in the human microbiota and utilising state-of-the-art science to answer important clinical questions. It is unique in being fully embedded in a large clinical campus. The Microbiome Research Centre is a collaboration between St George & Sutherland Medical Research Foundation (SSMRF), UNSW, Sydney and the South-East Sydney Local Health District (SESLHD).

#### Centre for Big Data Research in Health (CBDRH)

The Centre for Big Data Research in Health is the first Australian research centre dedicated to health research using big data. Its aim is to maximise the productive use of all possible sources of health big data in order to enhance the health and wellbeing of Australians and the global community. "Big data" have no agreed definition, but the term is in general applied to data that by virtue of their size and/or complexity pose challenges to traditional methods for management and analysis. In health, such data include the millions of records that are generated routinely by health services, real-time clinical data captured at the point-of-care, genomic data produced in research and clinical settings, and health-related data generated by the population at large through technologies such as wearable devices and social media.

#### Australian Centre for NanoMedicine (ACN)

The Australian Centre for NanoMedicine combines Medicine, Science and Engineering to deliver therapeutic solutions to research problems in medicine.

ACN is a translational research centre based on a multidisciplinary approach that undertakes basic, clinical and institutional technological research. This research is directed at increasing capabilities in specific disease-focused programs by bringing biological scientists and nanotechnologists together to encourage collaboration and development of new technologies.

#### Centre for Healthy Brain Ageing (CHeBA)

The Centre for Healthy Brain Ageing is positioned as an international centre of excellence in multidisciplinary research into the ageing brain. The work extends from: molecular work in the genetics and proteomics laboratories; to tissue culture and cell-related work in the Stem Cell Lab; to neuronal systems and networks in the Neuroimaging Lab; to clinical, epidemiological and sociological research; to research on ageing health policy using its strong links with teaching hospitals, aged care providers, state and federal governments and our established ageing cohort studies.

#### **Optics and Radiometry Laboratory (ORLAB)**

The Optics and Radiometry Laboratory is a self-sustaining test, calibration and research facility associated with UNSW. The facility has been in operation for more than thirty years, and has allowed researchers to build expertise in the areas of light, colour and optical testing. It provides services to industry, maintains a research program and plays an active role in supporting standards development at national and international levels. ORLAB has been NATA accredited to ISO 17025 since 1985 for a large range of activities. For much of the scope of testing, ORLAB is the only accredited laboratory in New South Wales and, for many services, is the only accredited laboratory in Australia.

#### **Recombinant Products Facility (RPF)**

The Recombinant Products Facility (RPF) and its highly skilled staff provide protein production and purification services for academic and industry researchers, including: protein production, sample harvest and conditioning, protein purification, and protein characterisation, as well as training users to perform the above techniques.





# SHORT COURSES

UNSW offers high-quality professional education for real world impact. Through its program of short courses, the University delivers learning outcomes to support partners in delivering excellence.

The University works with its partners to identify strategic goals and then design and develop—or tailor existing—courses to match. This collaboration results in academically rigorous and culturally relevant learning that drives business improvements.

The standard range of short courses on offer can be found online, or a specialist team is available to discuss specific requirements and design, and support creation of bespoke programs from concept to completion.

#### **Context of Health Data Science**

Provides an overview of how data is generated and used in the Australian health system. It gives an introduction to measuring health outcomes and disparities in health, describes major sources of Australian health data and discusses how these can be used by health data scientists to create evidence for policy and research.

#### Statistical Foundations for Health Data Science

Providing participants with an important grounding in statistical foundations. Multiple core concepts will be covered, including: the Law of Large Numbers and the Central Limit Theorem; probability distributions; likelihood and likelihood estimation; Bayes theorem and Bayesian estimation; Monte Carlo methods and resampling methods, such as the bootstrap; frequentist inference; and essential epidemiological and study design concepts.

#### **Computing for Health Data Science**

The ability to write clear, efficient and correct computer code is at the core of most data science practice and is a foundation skill set. During this course participants focus on 'computational thinking' by providing a thorough and principled introduction to computer programming using Python, algorithms, data structures and software engineering best practices.

#### Management and Curation of Health Data

Focuses on developing data wrangling skills required to assemble data suitable for analysis and research purposes. Participants, develop skills required to collect or obtain data, design data management strategies aligned with best practice, and appreciate the day-to-day practicalities of data curation.

#### Statistical Modelling I

Provides a sound grounding in the theory and practice of fitting statistical regression models, with focus on the flexibility of generalised linear models (GLMs). The course is taught using the R programming language.

#### **Machine Learning and Data Mining**

Introduces data mining and machine learning, including both supervised and unsupervised techniques. Participants learn about the underlying theory, as well as gain the practical know-how required to effectively apply these techniques to real-world health datasets, to answer new health data science problems.

#### Visualisation and Communication of Health Data

Offers a practical approach to creating appropriate, reproducible and transparent analyses and visualisations. Using R and RStudio, participants develop useful data science analysis and visualisation techniques for different types of data visualisation and communication. Geospatial information is explored through the construction of an interactive Shiny application.

#### Protein production, purification and analysis

Proteins are fundamental components of living organisms. Through this course, participants learn basics about proteins as well as techniques in production, purification and analysis for industry and biomedical application, through real-life scenarios and knowledge application.

#### Genetics and Clinical Genomics for Medical and Healthcare Professionals

Focuses on developing participants' skills in dealing with the increasing availability and frequency of genetic testing in the healthcare industry, by using case studies and knowledge application in different genetic test types, understanding results, pedigree analysis and associated ethical and legal concerns.

For more information, please visit <u>shortcourses.unsw.edu.au</u> or email <u>shortcourses@unsw.edu.au</u>

# WORKING WITH UNSW

UNSW works with a variety of partners including government, high-calibre corporate partners, small-medium enterprises and community groups in Australia and overseas.

UNSW operates at the forefront of global research and design to help deliver transformational innovations that advance Australia's capabilities and are instrumental in defining the future landscape.

By partnering with UNSW, your organisation will gain opportunities to access innovative research, ground-breaking discoveries and the very best students – the next generation of leaders.

We offer a broad range of engagement models and have decades of experience partnering with small and large organisations to deliver:

- Multidisciplinary expertise at the centre of leading and emerging research
- Access to world class technologies and infrastructure
- Dedicated industry-facing and government-facing organisational units, such as UNSW Knowledge Exchange and UNSW Division of Enterprise
- Highly effective partnership models including research strategy advice
   and support
- Collaborative research leveraging third party and government funding
- Access to our national and global research partners including Group of Eight Australian Universities; the international PLuS Alliance with Kings College London and Arizona State University; the New South Wales NUW Alliance with the University of Newcastle and University of Wollongong; the joint venture with Western Sydney University
- Access to students through professional development programs, projects and our industry placement program
- Customised and bespoke initiatives

We look forward to working with you to develop real world applications.





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