

Bionic solutions for chronic human diseases

ANNUAL REPORT
2015-2016

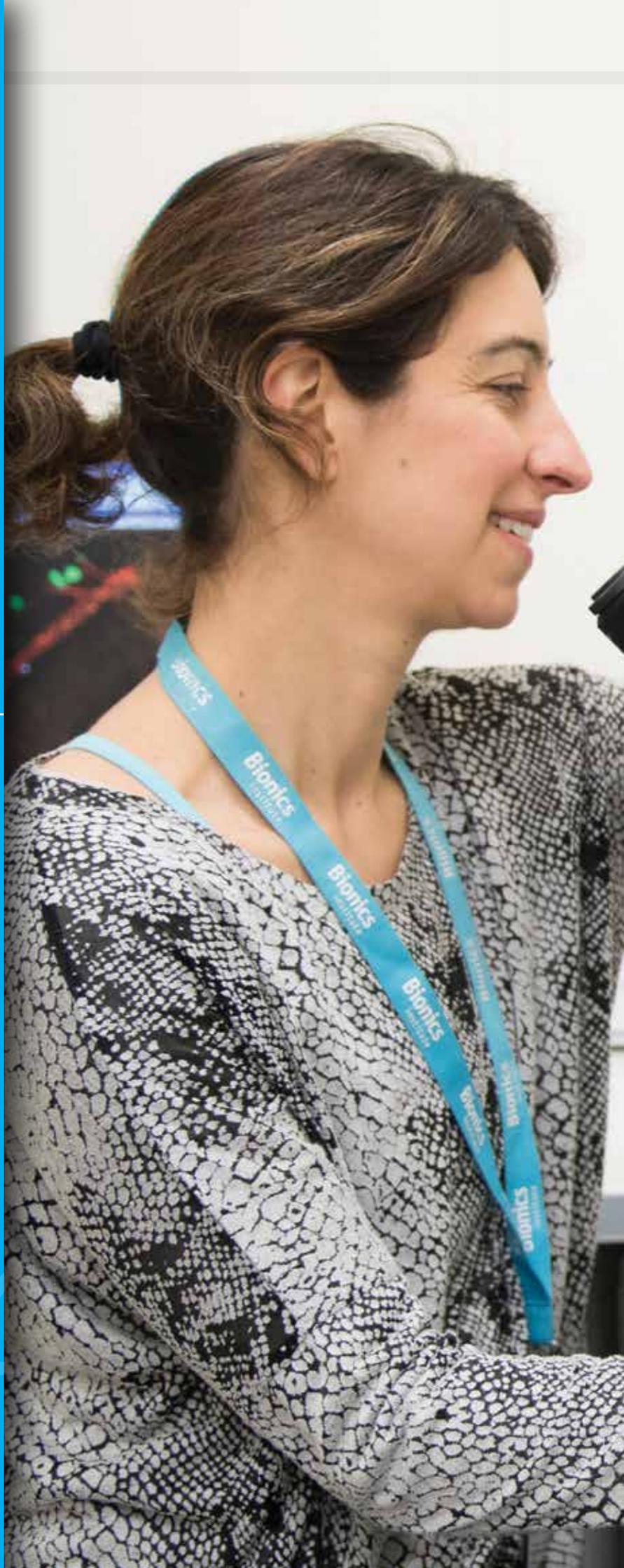
The Bionics Institute embraces innovation and collaboration to create life-changing medical devices.

Innovation springs from the ingenuity of our talented researchers, and delivers novel bionic solutions for the treatment of deafness, blindness, and debilitating neurological conditions.

Collaboration with clinicians and industry ensures new medical devices will be delivered to patients and transform their lives.

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Mr John Stanhope AM
Chairman

Chairman's report

Since taking on the role of Chairman of the Bionics Institute in November, I have been excited by the challenges and opportunities in promoting the life-changing work of our researchers.

Over the past 12 months the Institute has started on the strategic pathway towards translating our research into patient-driven commercial outcomes.

The Institute will always have research as its core function and we are proud that our expertise in the fields of hearing, vision and neurobionics has attracted funding from both Australian and international grant bodies. However, we recognize that the current research funding model in Australia is not sufficient, and there is a significant discrepancy in the funding allocated to research institutes and the resources required to properly carry out a research program. Consequently, the Institute is reviewing other means of strengthening its self-funding opportunities, including donors, Trusts and Foundations, contract research and commercialisation opportunities.

The potential for a sustainable source of funding offered by the Medical Research Future Fund is an exciting time for the research community in Australia and the Bionics Institute looks forward to its development and implementation, but we also note the importance of becoming more self-sufficient.

The Institute carried out an extensive review in 2016 in which an external consultant recognised the strength of the Institute's research capabilities and collaborations. We continue to build on these strengths and acknowledge that our clinical and research collaborations play a key role in our success. Our clinical partners enable us to design and develop solutions which will benefit their patients, and provide our research teams with immediate feedback and input. Patient-driven

outcomes remain a key focus for the Institute and we continue to liaise closely with advocacy groups.

Each of our research streams has a clear focus, centred on delivering the best possible outcome for patients. We acknowledge the crucial support of our volunteers across the fields of hearing, vision and neurobionics, who enable our researchers to refine and develop tailored solutions for a wide range of debilitating conditions.

We have had a number of changes to the Institute's Board in the past twelve months: in November 2015, Mr Gerry Moriarty AM resigned after sixteen years as Director, including twelve years as Chairman; Mr Neville Bertalli stepped down after four years; and, in May 2016, Professor Iven Mareels stepped down after eighteen years. I would like to thank them for their significant contribution to the Institute. I acknowledge the support of the Board members and thank them for their continued involvement on the Board and sub-committees, and I welcome a new Board Member, Mr Philip Binns.

I look forward to the year ahead with great anticipation, as Professor Robert Shepherd continues to direct our research and as we search for and appoint a CEO to lead our expanded strategy.

John Stanhope
Chairman





Professor Robert K Shepherd
Director

Director's report

The Bionics Institute continues to pursue innovative health solutions through research. This is essential to helping those in our community who are living with chronic conditions such as deafness, blindness, and a range of neurological disorders including epilepsy and Parkinson's disease.

Over the past year, it has been a privilege to lead such a talented group of researchers who, every day, strive towards finding new treatments for serious medical conditions. Our researchers, collaborating closely with clinicians, have worked on multi-disciplinary projects in bionic hearing, bionic vision, and neurobionics that will further the technologies needed to combat chronic illness and disease.

Our bionic hearing research program continues to grow, encompassing studies that will improve the quality of hearing provided by cochlear implants and hearing aids, and furthering our understanding of how the brain changes with deafness and adapts to restored hearing through a device.

The bionic hearing group commenced clinical studies using brain imaging techniques to develop objective techniques for programming cochlear implants, while the bionic vision preclinical and psychophysics teams have been busy preparing for the clinical trial of our second generation bionic eye due to commence late 2016.

The neurobionics program continues to push the boundaries in neuroscience and translational medicine with the development of new devices to safely and effectively treat people who have severe neurological disorders. The team is evaluating balance and posture problems in movement disorder patients, and rapidly advancing our deep brain stimulation system to treat the disabling symptoms of Parkinson's disease. Our device will deliver precisely the right amount of stimulation to the brain according to a patient's needs to more effectively alleviate their changing symptoms. The epilepsy research team is currently completing the preclinical studies and device development work for a novel seizure monitoring device, in preparation for a clinical trial in 2017.

Our research is not possible without multiple sources of funding and support from the wider community. We are grateful for the generosity of various Trusts and Foundations over the past year, and most importantly their support of our mission to create new and improved bionic devices for chronic human conditions. The continued efforts of our Ambassadors and volunteers are also very much appreciated. Their commitment is essential to raising awareness and the public visibility of our organisation, and enhances our community engagement programs.

We gratefully acknowledge the funding we receive from the Victorian Government through its Operational Infrastructure Support Program, and the Federal Government through its competitive Australian Research Council and National Health and Medical Research Council granting schemes. These sources of funding are crucial to maintaining our research excellence.

Over the past year, the medical research sector succeeded with its push for the Australian government to provide further funding to assist with the challenge of getting results out of the laboratory and into the hands of physicians for use with their patients. The Institute is pleased that the \$250 million Biomedical Translation Fund has been launched as part of a recommendation by the Federal Government's National Innovation and Science Agenda and is intended to progress medical research technologies through to commercialisation.

Australia must improve its ability to commercialise the excellent medical research undertaken in this country. The cochlear implant is a prime example of an Australian biomedical success story and our ability to successfully translate an idea into a clinical reality. However, there are many challenges in this process, and these were eloquently addressed by our 2016 Public Lecture keynote speaker, Catherine Livingstone AO. Catherine gave an excellent overview of the medical research translation challenge we face in Australia, noting the importance of collaboration in driving innovation and commercialisation in our sector.

On behalf of the Institute, I sincerely thank our Board for its passion, counsel, and direction throughout the year. Their drive to diversify our funding streams, including the pursuit of strategic commercialisation opportunities, will ensure the continued success of the Bionics Institute. I would like to particularly acknowledge the contribution of Gerry Moriarty AM who stood down as Chairman of the Board following 16 years of service. I also acknowledge the wonderful contribution of our new chairman, John Stanhope AM, who has taken to the position with great passion.

Finally, I would like to take this opportunity to announce my retirement as Director of the Bionics Institute. I have immensely enjoyed the last 11 years leading our talented team of researchers. While I have decided to retire from this role, I am delighted to be remaining at the Institute to pursue my research interests. I am looking forward to the opportunity to be more closely involved in a range of cutting-edge research projects, and continue to develop innovative medical devices.

With my involvement over such a long time in research on Australia's premier bionic device – the cochlear implant – I am excited by the breakthroughs I see occurring in vision, hearing and neurological research. We really are at a turning point, with new bionic technologies that will transform the lives of millions of people just around the corner.

Professor Rob Shepherd
Director

Translating research into patient benefits and medical bionic products

Spanning the critical interface between industry and academia, we are a leader in the provision and translation of knowledge into improved health and wealth – innovative health solutions for the community and increased wealth in the form of a pipeline of new products and a skilled workforce.

Due to the scale, scope and multi-disciplinary approach needed to achieve these goals, a high level of scientific, operational and commercial acumen across a number of academic, hospital and industry partners is required. We have the relationships, policies, structures and right people in place to effectively manage this constant 'innovation loop' between researchers, clinicians, patient groups, and industry. This approach has already led to four companies being spun out and/or incubated by the Bionics Institute.

In addition to the strong partnerships with clinicians, we have forged strong relationships with patient care and advocacy community groups as well as individual patients. These strong links between research, clinicians, patients and their community groups are critical for the successful development of any medical device. In a recent review, an external consultant confirmed that the Bionics Institute has a diverse skill set which enables clinical and technical problems to be quickly addressed, as well as strong clinical collaborations which provide for early-stage clinical feedback into the design and validation process.

In order to achieve our strategic commercial objectives, an increasing emphasis is placed on growing investment and commercial funding for research, and achieving commercial and clinical outcomes from our translational and fundamental research activities in each of the three key programs: bionic hearing, bionic vision, and neurobionics.



Our management of intellectual property (IP) enables and rewards successful translational research, innovation, publication, commercialisation, and clinical outcomes. We have 10 patent families under active management and several further patent applications under preparation across our three key programs.

Business Development

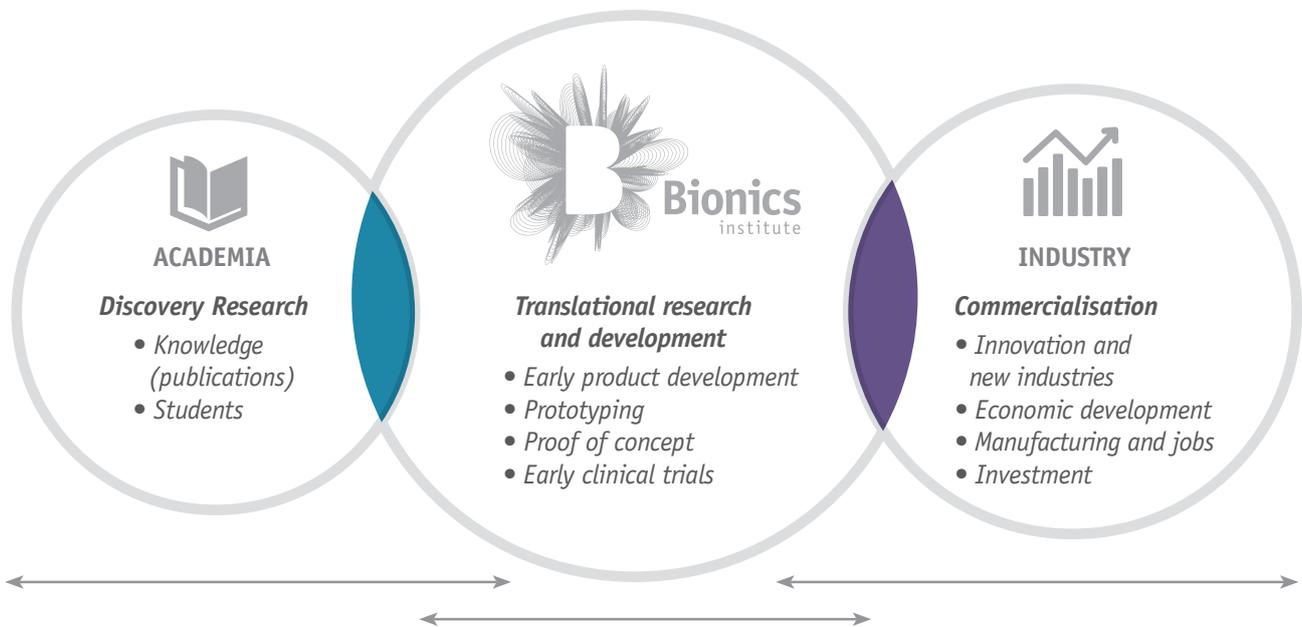
We have increased our focus on business development activities including the provision of collaborative and contract research services to industry, universities, and other R&D groups. The range of services includes medical device preclinical safety and efficacy testing, custom electrode prototyping and fabrication, and software development.

Bionic Hearing

We continue to build further on the strong base of collaboration and partnership with a number of organisations, including Cochlear Ltd. Cochlear Ltd has delivered hearing and quality of life benefits to many adults and children world-wide, having sold 450,000 cochlear implants. A number of research contracts associated with hearing-related manufacturing and R&D projects have been completed. We have also entered into a significant partnership with Pfizer that aims to develop clinically translatable therapies to treat hearing disorders. The partnership will bring together Pfizer's experience in drug development and our preclinical research expertise.

Bionic Vision

Together with our clinical partners, we have played a pivotal role in the development, regulatory approval, and clinical translation of Australia's first bionic eye. Initial work resulted in the successful implantation, switch-on, and perceptual testing of three blind adults who volunteered to participate in the development of a prototype device. Our current research, as a core party of Bionic Vision Australia, builds on the great success of this pilot clinical study, which was completed in 2014. A forthcoming clinical trial will evaluate the performance of the next-generation bionic eye; an exciting development in our commitment to those living with degenerative eye diseases. We are optimistic that this work will lead to the availability of a commercial bionic eye system through clinics within the next few years.



Neurobionics

The goal of our neurobionics program is to leverage cochlear implant and other platform technologies into complete clinical solutions for chronic, severe disorders of the central nervous system. These platform technologies under development will be used to treat a number of debilitating conditions, ranging from Parkinson's disease to inflammatory bowel disorder. Bionic Enterprises, our subsidiary company, provides the commercial pathway for this program by taking neurobionic devices developed in the Bionics Institute through early clinical trials and ultimately into the marketplace.

We are involved in a number of clinical studies that are the critical first step in demonstrating safety and preliminary device efficacy, and engaging clinicians early in the clinical and commercial pathway. These include a study of deep brain stimulation to treat movement disorders that aims to identify suitable biomarkers, optimise stimulation parameters, and evaluate closed-loop stimulation techniques in people living with Parkinson's disease and other disorders.

BIONIC ENTERPRISES

Bionic Enterprises (BE) was established in 2011 to provide the commercial pathway for our neurobionics research program. The Institute has invested significantly into BE to strengthen the company's early development.

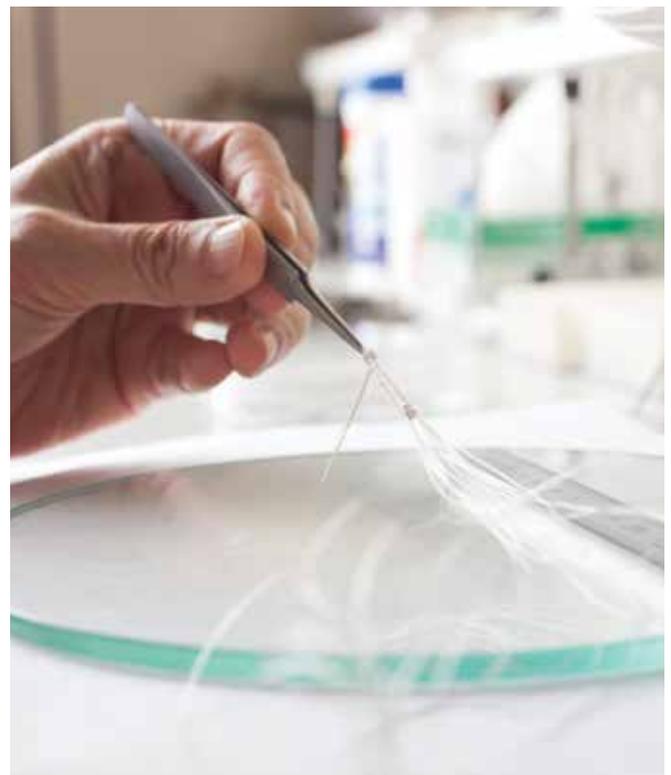
BE is focussed on neurobionics – the development of devices that monitor neural activity in the brain, spinal cord or elsewhere in the body and/or stimulate nerves electrically for therapeutic applications.

BE is committed to fast-tracking the development and reducing the cost of bringing new, safe and effective medical device products to the market. The lead product is an advanced device to treat the motor symptoms of Parkinson's disease. Significant progress has been achieved with the development of customised components essential for this device, and as part of the platform for subsequent devices. Negotiations are currently underway to

secure commercial access to some key technology. Other products will follow for treatment of a range of disabling neurological conditions including other movement disorders, epilepsy, severe chronic pain, and certain psychiatric disorders.

All devices meet a clear clinical need and address a gap in the market. Most conditions are of relatively high incidence with ten to thirty percent of patients poorly treated with existing treatments.

This strategy builds on the company's core strengths, addresses a clear clinical need, and provides a commercially attractive product for strategic partnering, licensing or acquisition via spin-out companies.





BIONIC HEARING

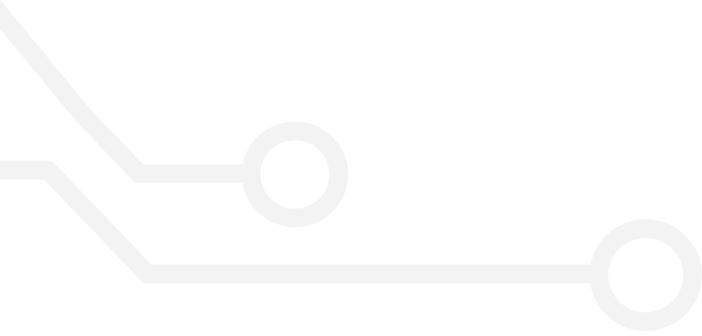
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Ms Catherine Gaunt
Dr Shefin George
Ms Eleanor Gould
Dr Katherine Henshall
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Ms Dilys Lam
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Mr Darren Mao
Prof Hugh McDermott
Prof Colette McKay
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Mr Kabir Sikder
Mr Thomas Spencer
Ms Ella Trang
Mr Matt Trewella
Ms Renee Tsongas
Mr Stefan Weder
Dr Andrew Wise
Dr Yan Wong
Ms Xin Zhou

OUR COLLEAGUES

Dr Patrick Atkinson (Stanford University)
Dr Meagan Barclay (University of Auckland)
Dr Mattias Björnmalm (University of Melbourne)
Mr Robert Briggs (Royal Victorian Eye and Ear Hospital)
Dr Ricardis Buividas (Swinburne University of Technology)
Prof Paul Carter (Cochlear Ltd)
Prof Frank Caruso (University of Melbourne)
Prof Stuart Cogan (EIC Laboratories, USA)
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Mr Claudiu Treaba (Cochlear Ltd)
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Dr Scott Wade (Swinburne University of Technology)
Prof Jan Wouters (KU Leuven, Belgium)



Bionic hearing

The goal of our bionic hearing program is to improve clinical outcomes for cochlear implant recipients, and those with hearing impairment.

To achieve this, we apply our unique multi-disciplinary approach and use diverse experimental tools – from brain imaging and smart engineering to nanotechnology and gene therapy.

Sensorineural hearing loss is the most common form of deafness and is typically due to damage to cells in the inner ear (cochlea). The delicate cells that sense the incoming sound waves (hair cells) can die as a result of genetic factors, disease, excessive noise exposure, and the aging process. In turn, this leads to the gradual degeneration of the nerve cells that send information to the brain (auditory neurons). Regardless of the cause, once these cells die, the hearing loss is permanent and irreversible.

Hearing loss affects approximately 3.6 million Australians and has widespread social and economic impacts. It can lead to significant problems in communication, education, employment and social isolation, and has an estimated yearly cost to the economy of around \$12 billion.

While hearing aids can help those with mild to moderate hearing loss, for those with more severe deafness the most appropriate intervention is a cochlear implant.

How does the cochlear implant work?

The cochlear implant is designed to produce hearing sensations by electrically stimulating the inner ear's auditory nerves that relay sound information to the brain. This device consists of an implanted electrode array within the cochlea and a stimulator which is surgically placed under the skin behind the ear.

An external sound processor, which sits behind the ear (similar to a hearing aid), captures sounds and converts them into a digital code. This information is sent wirelessly to the stimulator which converts the coded sound into electrical impulses and sends them along the electrode array. This stimulates the auditory neurons which send impulses to the brain where they are interpreted as sound.





"Harry is just a normal kid. The things he wears on his head allow him to hear but that doesn't make his personality different to anyone else's. He loves trains, trucks, Star Wars and watching TV."

– Tess, Harry's oldest sister.

HARRY'S STORY

Born profoundly deaf, Harry spent his early life in silence before receiving his first cochlear implant at the age of eight months. For Harry, now five years old, the cochlear implant has been a modern day miracle.

Harry's experience has led his parents, Daniel and Hollie, to become advocates for the importance of early detection and intervention programs for deaf infants.

"When we found out Harry was profoundly deaf, we knew we were on a solid path towards the cochlear implant, and towards Harry hearing and speaking almost immediately on account of the services which were made available," Daniel said.



“We are focussed on finding solutions for those cochlear implant users who do not receive the expected benefits from their device. This is particularly important in young children, during those crucial early years of language development.”

– Professor Colette McKay
(Translational Hearing
Research Leader)





IMPROVING CLINICAL OUTCOMES

We are carrying out a wide range of research projects with a common goal – to improve the speech understanding outcomes for cochlear implant users. The quality of hearing provided by this device varies widely across users: while most people achieve excellent speech perception, others receive only a small benefit from their implant. By understanding why this is the case, we will be able to develop solutions to improve speech perception.

 *Shortly after a person receives a cochlear implant, they visit their clinician to have it switched on and programmed to suit them.*

The settings of the electrical impulses sent to the cochlea must be adjusted so that the sounds heard are neither too soft nor too loud. The signal strength needed for sounds to fall within this 'comfortable' range varies between implant recipients, so the clinician must precisely program the implant to the individual so that it provides the best sound quality possible. This is a time-consuming process, and is clearly not possible in infants who cannot give verbal feedback. We therefore need a programming method that is quick, reliable, and does not rely on a patient's responses. Our approach is to use an individual's brain activity to determine when a sound is just audible. We are determining the brain activity patterns that correspond to hearing a sound, and will apply this knowledge to develop an automated method to help program cochlear implants.

 *To develop new strategies that improve speech perception for cochlear implant users, we must gain a better understanding of how the critical features of speech are perceived.*

We are measuring the ability of cochlear implant users to detect the rapid fluctuations in speech that provide important information about the identity of a word. We then compare different ways of conveying these fluctuations to find the way that best helps people to hear them. Results so far suggest that lowering the rate at which current pulses are delivered by the implant to the cochlea helps people to hear the important fluctuations in a signal, especially for soft sounds and when there is background noise present.

 *To understand speech a listener needs to be able to hear the different frequencies contained in the signal and to hear how they differ in strength from one frequency region to another.*

We are testing whether this is a key ability that explains differences in speech perception among implant users. We are testing speech understanding of cochlear implant users, and correlating this with the ability to detect small changes in signal strength between different regions of the cochlea. The results so far show that there is, indeed, a strong relationship between the ability to detect these differences and people's speech understanding. This project will lead to an easy way to predict whether a new implant patient will have difficulty developing speech understanding. This will enable clinicians to focus their management on helping the identified individuals adapt to their new implant to achieve a better outcome.

 *We are using a new brain imaging technique that uses light to find out why some cochlear implant users cannot understand speech as well as others.*

We are measuring how the brain adapts to deafness and cochlear implant use by using a new brain imaging method called functional near-infrared spectroscopy. This method uses light to map which areas of the brain are most active and well connected when people are listening to or watching someone speak. We have compared the brain activation patterns of cochlear implant users with normal hearing adults and found that there are significant differences in the way the brain processes speech in the two groups. Importantly, certain brain activity patterns are associated with poor speech understanding in cochlear implant users. This knowledge will help us to work out how to help these people by developing new therapies and new signal processing strategies for the implant that aim to overcome the identified problems.



IMPROVING COCHLEAR IMPLANTS

The cochlear implant has had a profound impact on the lives of 450,000 people world-wide. This device is very effective at conveying speech sounds in quiet conditions, but many recipients have difficulties understanding speech in noisy environments or appreciating the rich complexity of music. We are therefore investigating ways to improve the quality of hearing provided by this life-changing bionic technology.

 *The electrode array of the cochlear implant is located in a fluid-filled chamber of the inner ear and lies close to the auditory neurons that transmit information to the brain.*

A basic limitation of this arrangement is that the electrical current from each electrode spreads through fluid resulting in broad activation of auditory neurons. This means that the messages being sent to the brain are relatively crude compared to the digitally-encoded sound being sent to the electrode array. Our research is exploring new stimulation strategies to counteract this loss of precision. One promising method is called 'current focussing': we know it can restrict the spread of neural activation, but it requires stimulating more than one electrode at a time and higher currents. We are presently determining the safety limits of this approach and exploring novel electrode coatings to enhance the safety of this technique. This stimulation strategy has the potential to improve speech perception by providing more precise information about a sound's spectral (frequency) and temporal (timing) features.

 *Cochlear implantation in both ears is becoming increasingly common and while there are benefits to the user, they fall short of expectations.*

One of our projects seeks to understand why the benefits of using bilateral cochlear implants are relatively small and how the known benefits from using two ears (binaural hearing) can be restored. In order to localise a sound in space, the auditory brain primarily uses differences in the

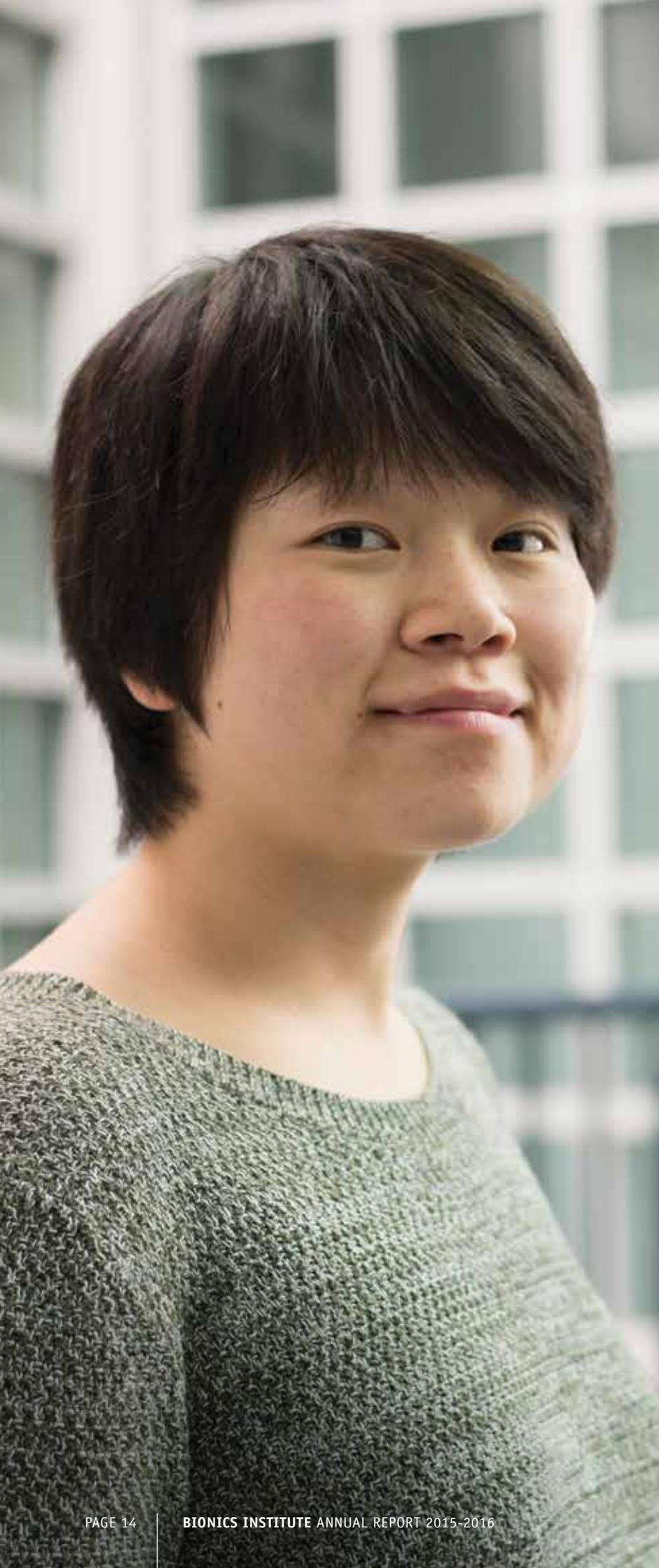
timing and intensity of the sound reaching each of the two ears. Comparing the information received by two ears also provides benefits when listening to speech in noisy environments. In long-term deafness, however, the brain's sensitivity to the timing (temporal) differences between the two ears degrades. Our aim is to understand how the brain interprets the information conveyed by bilateral implants and to establish procedures that will improve binaural temporal processing. The outcomes of this study will drive the technical innovations required to maximise the benefits and investment of receiving two cochlear implants.

 *Cochlear implants deliver safe electrical stimulation of the cochlea under strict guidelines to ensure there is no damage to nearby cells.*

Interestingly, the widely accepted limit of safe electrical stimulation was not determined in cochlear tissue but in brain tissue, and only for a short time. If this limit is too conservative, then it means we are not fully exploiting the capabilities of electrical stimulation of the cochlea. In order to determine a more meaningful safety limit, we are carrying out preclinical studies to examine the effects of long-term electrical stimulation over a wide range of current levels. If our hypothesis is correct, this research will open up many new and exciting possibilities for electrode design and stimulation strategies, leading to improved clinical outcomes for cochlear implant users.

“We know two ears are better than one when listening in noisy situations and locating where a sound is coming from. We want to understand how the brain adapts to bilateral cochlear implant use so that we can maximise the benefits gained from listening with two ears.”

– Associate Professor
James Fallon
(Senior Research Fellow)



Before coming to Australia in 2015, Xin received a Bachelor's degree (with Honours) in Acoustics from the Northwestern Polytechnical University in China. With a keen interest in acoustic signal processing, neuroscience, and cochlear implants, she knew that the Bionics Institute would be the perfect place for her to undertake a PhD.

"I want to understand why some cochlear implant users have excellent speech understanding using their device, while others don't. My research is using brain imaging to reveal differences in the language areas of cochlear implant users who have different levels of speech understanding. With this sort of information, we can then develop useful techniques that predict the probable outcomes of receiving a cochlear implant, as well as devise therapies to maximise speech outcomes after implantation," Xin said.

PhD student Xin Zhou



UNDERSTANDING DIFFERENT FORMS OF HEARING DISORDERS

Exposure to excessive noise, or even moderate noise exposure over a period of time, can damage the cochlea. However, in some people, this does not lead to increased hearing thresholds (a loss of sensitivity) but rather other problems, such as difficulties in understanding speech or constant ringing in the ears.



Some patients are told that despite their difficulties in understanding speech they have normal hearing and there is nothing that can be done for them.

These patients show normal sensitivity to sounds (normal hearing thresholds) but appear to have problems in processing the timing (temporal) information contained in complex sounds. This form of hearing impairment is often referred to as a 'hidden hearing loss', and has been linked to long-term noise exposure. This problem represents a largely hidden and under-treated patient population, and the underlying cause of the difficulties in understanding speech is not clear. We are using a range of complementary experimental approaches to address this gap in our understanding by measuring temporal processing deficits at different levels of the auditory pathway.



The methods currently used to detect and treat damage to hearing focus on sensory impairment; that is, an impaired ability to detect very quiet sounds.

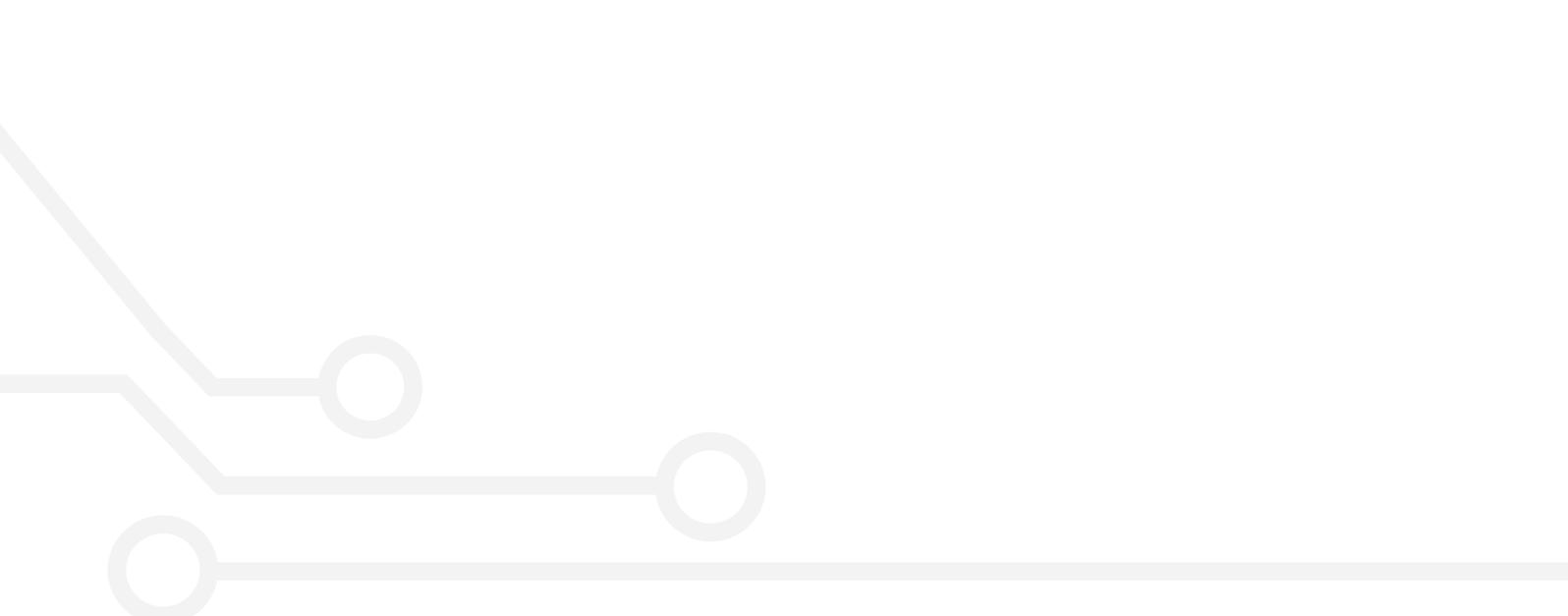
One of our projects is developing tools that can detect 'signatures' of degraded temporal processing in the auditory centres of the brain. Using brainwave signals recorded from the scalp, these tools focus on detecting and characterising neural activity that supports functional hearing ability, rather than detecting changes in hearing thresholds. We are

measuring brain activity in people with normal hearing and comparing it to those with different types of hearing loss or experiencing difficulties in understanding speech. Our aim is to identify patterns of brain activity that underlie good speech understanding in noise, and patterns that are associated with poor understanding. This information is vital if we are to design and develop therapies to address this type of hearing disorder.



Most people have experienced tinnitus (ringing in the ears); however, for some people it can be a permanent and debilitating condition that cannot be treated.

Tinnitus is often triggered by the loss of the cochlea's sensory hair cells which leads to a dramatic reduction in the level of activity in the auditory nerve. It is thought that this leads to an overall imbalance in the central auditory system and changes in how the brain cells signal to each other. One of our projects aims to test whether these maladaptive changes in the brain can be reversed by therapeutic electrical stimulation of the inner ear. We will investigate the best way to treat tinnitus with electrical stimulation and, in doing so, improve our understanding of the changes in brain function that cause tinnitus. Our ultimate goal is to develop a prototype bionic device, ready for clinical trial, which delivers a long-term treatment for people living with tinnitus.



BEYOND COCHLEAR IMPLANTS

The effectiveness of cochlear implants depends on the survival of a critical number of auditory neurons. We are exploring ways to protect and repair the damaged cells of the inner ear, or even restore or replace cells that have died. Our research is using gene therapy, stem cell therapy, and nanoengineering to achieve this.

 *We are exploring ways to protect and repair damaged cochlear cells, and ways to restore lost cells and hearing.*

We can use the inner ear's natural capacity for repair, but first we need a reliable and safe 'trigger' to start the process. Gene therapy has great potential to do this. Gene therapy has been successful in laboratory experiments: it can help the inner ear to produce natural factors that protect cells from degeneration after hearing loss. Additionally, gene therapy can 're-program' some cells to appear and function like new sensory hair cells. We have introduced genes into the inner ear to trigger the production of neurotrophins (factors that support the health and survival of neurons) and transcription factors (capable of re-programming cells to perform a new function). Respectively, these studies have shown we can protect the auditory nerve from degeneration and create new hair-like cells following hearing loss. Our ongoing research will help understand the processes involved in hearing restoration and explore its limits.

 *Gene therapy may also provide a way to improve the selectivity of the stimulation provided by cochlear implants.*

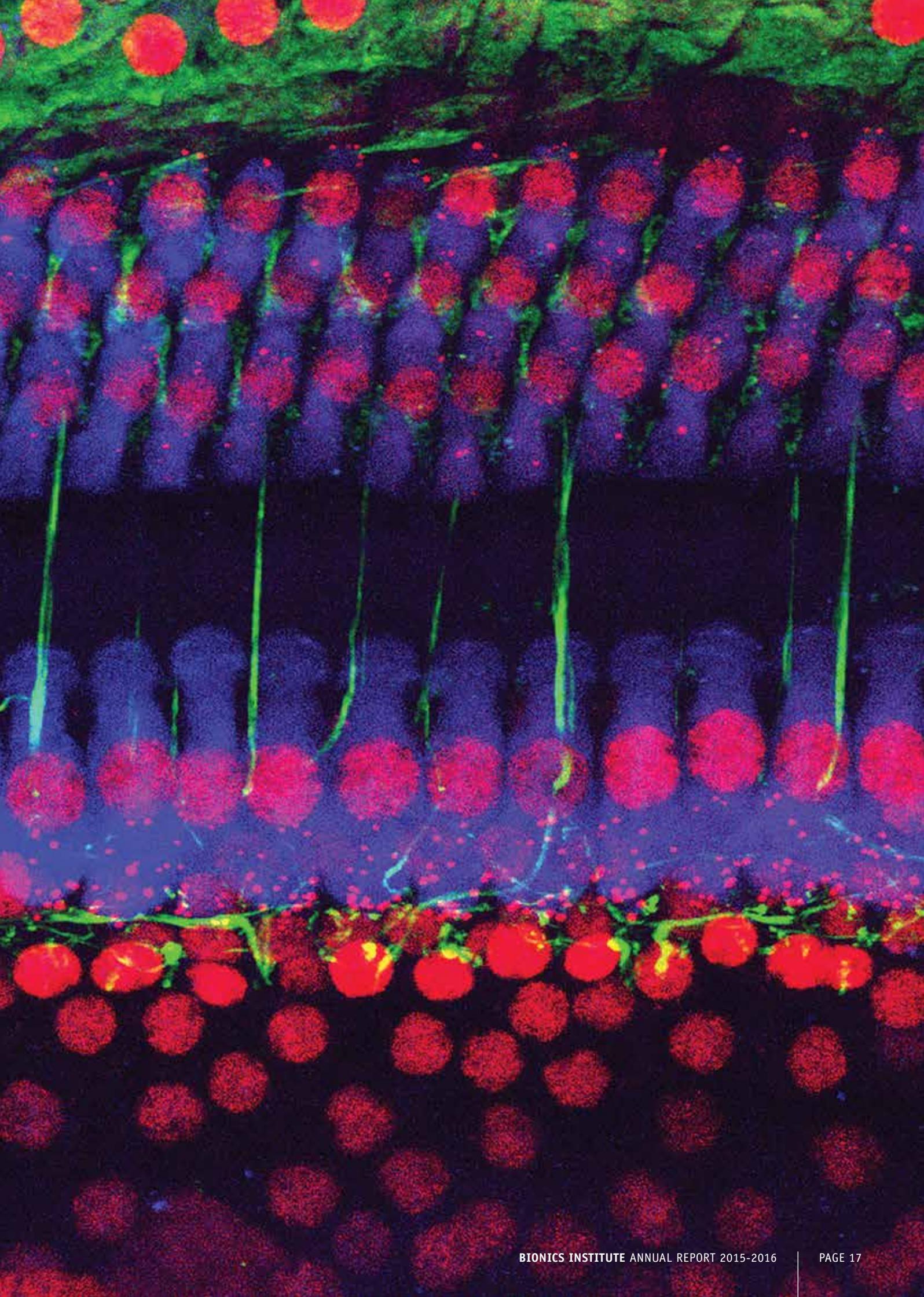
Some of the important features of complex sounds conveyed by the cochlear implant are lost due to the conductive nature of the fluid-filled cochlea: electrical current spreads through fluid, resulting in broad neural activation. New techniques are required to overcome this inherent limitation and we are exploring gene technologies as a way to improve the precision of electrical stimulation. Specifically, we are using gene transfer techniques to render auditory neurons responsive to light and will determine whether stimulating these neurons with light can deliver more precise activation than electrical stimulation.

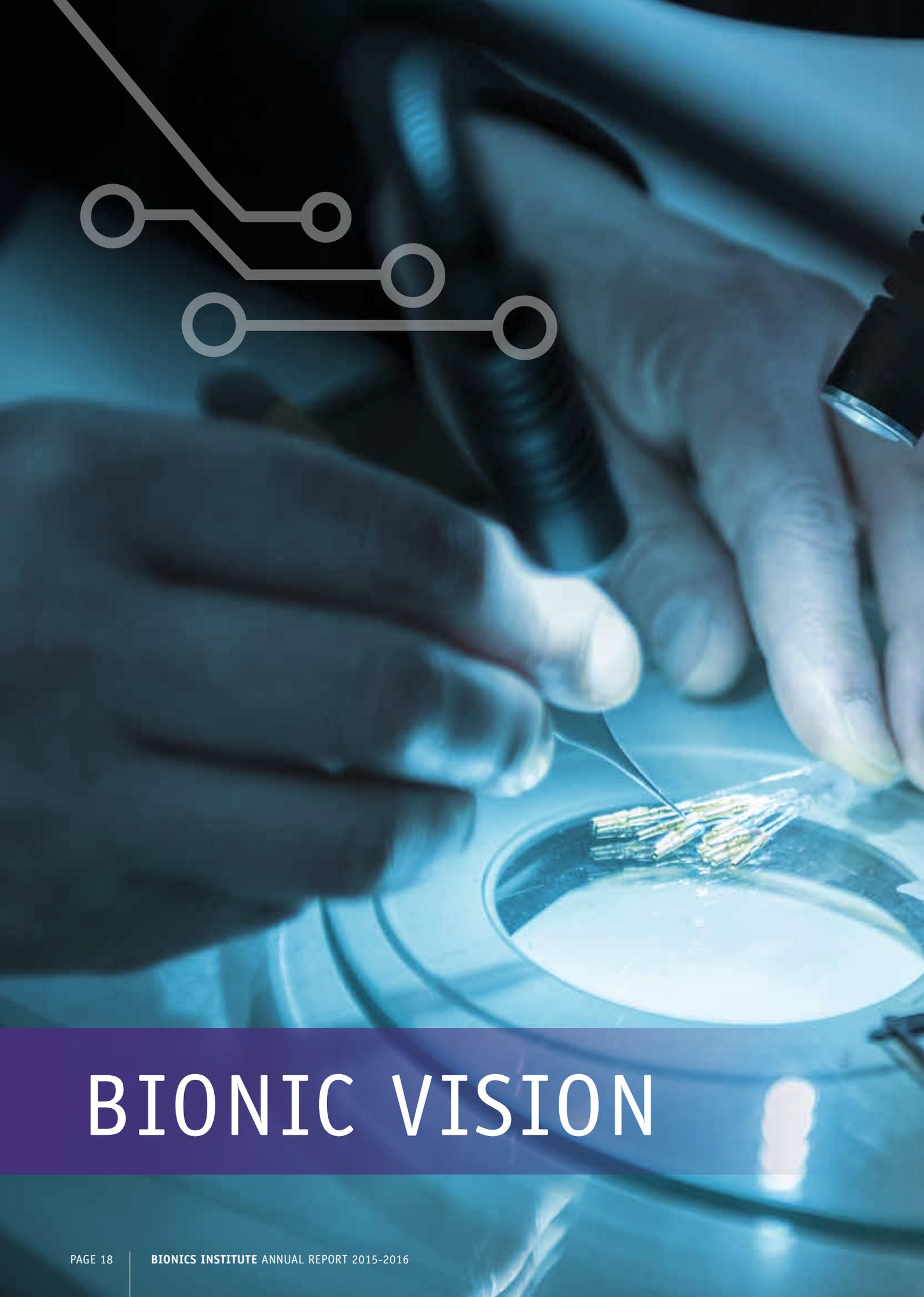
 *Stem cell transplantation therapy is emerging as a potential strategy for auditory nerve rehabilitation by providing a source of replacement neurons to the deaf cochlea.*

Our aim is to use stem cells to understand and regenerate the auditory system after deafness. We use a number of different methods in the laboratory in order to turn our stem cell populations into the cells that we desire (hair cells or auditory neurons), to test their function (physiology), to measure the number and type of connections they make within auditory tissue, and to assess how well they integrate into the cochlea after they are transplanted. By helping us understand the molecular and genetic mechanisms of diseases affecting the auditory system, this research offers potential to discover new treatments for hearing loss.

 *We are using cutting-edge nanotechnology to provide long term and controlled delivery of therapeutic drugs in order to prevent progressive hearing loss.*

In laboratory experiments, we have shown that nanoparticles loaded with nerve survival factors (neurotrophins) can be introduced into the inner ear. These particles slowly release the neurotrophins, and we have found this protects auditory neurons against degeneration following deafness. The ultimate goal of this research is to provide a treatment to prevent progressive hearing loss. This treatment will also benefit the increasing number of cochlear implant recipients with residual hearing by allowing them to gain maximum benefit from both electrical and natural hearing.





BIONIC VISION

BIONIC VISION RESEARCH TEAM

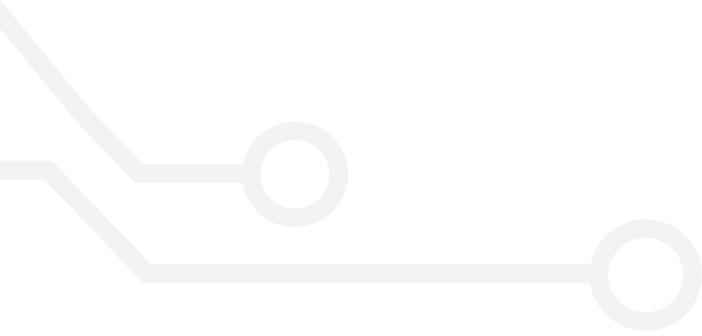
Mr Nick Apollo
Mr Owen Burns
Ms Stephanie Epp
A/Prof James Fallon
Ms Helen Feng
Ms Kerry Halupka
Mr Lachlan Hamilton
Ms Madhura Korikkar
Ms Vanessa Maxim
Prof Hugh McDermott
Ms Ceara McGowan
Mr Rodney Millard
Dr David Nayagam

Dr Matt Petoe
Prof Peter Seligman
Prof Rob Shepherd
Dr Mohit Shivdasani
Mr Kabir Sikder
Mr Nicholas Sinclair
Mr Thomas Spencer
Mr Patrick Thien
Mr Sam Titchener
Dr Joel Villalobos
A/Prof Chris Williams
Ms Jenny Zhou

OUR COLLEAGUES

BVA is an Australian wide collaboration so there are many people involved in this project. Colleagues who contributed to the research reported here include:

Dr Carla Abbott (CERA)
Dr Penny Allen (CERA, Royal Victorian Eye and Ear Hospital)
Dr Lauren Ayton (CERA)
A/Prof Nick Barnes (Data61)
Prof Peter Blamey (Blamey Saunders Hears)
Ms Alice Brandli (CERA)
Ms Tamara Brawn (University of Melbourne)
Mr Rob Briggs (University of Melbourne)
Prof Tony Burkitt (University of Melbourne)
Dr Shaun Cloherty (NVRI)
Dr Sue Finch (University of Melbourne)
Prof Erica Fletcher (University of Melbourne)
Dr David Garrett (University of Melbourne)
Prof David Grayden (University of Melbourne)
Dr Robyn Guyer (CERA)
Mr William Kentler (University of Melbourne)
Mr Jason Leavens (Cochlear Ltd)
A/Prof Chi Luu (CERA)
Dr Chris McCarthy (Swinburne University)
Prof Penelope McKelvie (St Vincent's Hospital Melbourne)
Dr Hamish Meffin (NVRI)
Dr Cesar Salinas-LaRosa (St Vincent's Hospital Melbourne)
Dr Bahman Tahayori (University of Melbourne)
Prof Richard Williams (St Vincent's Hospital Melbourne, University of Melbourne)
Dr Yan Wong (University of Melbourne)
Dr Jonathan Yeoh (CERA, Royal Victorian Eye and Ear Hospital)



Bionic vision

A clinical trial of a prototype bionic eye was successfully completed in 2014 in three patients with retinitis pigmentosa, the most common cause of inherited blindness. We have made significant improvements to the bionic eye's design and capabilities to produce the next generation device.

To prepare for the next clinical trial, we have carried out extensive testing of all components to ensure they are safe and effective.

Retinitis pigmentosa is a degenerative eye disease that affects approximately one in 3,000 people. It is a genetic disorder that causes the light-sensing cells of the retina (photoreceptors) to gradually die, starting in the peripheral retina. The first indication of visual impairment usually occurs somewhere between 10 and 30 years of age.

The loss of vision is progressive, moving from the edges of vision into the centre, until no useful vision remains. Presently, there is no cure or therapy to halt or reverse the vision loss.

However, there is a way to restore some useful vision to people with retinitis pigmentosa and other degenerative eye diseases – a bionic eye. This device replaces the function of the lost photoreceptors and electrically stimulates the surviving retinal cells that transmit information to the visual areas of the brain.

How does the bionic eye work?

The bionic eye consists of a small video camera, incorporated into spectacles, that captures the visual scene in front of the viewer. This image is sent to a vision processor that converts it into a coded pattern which, in turn, is sent to a stimulator. The stimulator activates an electrode array implanted close to the retina via a complex pattern of electrical impulses.

Each electrode stimulates a nearby area of retina and the cells that project to the visual areas of the brain, evoking a localised flash of light termed a phosphene. Multiple phosphenes are created by stimulating different electrodes in rapid succession and the brain pieces these together to form a visual image.





"When they told me I would be walking around without my guide dog or a cane, I froze at the thought of it. But when I tried, it wasn't so bad, and I found I could do it on my own. Taking part in the trial was a wonderful experience; I would definitely do it again."

– Murray

MURRAY'S STORY

For Murray, his diagnosis at the age of seventeen with retinitis pigmentosa would change his life forever. Several years later, he was classified severely blind and was only able to see bright light and different colours swirling in front of him.

Before he received his first guide dog, he moved around using a cane. He has a different guide dog today, which is named after the Hudson River. As well as helping him navigate around his environment, Hudson is also a great companion.

Despite Murray's diagnosis with retinitis pigmentosa, he has worked full time for the last 30 years. He receives a number of community services included in the National Disability Insurance Scheme which makes the tasks around the home easier.

Murray was first asked about participating in the clinical trial of the prototype bionic eye by Bionic Vision Australia researcher, Dr Lauren Ayton from the Centre for Eye Research Australia. He accepted, saying that he felt the need to help the next generation of blind people.

As part of the 24 month trial (2012 – 2014), he was required to spend many hours in a specially-designed Bionics Institute laboratory and carry out tasks of everyday living, including placing items on shelves. He also successfully navigated an obstacle course completely unaided, something he never thought would be possible.



THE NEXT GENERATION BIONIC EYE

A clinical trial of Australia's first bionic eye was completed in 2014 and was a great success.

The prototype device implanted in three Victorian patients with retinitis pigmentosa was shown to safely and effectively evoke visual images, and allowed users to perceive shapes, movement, and navigate around obstacles.

This positive outcome was the result of the concerted effort of scientists, engineers, surgeons, and clinicians from a number of the institutions that formed Bionic Vision Australia funded by the Australian Research Council (2010 – 2015).

The Bionics Institute was responsible for the design, manufacture, and safety testing of this first device, as well as testing the patients' perceptions in our purpose-built laboratory.

"We are improving the design of our bionic eye implant, along with the method of stimulation, in order to improve the resolution and provide more meaningful images to patients. For each step we take, we ensure it is both safe and effective."

**– Dr David Nayagam
(Research Fellow)**



During the past year, we have been preparing for a clinical trial of the next generation device, due to commence in late 2016. Our researchers have been working on all components of the bionic eye to improve the technology and the visual experience of recipients.



The prototype electrode array consisted of 22 channels.

The next generation device has a larger, higher density electrode array consisting of 44 channels which will provide a wider field of view with more detail.



Whereas the prototype device used an external plug to connect the electrode array to laboratory equipment, the stimulator of the next generation device will be fully implanted.

This will allow the continued testing of the recipients' perceptions within our laboratory but also enable the recipients to use the device in everyday life. Thus, recipients will receive maximum benefit from using the device and our researchers will be able to obtain far more information about the device's capabilities. Importantly, the day to day use of the bionic eye will allow the brain's natural plasticity to contribute to re-building an understanding of the visual world.



In an electrode array containing many individual electrodes there are numerous patterns of stimulation possible.

From the preclinical and clinical studies with the prototype device we found that there were advantages to stimulating multiple electrodes at the same time. However, it was impractical to investigate every possible combination of electrode and stimulation parameters and simultaneous stimulation. We have therefore developed a computer model that can accurately predict responses in the visual brain to multiple electrode stimulation of a blind retina. This has allowed us to explore a large number of possible stimulation combinations and their interactions, and determine which activate the visual brain the best.



For each advancement in electrode design and stimulation strategy, we have undertaken rigorous laboratory testing to ensure safety and effectiveness.

We have shaped the electrode array to be safe and stable for implantation between the outer layers of the eye. Extensive preclinical studies have shown that the array can be implanted with a maximum of ease and safety. We have also carried out reliability 'bench' tests to ensure that individual components can withstand a lifetime of wear and tear.

The clinical trial of the prototype bionic eye was critical in determining its safety and effectiveness. A key outcome of this trial was also identification of some of its limitations and how they affected patients' ability to perform tasks. In the past year, we have been working on ways to provide better functional vision for recipients of the next generation bionic eye.



Our eyes are constantly moving, either to orient to an object of interest, follow a moving object or making tiny movements, which we are unaware of, when we fixate on an object.

The camera used with the bionic eye, however, is in a fixed position and cannot itself respond to these eye movements. This means that bionic eye recipients need to move their heads to scan the visual world rather than their eyes. In a study that is using a bionic eye simulator (virtual reality headset) and normal-sighted volunteers, we are characterising the importance of natural gaze on a patient's ability to perform everyday tasks. With this information, we are designing an eye-tracker for patient use, which will allow recipients to use their eye movements to explore the visual environment more naturally.



The visual system adapts to constant stimulation.

The bionic eye uses a train of electrical impulses to stimulate the retina and evoke a visual perception. However, the visual system adapts to this constant stimulation and a phosphene that appears initially bright, quickly fades. This perceptual fading makes it difficult for the bionic eye to produce a stable image for recipients. We have been investigating ways to reduce this fading and have found that by randomly and minutely varying the electrical pulses we can increase the activity in the visual brain. This is the first step in developing a new stimulation strategy to improve the visual experience for bionic eye users.



The phosphenes evoked by stimulating adjacent electrodes are often large, irregular and overlapping.

While the visual perception evoked by the prototype device allowed users to identify large objects and avoid them (i.e., successfully navigate their environment), it was not sufficient to provide the finer details of the visual world. Providing better visual resolution is not as simple as adding more and more electrodes: this comes with significant engineering challenges and safety considerations. Instead, we are working on ways to create 'virtual' electrodes by using novel methods of stimulation. These show great promise in allowing us to create more, smaller, and more uniform phosphenes without needing to change the safety-proven design of our retinal implant.





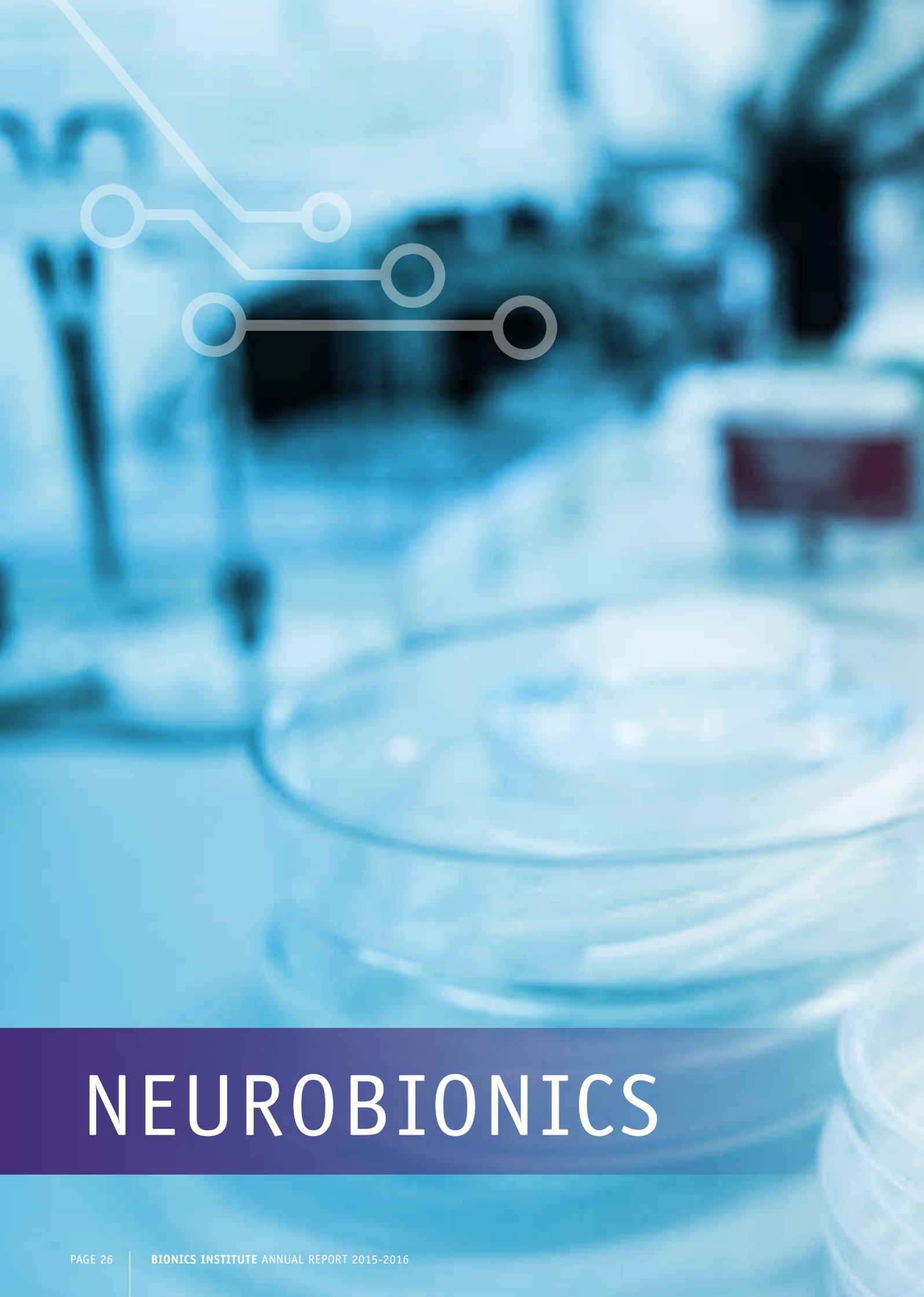
Tom Spencer has always been fascinated by sensory neuroscience and bionic devices.

As part of his Bachelor of Science at the University of Western Australia, he completed an Honours research project investigating how cochlear implants might be used to treat tinnitus (chronic ringing in the ears).

During this time, he learned about the Institute's bionic vision research program and recognised an opportunity to be involved in the early development of a cutting-edge biotechnology. In 2014 he moved to Melbourne and joined the bionic vision team as a PhD student.

"As part of my PhD I am investigating the use of new electrical stimulation techniques to improve the resolution of the bionic eye and provide better visual acuity to recipients. I am thoroughly enjoying working in such a great environment with such friendly and intelligent people. Being able to carry out research that has the capacity to change people's lives is intensely fulfilling, and I hope to continue with the Bionics Institute beyond my degree," Tom said.

PhD student Tom Spencer



NEUROBIONICS

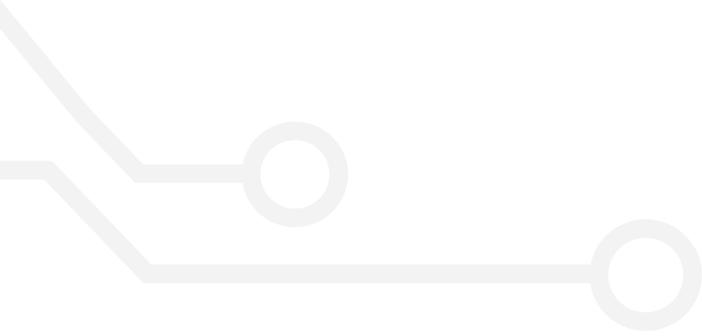
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Prof John Furness (Florey Institute)
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Dr Peter McNeill (St Vincent's Hospital Melbourne)
Prof Michael Murphy (St Vincent's Hospital Melbourne)
Dr Richard Peppard (St Vincent's Hospital Melbourne)
Dr Anneke Van Der Walt (Royal Melbourne Hospital)
Dr Adam Vogel (University of Melbourne)



Neurobionics

Our neurobionics program encompasses the development of medical devices that interface with the brain or peripheral nervous system and stimulate nerves electrically to gain a therapeutic benefit.

We are bringing together the know-how of scientists, engineers and clinicians to create innovative implants for the treatment of Parkinson's disease, epilepsy diagnosis and management, and to tackle inflammatory diseases.

Parkinson's disease is a degenerative brain disorder that affects around 75,000 Australians. It is caused by the progressive loss of certain nerve cells located in a brain area that is crucial for normal movement. This leads to a progressive and debilitating loss of motor function with typical symptoms of tremor in the arms and legs, muscle stiffness, stooped posture, and a slow, shuffling gait.

Unfortunately, up to thirty percent of patients do not obtain adequate symptom relief with conventional medications: however, deep brain stimulation (DBS) is an effective treatment option. While existing DBS systems significantly improve quality of life, they have several shortcomings that can lead to poor or variable symptom relief and other complications.

For this reason, the Bionics Institute embarked on an extensive research program to produce an advanced DBS system with many innovative features.

How does deep brain stimulation (DBS) work?

DBS is a surgical procedure used to treat disabling neurological symptoms. DBS uses a surgically implanted, battery-operated medical device similar to a heart pacemaker to deliver electrical stimulation to specific areas in the brain that affect movement.

The DBS system consists of electrode arrays implanted in both sides of the brain and extension leads that connect to a stimulator implanted under the skin. The stimulator delivers the electrical pulses to the brain which block or alter abnormal neural activity. This alleviates the motor symptoms in disorders such as Parkinson's disease and essential tremor.





"When I'm shaking flat out I cannot use cutlery. I cannot prepare food. I can't drive. With the DBS therapy I've got a speech impediment as a side effect, but that is nothing compared to the severity of the tremor left untreated."

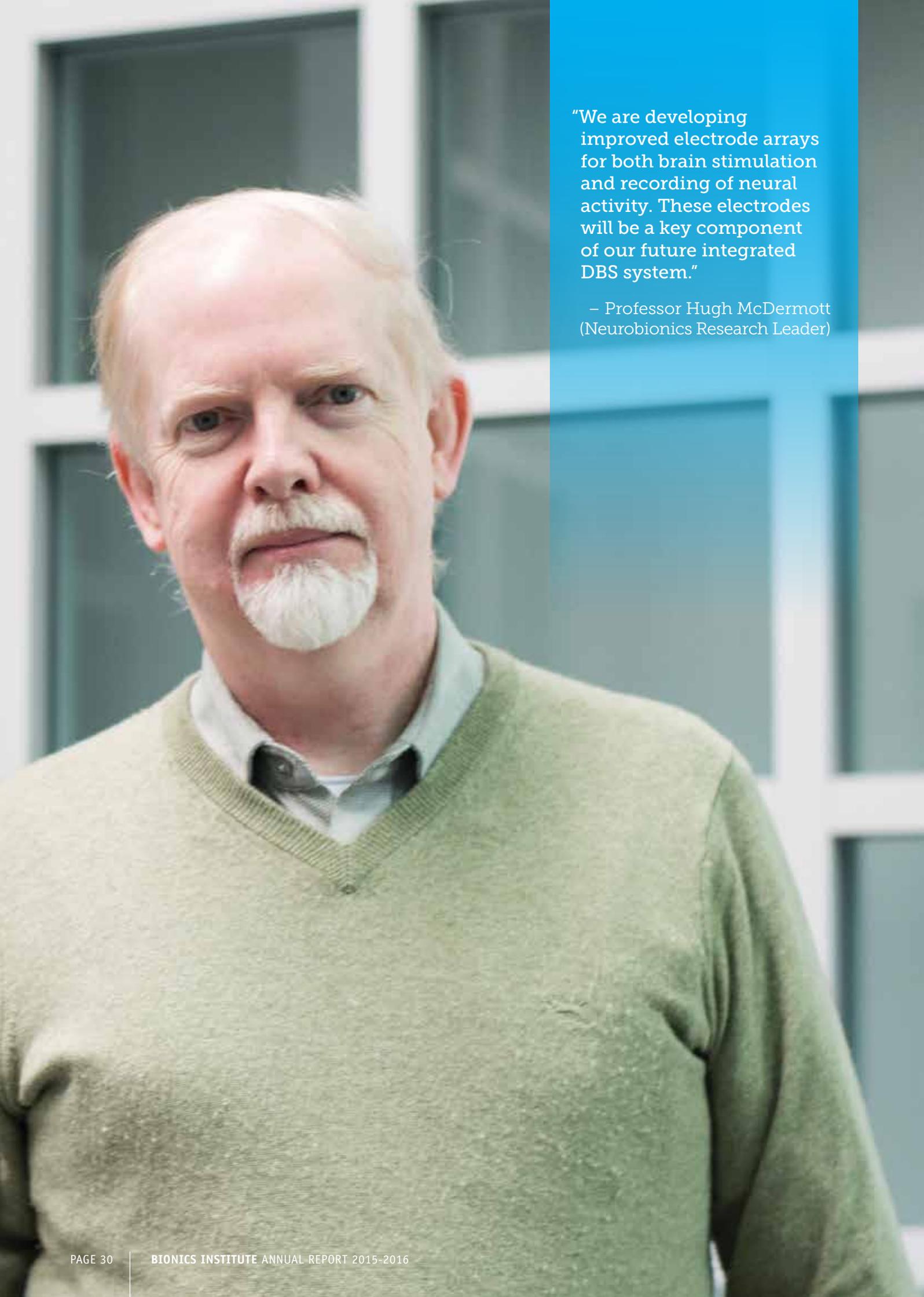
– David

DAVID'S STORY

David's symptoms of Parkinson's disease made it impossible to carry out many tasks of day to day living. He was diagnosed with tremor dominant drug-resistant Parkinson's over five years ago, and received DBS treatment last year.

David uses a currently available DBS system which successfully alleviates his tremor, but there are some drawbacks. One of the limitations is that when he has the device on, during his waking hours, it provides a constant amount of stimulation. The level of stimulation can only be set during visits to the neurologist. However, David's symptoms can vary during a single day and over time, so sometimes the device may be providing too much stimulation, while at other times not enough. This, in turn, can lead to side effects or poor symptom relief.

Our advanced DBS system aims to reduce the side effects caused by over-stimulation by precisely delivering the required amount of stimulation according to a patient's needs at any given moment.



"We are developing improved electrode arrays for both brain stimulation and recording of neural activity. These electrodes will be a key component of our future integrated DBS system."

– Professor Hugh McDermott
(Neurobionics Research Leader)



AN ADVANCED DBS SYSTEM TO TREAT MOVEMENT DISORDERS

The DBS system we are developing has many advancements in design and function compared to currently available devices. The improved components of our DBS system have undergone several design iterations and extensive testing for safety, durability, and effectiveness.



A major innovation in our DBS system will be its ability to adapt to the changing symptoms of an individual patient.

Available devices deliver a single level of stimulation that is determined and fixed during a patient's visit to their neurologist. However, over a single day this fixed stimulation level may sometimes be ineffective in maintaining symptom relief while at other times produce undesirable side effects. Our goal is to address this limitation by developing an adaptive (closed-loop) stimulation strategy so that treatment is personalised and targeted in real time.



Closed-loop stimulation requires recording from the brain and identification of a feature of brain activity that indicates a worsening of symptoms.

The presence of this feature will in turn trigger a change in the pattern of stimulation which will alter brain activity to lessen the symptoms, thereby 'closing the loop'. Our clinical studies to evaluate these novel techniques are continuing in short-term trials in patients in several Melbourne hospitals. These studies have yielded some exciting results which we believe will radically improve the treatment of Parkinson's disease.



In the past year we have been refining our design of a smaller and thinner electrode array with more sites along its tip for brain stimulation.

We have shown that our electrode design requires less insertion force, resulting in reduced trauma to the brain. Furthermore, the availability of more stimulation sites (electrical contacts) means there is greater flexibility in successfully targeting the correct brain area.



In current DBS systems the stimulator is surgically implanted in the chest, requiring long lead-wires to connect it to the brain electrodes.

Due to their trajectory under the skin of the neck, these lead-wires are prone to breakage. Our system will have the implanted stimulator located on the side of the head much like the arrangement used in cochlear implants. This means simpler surgery and the shorter connecting wires will be in a more stable environment. To accommodate a different stimulator, that also has the capacity to record brain activity for closed-loop stimulation, we have designed a sophisticated connector that links it to the brain electrodes.

Our DBS development program is complemented by a range of research projects aimed at improving outcomes for those living with movement disorders and using existing DBS devices. A key part of these studies is to develop new technologies to accurately measure motor symptoms, including tremor, gait and posture, so that new treatments can be accurately assessed.



Rigidity is a key symptom of Parkinson's disease and is often the most debilitating.

Patients find it very difficult to move and this makes it hard to live a normal life. Rigidity is also an early warning sign of Parkinson's disease and forms part of the diagnosis. Drug therapies, as well as DBS, can alleviate this symptom; however, there is not a precise method of assessment to guide clinicians. Therefore, an accurate way to assess rigidity is of utmost importance. We have developed a light-weight portable instrument that is placed over the palm of the patient and attached to the fingers: it automatically moves the fingers and determines rigidity using embedded sensors. We are planning to test this new device in patient trials later in 2016.



Balance disturbances commonly emerge in the advanced stages of Parkinson's disease.

These result in reduced mobility, increased risk of falls, and diminished quality of life. The effectiveness of DBS in treating balance and walking problems remains unclear. A reason for this uncertainty is the measures commonly used by clinicians are insensitive and subjective, making it difficult to determine changes in ability. We therefore need more precise measures to understand the effects of DBS on balance, and whether targeting a different brain area may improve disturbances in balance. To enable this we have developed a novel instrumented 'pull test'. It is based on the system currently used by clinicians but incorporates a sophisticated motion tracking system. We are currently comparing this new system to other commonly used balance assessments.



Therapies such as DBS can improve patient quality of life, yet the clinical management of a growing patient population creates a significant bottleneck and reduces access to this treatment.

Clinical assessments of movement and walking deficits are subjective, time-consuming, and often insensitive to minor (but significant) fluctuations in disease state. There are instrumented 'motion capture' systems available to make accurate clinical assessments but these are largely unavailable to patients due to their high cost and needing large spaces. We are therefore developing a low-cost, portable system for assessing walking problems; this system will be used to measure treatment outcomes and disease progression. We envisage that this system, in the future, will allow in-home monitoring and assessment via telemedicine. Such a device will lead to better patient outcomes through better patient management and also reduce the burden on healthcare providers.





With her training in physiotherapy, Joy Tan knows the impact of movement problems on a person's life. This impact is extreme and debilitating in those living with Parkinson's disease.

Joy joined the neurobionics research team in 2014, first as a research assistant and then as a PhD candidate. Her project is investigating instability in posture and balance in those with Parkinson's disease. Working closely with clinicians, she is examining the effectiveness of a new brain target for DBS to alleviate posture and balance deficits. Part of her project has been to work with our engineers to develop a new instrumented system to precisely measure balance.

"The Bionics Institute is a stimulating and supportive environment to undertake my research as a PhD student. Senior researchers and other students are always approachable and helpful. Working with a team of supervisors from different professional backgrounds brings many fresh ideas and perspectives to my project. Discovering new methods for providing the best treatment outcomes for patients is extremely rewarding; it drives me to keep doing what I'm doing," Joy said.

PhD student Joy Tan



A NEW APPROACH TO EPILEPSY DIAGNOSIS

Epilepsy is a common neurological disorder that affects approximately two percent of the population: in Australia, this equates to nearly half a million people. Disruption in the brain's normal patterns and rhythms of activity, leading to a state of heightened excitability, results in a seizure that can vary from brief 'absences' or strange sensations to convulsions and loss of consciousness.

The underlying cause of epilepsy may be the result of a brain injury or illness (e.g., meningitis), but in six out of ten cases the exact cause is unknown.

In some cases, an epileptic event can result in a blackout. Blackouts are a surprisingly common complaint affecting up to fifty percent of people at some point in life. They may be due to seizures, heart irregularities or other causes, but definite diagnosis is often difficult because these events are typically infrequent, perhaps weeks or months apart.

What is the need?

The problem of diagnosing the cause of intermittent blackouts remains unsolved and leaves patients in a state of limbo, often limiting their activities and social interactions.

To rule out or confirm epilepsy as the cause, standard EEG recordings are the best diagnostic tool but these are impractical over long periods and may not capture an event. Both patients and clinicians alike need a diagnostic system that can monitor brain activity over long periods of time.

This device needs to be able to detect and record seizure activity safely and effectively, be portable so a patient is not confined to a hospital, and be minimally invasive. Such a device would also solve another problem – the ongoing management of drug therapies to relieve seizures. Getting the drug regime right is sometimes a problematic and drawn-out process requiring many visits to the clinic.

Two years ago, researchers at the Bionics Institute with clinical colleagues at St Vincent's Hospital Melbourne embarked on a research program to develop a long-term brain monitoring device for epilepsy diagnosis and treatment management.



Our approach was to design and build a small and flexible electrode that could be implanted under the scalp and allow the long-term monitoring of brain activity.

The implant was designed so it requires minimal surgery and risk, in much the same way as implantable monitors are currently used to diagnose heart abnormalities.



We have continually refined the prototype implant and tested that it is safe and effective.

We have developed the hardware and software required to record brain activity, determined the best location to implant the electrode, and tested that it is stable over time. We have also designed and created prototypes of the specialised instruments required for surgery. The final device will also have the capability of improving patient safety through remote monitoring, with researchers envisaging a 'call-home' function to alert carers of a seizure.

“Our technology will allow us to use electrical impulses to modulate activity in the vagal nerve in order to reduce inflammation in the gut.”

– Dr Sophie Payne
(Research Fellow)





A BIONIC APPROACH TO BOWEL DISEASE

Inflammatory bowel disease, including Crohn's disease or ulcerative colitis, are debilitating, relapsing conditions that first emerge in young adulthood and affect patients throughout their life. These conditions are widespread within the community, with approximately 61,000 Australians affected, and are associated with huge costs to health services. Current drug therapies are often associated with serious side effects and sub-optimal symptom relief.

The Bionics Institute is part of a collaborative, Melbourne-based research program that aims to develop an implanted device to control the inflammation that causes the intermittent bouts of severe abdominal pain, diarrhea and fever.

Our aim is to develop a patient-specific, automated device to safely and effectively treat the symptoms of inflammatory bowel diseases.

How will a bionic device alleviate symptoms?

This device will constantly monitor the degree of inflammation in the gut and, when a certain threshold of inflammation is detected, a signal will be sent to a stimulator implanted under the skin. The stimulator will send electrical impulses to an electrode array that contacts the vagus nerve, a key peripheral nerve that affects gut function. In this 'closed-loop' system, the timing and pattern of stimulation will automatically be adjusted depending of the degree of inflammation in the gut. This will allow safe, efficient and individualised treatment of inflammation, will have minimal side effects compared to drug therapies, and reduce the need for frequent consultations with clinicians.

In late 2015, we commenced a collaborative project to create novel electrodes that will enable detection of gut inflammation and will therapeutically stimulate the vagus nerve. We have already made some exciting discoveries.



For the Bionics Institute, the first stage of this project is to find a feature of bowel inflammation that can be measured and monitored – a so-called biomarker.

Our researchers have recently identified a suitable biomarker and are developing a means to measure it. This will allow assessment of the severity of inflammation in 'real time' and will provide the input to an implanted, closed-loop bionics device that works to reduce inflammation.

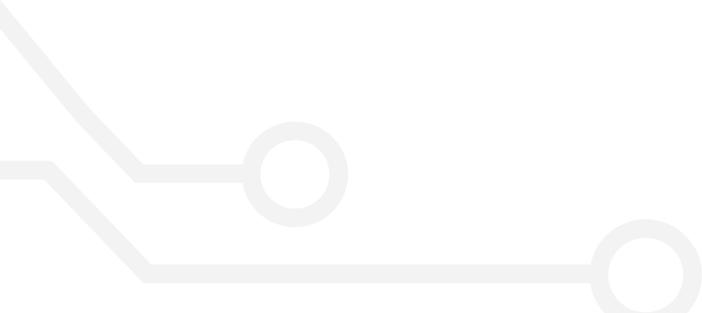


Devices that modulate the activity of peripheral nerves to restore healthy organ function offer new and exciting possibilities for future treatments for inflammatory and metabolic diseases, and even chronic pain.

This approach that we are pioneering today may one day replace the use of pharmaceutical agents and also manage conditions currently not treatable with traditional methods.



The partners in this project are: the Florey Institute of Neuroscience and Mental Health, Bionics Institute, University of Melbourne, and Austin Health.



Future leaders in translational research

Students are integral to research success at the Bionics Institute. These high-calibre young scientists have a passion for research, demonstrating initiative, independence, and inventiveness. Undertaking research at the Bionics Institute allows students to cultivate expert skills in the fields of bionic hearing, bionic vision, and neurobionics.

Working with our experienced senior researchers, students gain a range of multi-disciplinary skills spanning physiology, biomedical science, audiology, psychology, engineering, physics, mathematics, computer science, and other related fields. The high standard of training they receive with the Institute will serve them well in their current and future research endeavours with active mentorship and a dynamic and supportive culture.

Students undertaking their PhD at the Institute have been able to enrol through the Department of Medical Bionics within the University of Melbourne's Faculty of Medicine, Dentistry and Health Sciences since 2013. We also welcome students from other faculties and universities.

Our senior researchers mentor students who are working on a wide range of projects within our three major research programs, and provide supervision of those undertaking Honours, Masters, and PhD degrees. Local and international students also gain valuable experience in our laboratories through internships and the Undergraduate Research Opportunities Program coordinated by Biomedical Research Victoria.

Supporting our students

We gratefully acknowledge organisations that have provided support for our students and early career researchers throughout the year.

We would like to thank the Harold Mitchell Foundation for their Travel Fellowships which enable a student each year to present their research findings to international audiences: this opportunity greatly assists their academic development and allows them to start forming their own professional networks.

We also thank Woodards Charitable Foundation and QBE Foundation for providing welcome funding for a student scholarship.





Congratulations Dr Shefin George

Dr Shefin George is our most recent graduate and the first student to complete a PhD through the Medical Bionics Department (University of Melbourne). Her thesis investigated new stimulation techniques to improve the quality of hearing provided by cochlear implants.

In her short research career, she has received an impressive number of awards and prizes, and has taken a prestigious post-doctoral research position at Stanford University, USA. Using diverse techniques, her current research involves understanding how the sensory cells of the inner ear translate sound vibrations into electrical signals.

Shefin said, "My passion for life science and my curiosity to solve real-life problems through principles of maths and physics has helped me pursue a career in biomedical engineering. This led me to the Bionics Institute with its excellent reputation for research in medical bionics to improve people's lives. I thoroughly enjoyed my studies and research at the Institute and all that I learned there."

"I had an excellent, experienced supervisory team that helped me along my path towards becoming an independent scientist."

– Dr Shefin George

Community involvement

Our fundraisers and Ambassadors are fundamental to supporting our research at the Bionics Institute. They support our existing research programs, as well as new areas of clinical need. As the funding environment tightens, we become more reliant than ever on philanthropic contributions and community awareness of our work.

To generate the community support and awareness needed to drive our funding efforts, we engage in a wide range of activities including community and educational engagements by our researchers, public lectures, hosting visits from federal and state parliamentarians, and submissions to government. We gain a great deal of support from our highly motivated supporters and Ambassadors who undertake their own fundraising to great effect and raise the profile of our work. We sincerely thank all of our supporters for their ongoing efforts and achievements, and highlight here just a few of the year's events.

In June 2016 we had a fantastic afternoon celebrating hearing research at the Bionics Institute. It was wonderful to hear from our speakers, and meet and reconnect with Ambassadors and friends of the institute. Their personal stories inspire so many others on the same journey, whilst also promoting the research being done by the Institute. Three of our senior researchers presented to the group also, including Professor Colette McKay. Colette spoke about a project that is close to her heart, which aims to improve the quality of hearing provided by cochlear implants in infants as young as four months old. She continues her quest to raise funds to set up a dedicated infant hearing laboratory at the Institute.

The Institute celebrated with another Ambassador, John Nelson, with the launch of his book *Help the Children Hear* in September 2015. This book recounts his four bike rides around Australia and New Zealand with his fellow Rotarian Ted Lowe. A week before starting the first fundraising ride, John became very ill and needed to have both legs amputated, but this did not change his determination. Over the course of seven years and three additional rides, John rode an astounding 18,000 km on a recumbent bike and raised \$130,000 for our cochlear implant research. The Institute is extremely grateful and inspired by John's determination, strength, and enthusiasm to support our medical bionics research.

In October 2015, Ambassador Suzanne de Pelsenaire held an Open Garden event to raise money and awareness for the Bionics Institute. She invited the public from across Melbourne and raised more than two thousand dollars over the two day event. Suzanne donated the proceeds from the weekend to our bionic hearing and neurobionics research programs.

The Bionics Institute team enjoyed a fantastic day participating in a 'Walk in the Park' on August 30th 2015 to support and raise awareness for Parkinson's Victoria. The generosity of many people contributed to a total of \$197,430 raised by 3,000 walkers and their supporters. These donations will greatly assist in the search

for a cure and the delivery of vital support services to people living with Parkinson's disease, their families, and carers.

Each year, we hold an Annual Public lecture to highlight the importance of Australian medical research, with a special focus on new technologies and devices. In 2016, our keynote speaker was Catherine Livingstone AO, who spoke to the two hundred seat auditorium at the Melbourne Museum. Many great minds from across Melbourne came together for the event, from academia and research to business leaders and entrepreneurs. Catherine spoke about driving innovation and interactions between research and industry so that more technologies can progress to the marketplace and therefore be made available to clinicians and patients.

Community engagement is critical to raising the profile of our research and its goals. We invite you to get involved in raising awareness about bionics research through your club, school or workplace. We can organize an inspirational speaker from the Bionics Institute to come and present to your group and learn more about the extraordinary work we are doing.

This is a tremendously exciting time to be involved with the Bionics Institute. We are on the verge of the exciting next phase of our journey from the bionic ear to the bionic era.



John Nelson (right), with fellow Rotarian Ted Lowe, launched his book 'Let the Children Hear' at the Bionics Institute in September 2015.

New discoveries need funding

We are developing new technologies for disorders of the ear, eye, and nervous system. Support from the community is vital for our researchers to continue their innovative work – creating new devices for physicians to use with their patients.

If you wish to make a donation to a specific research program or establish a student scholarship, we would be happy to honour your request.

Donations

Payment can be made by:

- Cheque or Money Order – made payable to the 'Bionics Institute'
- Credit card – mail, phone 03 9667 7500 or fax 03 9667 7518
- On-line – via our secure website www.bionicsinstitute.org

All donations over \$2.00 are tax deductible.

Regular Giving

By making a regular monthly commitment to the Bionics Institute you can help support long term medical bionics research. You can set up your tax deductible gift from as little as \$10 per month (33 cents a day) using automatic credit card payments. The donation can be changed or cancelled at any time.

Celebration Gifts

Are you planning a special celebration to mark a birthday, christening, wedding, or anniversary? Why not consider asking your guests to make a celebration donation to the Bionics Institute in lieu of buying a gift.

Memorial Gifts

A memorial gift is a thoughtful way to honor the memory of a loved one. Tribute donations received by the Bionics Institute help us to continue our research and develop medical bionics solutions to improve the health and quality of life of generations to come.

Bequests

Leaving a bequest is a wonderful and practical way of making a real difference to people's lives. All bequests, large and small, contribute significantly to our important medical bionics research programs, and will help many children and adults enjoy a better quality of life.

Please contact us to obtain a copy of our bequest brochure or to discuss, in confidence, leaving a bequest in your Will.

To obtain more information on donations, memorial gifts and bequests, please contact our Fundraising Officer on 03 9667 7500 or email pr@bionicsinstitute.org



Archive image (1990) of bionic ear recipient Sian.

We have come a long way, and will go further with your help

The Australian bionic ear is the result of pioneering research by Professor Graeme Clark and his team in the 1970s at the University of Melbourne's Department of Otolaryngology.

The prototype multiple-electrode bionic ear was implanted in the first adult at The Royal Victorian Eye and Ear Hospital in 1978.

The team discovered how to analyse the complex speech signal and present it as electrical stimulation to the hearing nerve so that speech could be understood. They were also successful in engineering a portable speech processor small enough to wear.

A global clinical trial commenced in 1982, and successfully established that the device was safe and effective. In a world first, the multiple-electrode bionic ear was approved by the US Food and Drug Administration in 1985.

We have come a long way, with the Australian bionic ear now providing the gift of hearing to 450,000 people in more than 120 countries. Whilst we continue to improve this technology, we are excited about the new devices currently in development that will assist others in the community with conditions such as blindness, epilepsy, Parkinson's disease, and inflammatory bowel disease.

"If I didn't have cochlear implants then I wouldn't be able to do the things that I love, like music and dancing – it's a miracle to have them."

– Alana



The Bionics Institute acknowledges and thanks its generous supporters

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We also express our appreciation to other individuals and companies, particularly monthly givers, who donated and supported us throughout the year.

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Victorian Lions Foundation Inc
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Ambassadors

Our Ambassador programs would not be possible without our dedicated volunteers. Thank you for your ongoing participation.

*Our research is supported by government and institutional grants including the National Health and Medical Research Council, Australian Research Council, National Institutes of Health (USA), Defense Advanced Research Projects Agency (USA), Victorian Government's **veski** Innovation Fellowship scheme, Melbourne Neuroscience Institute Interdisciplinary Seed Funding, and St Vincent's Hospital Melbourne Research Endowment Fund.*

The Bionics Institute gratefully acknowledges the support it receives from the Victorian Government's Operational Infrastructure Support Program and the Federal Government's Independent Research Institutes Infrastructure Support Scheme.

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Summarised financial report

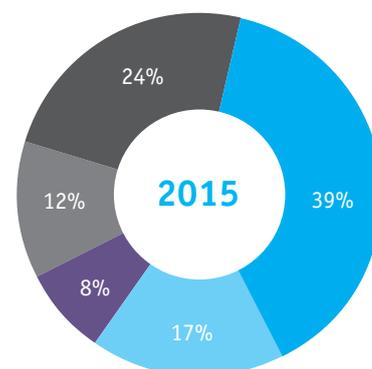
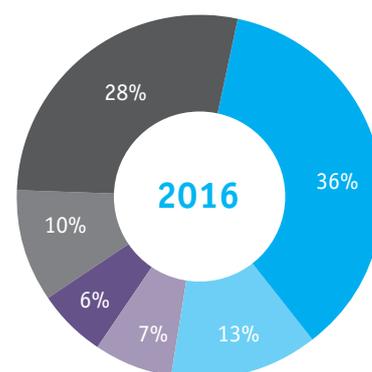
ABRIDGED FINANCIAL STATEMENT

for the year ended 30 June 2016

FUNDING OF OUR RESEARCH

CONSOLIDATED INCOME STATEMENT	2016	2015
REVENUES FOR ORDINARY ACTIVITIES	\$	\$
Federal Government grants	2,171,550	2,281,511
Victorian Government grants	483,936	496,198
Foreign grants	502,039	-
Trusts & foundations	742,793	865,408
Public fundraising	200,025	373,401
Research contracts	465,565	559,270
Investment & interest income	631,052	813,357
Other income	740,992	816,354
TOTAL REVENUE FOR ORDINARY ACTIVITIES	5,937,952	6,205,499
Less expenditure on ordinary activities	(7,425,901)	(7,132,544)
DEFICIT ON ORDINARY ACTIVITIES	(1,487,949)	(927,045)
Gain on sale of property	1,712,307	-
(Loss)/gain on sale of available-for-sale financial assets	(467,236)	719,987
NET DEFICIT	(242,878)	(207,058)

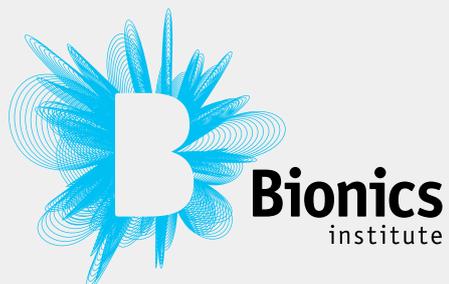
CONSOLIDATED STATEMENT OF FINANCIAL POSITION	2016	2015
	\$	\$
Current Assets	5,125,444	4,540,729
Non-Current Assets	12,883,523	12,532,166
TOTAL ASSETS	18,008,967	17,072,895
Current Liabilities	2,918,312	1,989,227
Non-Current Liabilities	95,937	60,959
TOTAL LIABILITIES	3,014,249	2,050,186
NET ASSETS	14,994,718	15,022,709
TOTAL INSTITUTE FUNDS	14,994,718	15,022,709



The financial information and statements presented in this report are based on unaudited management accounts which are used by the Directors to monitor the activities of the Institute. Directors do not believe the audited financial report prepared under the current Australian Accounting Standard AASB 1004 on contributions shows the Institute's obligations relating to grants and other funding received, and matches the performance of the research activities between income and expenditure.

Full audited financial statements are available from the Institute's registered office by request.





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