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From the bionic ear to a bionic era.
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From the bionic ear to a bionic era the Bionics Institute is leading the way in delivering health solutions to otherwise intractable conditions that affect thousands.

A long and successful record in the development of the bionic ear, major achievements in the pursuit of a bionic eye and an expansion into neurological and psychiatric disorders sees the Institute at the forefront of medical bionic device research internationally.
During the past year the institute has further developed its three research programs; bionic hearing, bionic vision and neurobionics.

The Institute has established a subsidiary company, Bionic Enterprises, as its commercialisation arm with external advisors who have relevant venture capital and commercialisation experience. Bionic Enterprises contracts its research to the Institute and will seek early stage investment to test and manufacture prototypes, and conduct clinical trials of new bionic devices. It is expected this will result in new innovative spin off ventures which will provide new income for future Bionics Institute research.

Currently in the pipeline are neurobionic devices for the relief of chronic pain, epilepsy, obsessive-compulsive disorder and essential tremor. The Institute and Bionic Enterprises will be using the scientific and engineering experience, expertise and knowledge gained over 25 years to make these devices a reality.

The Institute is a key member of the Bionic Vision Australia (BVA) consortium that received Commonwealth Government funding after the 2020 Summit to develop a bionic eye. We were very pleased to be significantly involved in BVA’s recent major milestone of implanting the first prototype bionic eye devices. The Bionics Institute is now conducting perception testing on these early patients. This is an historic development for Australia, however the commitment and ingenuity required to fully develop this device as a commercial product is still very considerable. I would like to congratulate all the engineers and scientists who have worked tirelessly on this important innovation so far.

The Bionics Institute is recognised as one of Australia’s most dynamic and innovative medical research institutes and leverages its relatively small size through partnerships with a range of collaborating organisations. The most important of these is the University of Melbourne. We were very pleased to be invited by the University to be one of only four medical research institutes to enter an enhanced research collaboration agreement during the year. This brings new benefits to the Institute and importantly retains the Institute’s independence.

As part of this enhanced agreement with the University of Melbourne, a new Medical Bionics Department has been established within the Faculty of Medicine, Dentistry and Health Sciences with Professor Rob Shepherd now having dual roles, as Director of the Institute and as the inaugural Professor of Medical Bionics and Head of the new Department. The establishment of the Department allows for a closer post-graduate education relationship between the Institute and the University and will provide administrative, funding and collaborative research advantages.

The continued success of the Institute would not be possible without the dedication of our researchers, students, administrative staff, and the Board. I would like to thank them all for their significant efforts throughout the year. Other highly valued contributions come from our Ambassadors, donors, corporate sponsors, honorary clinical research fellows, and philanthropic organisations that give so generously to support the Institute’s research. Without this support many of our programmes would not be possible.

The Institute remains committed to its strong philosophy of collaboration with academia, industry and clinical practitioners and we acknowledge the engineers, scientists, and clinicians that give their time to help us realise our research outcomes and device developments that will ultimately improve the health of our country.

On behalf of the Board, I would like to thank the Institute’s executive team led by the Director, Professor Rob Shepherd who continue to help grow and very effectively manage the Institute.

Finally I would like to pay special tribute to our fellow Board members who have retired during the year Mr Jack Smorgon AO, Mr Li Cunxin and Ms Kathleen Jordon. Their many years of sound advice, enthusiasm, and dedicated service is greatly appreciated. We welcome onto the Board Mr Neville Bertalli, Mr Roger Gillespie OAM, Dr Stella Clark and Mr John Stanhope whose varied backgrounds and exceptional experience will bring new depth and knowledge to the governance of the Institute. I also record my thanks to the external members of our Commercialisation Committee Robert Trenberth, Phillip Binns and Ergad Gold and the members of the Scientific Advisory Committee Professors Iven Mareels, Malcolm Horne, Peter Hunter and Mr Anthony Shilton, who have each contributed important insights and provided excellent guidance to the Institute’s activities.

Gerry Moriarty AM
FTSE FIEAust FAICD
Chairman
The Institute has established a subsidiary company, Bionic Enterprises, as its commercialisation arm with external advisors who have relevant venture capital and commercialisation experience.
Prime Minister Julia Gillard, in her video message for the launch of the Bionics Institute last year, said that, “Australia has a proud history of medical bionics research and all Australians should be excited by the prospect of more discoveries.” There is no doubt in my mind that the Institute is on the cusp of great scientific and engineering breakthroughs.

Our work as a key member of the Bionic Vision Australia (BVA) consortium has taken a significant step forward, with the Institute designing, manufacturing and evaluating the safety of Australia’s first prototype bionic eye device that has been implanted in two patients with a third patient due for surgery in the near future. This device has been delivered on time and within budget and is a world first by being implanted behind the retina.

Even before the formation of BVA our researchers had laid the ground work in making the bionic eye a reality. This work was only made possible by the generous contributions from the Ian Potter Foundation, John T Reid Charitable Trusts and the Bertalli Family Foundation.

**Growing our research base**

The Bionics Institute is committed to growing our research base significantly over the next five years. We will grow our core competence in hearing research, and see a number of new and improved hearing technologies emerge that will provide significant benefit to bionic ear recipients and hearing aid users.

The next phase in the development of the bionic eye device will see us undertake psychophysical testing with the recipients of the prototype device. One patient’s device has already been ‘switched on’ in a purpose built laboratory within the Institute and testing has commenced. The testing is designed to document the visual percept evoked from each electrode within the array in order to build a visual “map” for each patient. This information is required to develop a visual processing strategy that will enable patients to use their device in everyday life.

Our major area of expansion is in neurobionics. The Institute has been fortunate to secure $862,000 in funding over the next three years from the Colonial Foundation. This money is partly directed towards the design of prototype electrodes as well as the safety studies associated with the development of a deep brain stimulation (DBS) device.

A future DBS device will provide symptom relief for people suffering from a range of otherwise intractable neurological and psychiatric conditions such as epilepsy, Parkinson’s disease, essential tremor, obsessive-compulsive disorder and others.

To expand emerging neurobionics program, the Victorian Lions Foundation is working with the Institute to establish a Neurobionics Research Fellowship for a talented engineer, scientist or clinician who will be central to the research.

**Strong relationships**

In January 2012 we strengthened our relationship with the University of Melbourne with the creation of a Medical Bionics Department, located at the Bionics Institute, within the Faculty of Medicine, Dentistry and Health Sciences. I am delighted to be the founding Head of this new department. I believe this agreement represents a significant opportunity for both institutions, while retaining our status as an independent not-for-profit research institute. By working together we will be able to address significant medical and health concerns and achieve outcomes which would potentially not be achievable by either organisation alone. The establishment of this new Department will allow us to build on our existing international reputations by combining our complementary strengths and research capabilities.

Our place and affiliations within Melbourne’s Eastern Hill precinct that encompasses two world-class teaching hospitals – the Royal Victorian Eye and Ear Hospital and St Vincent’s Hospital – ensure our research and its clinical application are integral parts of this exciting translational research hub. The plans for redevelopment of the Royal Victorian Eye and Ear Hospital and development of the Aikenhead Centre for Medical Discovery at St Vincent’s Hospital include new facilities for the Institute, and we are proud partners in these ongoing ventures. The Eastern Hill precinct is known for its significant contributions to medical research and clinical care, and these planned developments will enhance the precinct’s collaborations and productivity.

The Institute’s success in delivering practical health outcomes for people with a variety of conditions stems from our multidisciplinary and collaborative approach to research. We bring together engineers and scientists from diverse fields, and train the next generation
Our work as a key member of the Bionic Vision Australia (BVA) consortium has taken a significant step forward, with the Institute designing, manufacturing and evaluating the safety of Australia’s first prototype bionic eye device.

We engage with leading clinicians across Australia and internationally to ensure our outcomes are relevant to clinical application. This year we have grown our network of Honorary Clinical Research Fellows from nine to 29; they contribute to our knowledge base as well as collaborate on many projects.

Following the success of the Institute’s first international conference on medical bionics in 2008 we committed to a larger conference in November 2011. The conference, which was held at a resort at Phillip Island about 100 kilometres south east of Melbourne, attracted almost 180 registrants from around Australia and the world. The community atmosphere, the quality of the speakers and their passion for the subject helped facilitate great engagement in the conference. This level of enthusiasm opened discussions about future collaborations and the sharing of information across fields of research and countries. With the overwhelmingly positive feedback from the delegates the Institute has committed to host another conference in 2013.

Supporting the Institute

The Institute has a small and loyal group of supporters who give generously of their time and resources. Their commitment to the Institute and our work is greatly appreciated. Those of you I get to meet share a passion for our work, and this continues to motivate me and the Institute’s researchers.

Corporate sponsorship and philanthropy provide resources and public exposure that we cannot attain on our own. The mutually beneficial relationships we have with Woodards, Ritchies SUPA IGA, Colgate-Palmolive, and The Australian Ballet are of great benefit to the Institute.

Ambassadors work tirelessly to help promote the Institute. Volunteers either with a cochlear implant or related to a recipient speak to community groups about our work and their experience with bionic hearing. It is their first-hand account of the technology that provides listeners with such a compelling story. Our Ambassadors are our greatest local support network and we appreciate their continued efforts.

We are very grateful for the generous commitment of trusts and foundations that continue to underpin the work of the Institute. Almost 20 per cent of our income is derived from philanthropic sources and these contributions either help top-up scarce government funding or establish new and exciting ventures.

I would particularly like to acknowledge the support we receive from the Victorian Lions Foundation through 25 years of funding of the Lions International Hearing Research Fellow.

We also acknowledge the vital support we receive from the Victorian Government through its Operational Infrastructure Support Program, and the Federal Government’s Independent Research Institutes Infrastructure Support Scheme.

Our people

The Bionics Institute is committed to training the next generation of researchers in Medical Bionics and I would like to congratulate our latest graduate, Dean Freestone, on his successful PhD completion.

Several of our new fellows and students have come to us from overseas. We are delighted that our international reputation continues to attract such talent to our laboratories. These visitors not only bring new opportunities to exchange skills and ideas but also build lasting relationships and friendships with laboratories and institutions around the world.

I would like to congratulate the Institute’s Deputy Directors, Professors Peter Blamey and Hugh McDermott, for the significant acknowledgements of their contributions to science. Hugh was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) for his contributions to improved sound-processing techniques for cochlear implants and hearing aids. Each year, following a rigorous evaluation procedure, the IEEE Fellow Committee recommends a select group of recipients for one of the Association’s most prestigious honours – an IEEE Fellow. Peter Blamey was one of four scientists and engineers awarded the prestigious Clunies Ross Award by the Australian Academy of Technological Sciences and Engineering.

Peter won the award, which celebrates an outstanding achievement in the application of science and technology, for his international contribution to hearing science, and in particular to hearing aid design and the cochlear implant.

I would like to thank our Board under the Chairmanship of Gerry Moriarty, for their direction and counsel throughout the year. Their guidance through a year of significant change has been most appreciated.

Most importantly, I would like to thank our talented staff and executive team for their wonderful contributions to scientific discovery, commercialisation of that discovery and to the richness of life at the Institute. Their unflagging effort ensures the Bionics Institute is at the international forefront of medical bionics research.

Professor Robert K Shepherd
BSc, DipEd, PhD
Director
Improving the performance of the bionic ear and hearing aids, slowing or halting the deafness process, and understanding how the brain rewires itself after the introduction of a bionic ear are just some of the ways we take a holistic approach to researching and tackling hearing loss.
How do we improve sound perception for people with cochlear implants and hearing aids?

A new sound-processing strategy that benefits bimodal listeners

Due to the success of cochlear implantation there is an expanding population of recipients that use a hearing aid in one ear and a cochlear implant for the other. This combination of electric and acoustic hearing is termed bimodal stimulation, and has the potential to improve the perception of a sound’s location, as well as the perception of speech in noisy environments. In normal hearing listeners, the auditory brain uses small differences in the sound reaching the two ears (binaural cues) to localise sounds in space, as well as ‘unmask’ signals hidden in noise. However, the signal processing strategies of cochlear implants and hearing aids were developed independently so that the potential advantages of binaural hearing and bimodal stimulation have not been fully realised to date.

This research aims to develop a unified signal processing strategy for combined implant and hearing aid stimulation so that binaural cues are optimised. This new strategy aims to maintain the correct timing between stimulation of the two ears, and also has the potential to improve pitch and music perception for the listener.

Over the past year we developed and evaluated a loudness normalisation strategy and fitting method developed specifically for bimodal stimulation.

This research is funded by a European Union Marie Curie Fellowship and a Flemish Government Fellowship to visiting researcher Dr Tom Francart. Funding is also provided by Cochlear Ltd. The team includes Dr Tom Francart and Prof Hugh McDermott.

Cochlear implant results show efficacy of hearing aids in preserving auditory function

In 1996, a model of auditory performance over time was described for cochlear implant users, based on information from 800 post-linguistically deaf patients. This original study described how duration of severe-to-profound hearing loss, age at cochlear implantation, age at onset of hearing loss, cause of hearing loss, and cochlear implant experience affected outcomes. The aim of the present study was to update this model, and involved the collection of a large amount of data from international cochlear implant clinics to identify reliable predictors of outcomes for implant recipients. Twelve clinics from across Europe, North America, and Australia agreed to collaborate, and the data from 2,251 patients implanted since 2003 were retrospectively collected. The data included relevant information about each patient both before and after cochlear implantation.

Our analysis has shown that the five main factors influencing individual differences in auditory performance of cochlear implant recipients in 1996 (listed above) still have significant effects in 2011, although the relative importance of the factors have changed. Cochlear implant experience was one of the most significant factors and the effects of duration of deafness and age have reduced. Different patient selection
The changes in hearing performance over time with moderate hearing loss (mHL) and then severe-to-profound hearing loss (s/pHL). The graph shows the positive effect of hearing aid (HA) use prior to cochlear implantation and the subsequent enhanced improvement in performance.

Understanding what cochlear implant users hear

Cochlear implants restore speech understanding by directly stimulating the primary auditory neurons within the cochlea using electric pulse trains. Acoustic simulators have been developed to gain insight into the relationship between patterns of electrical stimulation and what a cochlear implant user hears. These simulators function in a similar way to cochlear implant sound processors, transforming a complex sound into its component parts by filtering and feature extraction. However, there are limitations to the usefulness of available simulators as predictors of speech perception, and it is known that the sounds produced by simulators may be very different from the corresponding signals heard by implant users.

To address this limitation we have examined the perception of deaf adults who have a cochlear implant in one ear and residual low-frequency hearing in the other ear. Participants were asked to choose and adjust an acoustic stimulus so that it matched the perception resulting from stimulation of a single electrode located in the low-frequency region of the cochlea. We intentionally chose a simple pattern of stimulation for this study before considering more complex auditory stimuli. We found that stimulation of this single electrode resulted in a complex perception that was neither white noise nor a pure tone. Therefore, existing acoustic simulators do not represent accurately the sound sensations created by electric stimulation. These results represent a first step in understanding more fully what implant recipients hear. Future studies will examine the perceptions associated with other electrodes, including electrode arrays implanted in people who have near-normal acoustic hearing in the non-implanted ear, and how these change over time and with implant use.

This research is funded by the NH&MRC and funding to visiting researcher Dr Diane Lazard from the Fondation Bettencourt-Schueller and Cochlear Ltd (France). The team includes Dr Diane Lazard, Dr Jeremy Marozeau and Prof Hugh McDermott.

Improving cochlear implant performance in challenging listening situations

Despite having good speech perception abilities in quiet settings, most cochlear implant recipients experience difficulties in perceiving music and sounds in noisy environments. Many studies have suggested that such difficulties are due partly to the broad spread of current from each electrode, which leads to the stimulation of a larger population of auditory nerve fibres than intended and therefore less specific information is conveyed to the auditory brain. In order to rectify this problem, new stimulation strategies are being investigated. These strategies exploit current combination and cancellation effects across electrodes, and therefore require the activation of many electrodes simultaneously. As this is not practical using existing implants, a new experimental device will be used with five patients that includes an electrode array driven by an external stimulator. Two patients have recently been implanted with the device, and a further two have recently volunteered to participate.

The broad aim of this project is to determine whether these novel stimulation strategies...
for cochlear implants that make use of multiple, simultaneously active current sources can improve outcomes for recipients.

The first experiments suggest that: 1) stimulation of multiple electrodes might improve frequency selectivity which may lead to better understanding of speech in noise; and 2) simultaneous stimulation of multiple electrodes might be crucial to induce better pitch sensation and appreciation of music.

Experiments have been scheduled to test auditory stream segregation, complex pitch perception, and the understanding of speech in noise. If successful, the experiments will lead to the development of a new cochlear implant system that represents a major leap forward and will provide a substantial benefit in the quality of life of deaf people.

This research is funded by The Garnett Passe and Rodney Williams Memorial Foundation. The team includes Prof Colette McKay, Prof Hugh McDermott, Dr Jeremy Marozeau, Mr Robert Briggs (University of Melbourne), Prof Stephen O’Leary (University of Melbourne), and Dr Chris van den Honert, Dr Christopher Long, Dr Zachary Smith, Dr Brett Swanson, Mr Joerg Pesch (Cochlear Ltd).

A hearing aid for auditory neuropathy

Auditory neuropathy is a condition affecting hearing nerves that can result in impaired speech perception even though hearing thresholds may be close to normal. This project is developing and evaluating hearing aids with advanced sound processing that may compensate for the effects of auditory neuropathy, and produce improved speech perception.

Twenty hearing aids have been produced and will be used by up to ten people with auditory neuropathy in take-home trials to run over several months. The aids themselves, although prototypes, use commercial hardware and could be mass produced for market within six months without further investment if the trial achieves a successful outcome. Fitting software for the trial has been based on existing commercial fitting techniques and could be used with the new product with a little further development.

It is estimated that up to 10 per cent of hearing aid users suffer from auditory neuropathy, and the approximate value of the hearing aid market worldwide is $3 billion pa. In addition, about 80 per cent of people who would benefit from hearing aids do not currently use them. Some proportion of these people may benefit from an auditory neuropathy hearing aid if one was available.

This research is funded by a contract from Hearing Lab Technologies (HLT) LLC and a Deafness Foundation grant. The team includes Prof Peter Blamey, Prof Hugh McDermott and A/Prof Gary Rance (University of Melbourne).

Improving the perception of music

The ability to hear parts of a complex auditory environment separately, such as appreciating the lines of melodies played by different instruments within an orchestra, is called auditory stream segregation or streaming. Streaming is the ability to separate and combine different components of auditory information according to their sources, and is mainly based on perceptual differences between sound sources. Unfortunately, hearing impairment affects the ability to perceive important differences in the pitch (the sensation of notes going up or down the scale) and timbre (the tone quality or sensation that makes different instruments playing the same notes still sound different) of different sources.

This project aims to develop a new sound processor that allows people with hearing impairments to appreciate the complex interplay between different parts of music by automatically separating incoming sound
Overall, ratings of the music were typically higher for percussion pieces. The concert successfully elicited similar responses from both groups in terms of interest, enjoyment and musicality, although technical aspects, such as understanding, localisation, and instrument identification continue to be problematic for cochlear implant users.

This research is funded by the Australia Council, Arts Victoria, and Cochlear Foundation. The team includes Dr Jeremy Marozeau, Dr Hamish Innes-Brown, Mrs Agnes Au (University of Melbourne), A/Prof Catherine Stevens (University of Western Sydney), A/Prof Emery Schubert (University of NSW) and Dr Robin Fox (composer).

Music for the bionic ear

In 2010, six composers were commissioned to create works for performance at two concerts intended to be accessible to cochlear implant users as well as normally-hearing friends and family. In addition to the production of the concert itself, data were collected via survey forms and post-performance focus groups.

In collaboration with colleagues in Sydney, a study is now underway to determine whether cochlear implant users and normal hearing listeners might for the first time report similar ratings on cognitive, engagement and technical aspects of a live musical performance.

The concert was described in advertising as ‘new music, specifically designed for cochlear implant recipients, their normally-hearing friends and family, as well as music-lovers’. Participants in this study were audience members who attended the concerts; a mix of hearing aid users, cochlear implant users and normally-hearing listeners.

Questionnaires were distributed to the audience, and 407 completed questionnaires were returned after the performances. Responses from groups of normally-hearing listeners ($n = 44$) and cochlear implant users ($n = 44$), matched in age and musical ability, were compared to determine whether the specially-commissioned works would elicit similar responses from both groups.

No significant group differences were found on measures of interest, enjoyment and musicality, whereas ratings of understanding and instrument localisation and recognition were significantly lower from cochlear implant users.

“A study is now underway to determine whether cochlear implant users and normal hearing listeners might for the first time report similar ratings on cognitive, engagement and technical aspects of a live musical performance.”

![A complex piece of music can be divided into simpler parts and sent to a hearing aid and a cochlear implant separately.](image-url)
Auditory neuroscience

The plastic effects of a bionic ear on the central auditory pathway

Like the many instruments in a symphony orchestra all following the conductor, the different regions of the cochlea respond to different frequencies of sound with precise timing. It is this precise frequency and temporal processing, which is continued throughout the entire auditory pathway that helps us make sense of our complex acoustic world. Unfortunately, prolonged periods of deafness, particularly from a young age, can result in the scrambling of the frequency organization and a blurring of the temporal precision.

Our previous work has shown that cochlear implant use, from either a young age or later in life, can ameliorate many, if not all, of the changes that occur during long periods of deafness. However, what is less clear is the time course of these changes, and whether they can be influenced by specific training or rehabilitation.

In order to better understand the functional implications of the significant changes observed with long-term deafness and cochlear implant use, we have developed sophisticated recording capabilities and behavioural testing procedures. This combination of chronic electrical stimulation (with a cochlear implant), chronic brain recordings, and behavioural testing is unique to the Institute, and will allow us to examine the precise time course of changes within the central auditory pathway. We can now observe how changes in frequency organisation and temporal processing evolve over time, rather than observing a single ‘snap-shot’.

The plastic nature of the central auditory pathway has certainly been a contributing factor to the success of the cochlear implant. Improving our understanding of changes in the auditory system over time opens up the possibility of harnessing this plasticity. This will be a vital aspect of our continuing aim to improve the performance of cochlear implants and the benefits gained by users.

Auditory neuron responses to electrical stimulation

The bionic ear works by electrically activating auditory neurons within the cochlea. The electrode array of the bionic ear is inserted into the cochlea and contains many electrode contacts that can activate the auditory neurons. However, little is known about how the individual auditory neurons respond to the signals from the electrode array and how extended periods of deafness may influence the ability of the neurons to provide sound information.

In this project we are examining the activity from auditory neurons in response to electrical stimulation from a bionic ear. We have examined the ability of auditory neurons to provide information that is related to the pitch of incoming sounds by measuring the overall responses of the neurons to electrical stimuli delivered to the individual electrode contacts. The results from these experiments provide important information necessary in designing the next generation of bionic ears.

This research is funded by NIDCD (HHS-N-263-2007-00053-C) and the Victorian Lions Foundation. The team includes Dr Andrew Wise, Dr James Fallon, Ms Alison Evans and Prof Rob Shepherd.

Electro-acoustic hearing

Cochlear implants convey spectral and temporal information to deaf people, bypassing the missing or damaged hair cells to electrically stimulate the residual primary auditory neurones of the cochlea. Cochlear implants were initially provided only to patients with no usable hearing in either ear. However, both children and adults with useful amounts of low-frequency hearing (i.e. severe mid- to high-frequency hearing loss) are now routinely implanted. These cochlear implant recipients have access to information from both acoustic hearing (via their remaining low-frequency hearing) and electric hearing (via their cochlear implant stimulating the more basal, high-frequency region of the cochlea).

The current clinical focus is on: who are the most appropriate candidates for electro-acoustic stimulation; the fitting procedures

Example response areas. The initial response was recorded from an electrode in auditory cortex in response to cochlear implant stimulation prior to any auditory experience. The final response was recorded from the same cortical electrode after 6 months of cochlear implant use. The difference between the two recordings illustrates the changes that occur in the auditory pathway as a result of chronic cochlear implant use.
Therapies for hearing protection and restoration of cochlear function

to use for optimal performance with electro-acoustic stimulation for each individual; and the best way to preserve as much of the existing hearing as possible. However, there is very little known about how inputs from the two modalities are represented and integrated in the central auditory pathway, or the effects of long-term partial deafness and chronic electrical and acoustic stimulation on these processes. This project is investigating the effects of long-term partial deafness, either from a young age or in later life, and chronic electrical and acoustic stimulation on the way in which stimuli in the two modalities are represented and integrated in primary auditory cortex.

This research is funded by the NH&MRC. The team includes Dr James Fallon, Dr Sam Irving, Prof Dexter Irvine, Prof Hugh McDermott, Ms Alison Evans, Ms Nicole Critch, Ms Amy Morley, Dr Andrew Wise, Mr Rodney Millard, Ms Helen Feng and Prof Rob Shepherd and Dr Kristien Verhoeven and Frank Risi from Cochlear Ltd.

A drug-delivery system for nerve survival factors in the inner ear using nanotechnology

Exposure to trauma-causing noise, some anti-cancer drugs and a certain class of antibiotics can kill the delicate sensory (hair) cells in the inner ear. When these hair cells die, primary auditory neurons that make contact with these hair cells degenerate. Since these neurons are also targets of cochlear implants, we are examining ways to deliver nerve survival factors (termed neurotrophins) to these neurons to prevent their degeneration. One of the factors that has generated considerable interest in this field is brain-derived neurotrophic factor (BDNF).

In this study, we have collaborated with material scientists from the Department of Chemical and Biomolecular Engineering at the University of Melbourne to design small, porous particles which can bind BDNF. Because the dimension of the pores in these particles is in the range of nanometres, these particles are also known as nanoporous peptide particles (NPPs). During loading, BDNF binds to these NPPs through electrostatic attraction between its positively-charged amino acids and the negatively-charged interface of these particles. When these BDNF-encapsulated particles are transferred into an environment with a physiologically relevant pH, BDNF is gradually released. When we surgically placed these BDNF-encapsulated particles into a fluid-filled cavity within the inner ear of an animal model, we found that many of the primary auditory neurons survived, instead of degenerating. The protective effect of our BDNF-encapsulated particles could be seen as early as 20 days post-treatment. To extend the duration of protection, we are currently improving the technology to create particles which are bigger and can release greater quantities of the nerve survival factor.

This research is funded by the NH&MRC and NIDCD (HHS-N-263-2007-00053-C). The team includes Prof Rob Shepherd, Dr Justin Tan, Dr Andrew Wise, Dr Fergal Glynn, Ms Xiao-pei Yip, Prof Frank Caruso (University of Melbourne) and Dr Yajun Wang (University of Melbourne).

Long-term survival of auditory neurons following cell-based treatment and cochlear implantation

Auditory neurons are the target cells for electric stimulation by a cochlear implant. However, in deafness, the auditory neurons undergo progressive degeneration which may have implications for clinical performance using a cochlear implant. The application of nerve survival factors, known as neurotrophins, can prevent the degeneration that normally occurs.

The project aims to use clinically relevant, cell-based neurotrophin delivery techniques, in conjunction with a cochlear implant, to support long-term auditory neuron survival in deafness. We have successfully genetically modified cells to secrete the neurotrophin BDNF for at least six months, and have demonstrated that these cells enhance the survival of auditory neurons in tissue culture experiments. These BDNF-expressing cells have subsequently been encapsulated in a biocompatible matrix and tested for longevity of survival effects on auditory neurons in deafness. Preliminary data indicates that the survival effects of these cells last for at least three months, and that concurrent treatment with cell-based neurotrophin treatment and a cochlear implant enhances survival effects.

Cell-based neurotrophin treatment may provide a clinically relevant way to maintain a viable population of auditory neurons that can be stimulated by a cochlear implant, to improve the speech perception and language benefits to deaf patients.

This research is funded by the NH&MRC and The Garnett Passe and Rodney Williams Memorial Foundation. The team includes Dr Lisa Gillespie, Dr Mark Zanin, Prof Robert Shepherd, Prof Alan Harvey (University of Western Australia), Prof Dwaine Emerich (NSGene, USA) and Dr Chris Thonas (CytoSolv, USA).

Protecting and restoring cochlear sensory cells with targeted gene therapy

Irreversible sensorineural hearing loss results from the damage or loss of cochlear hair cells and/or hearing nerves. Currently, the only clinical option for people with severe to profound sensorineural hearing loss is a cochlear implant. However, emerging gene therapies may enable the replacement or repair of hair cells and hearing nerves for restoration of hearing. The Institute is investigating the applicability of gene therapy in the cochlea to provide cellular sources of genes required for the protection and/or regeneration of hair cells and nerve fibres after the onset of hearing loss.
We use a gene therapy technique that targets the organ of Corti of the cochlea where the hair cells and nerve endings are located. We are examining neurotrophin genes called Ntf-3 and BDNF for nerve survival and nerve fibre regeneration, and a gene called Atoh1 for hair cell regeneration.

We previously discovered that neurotrophin gene therapy administered shortly after deafness resulted in protection of hearing nerves and regeneration of nerve fibres towards areas of neurotrophin gene expression in the organ of Corti. To expand on this discovery, we investigated three important aspects that could influence clinical translation of the technique: long-term outcomes after gene therapy; the effectiveness of gene therapy after short-term or long-term hearing loss; and the safety of gene therapy in the cochlea.

### Sustained outcomes of neurotrophin gene therapy

Important to the clinical translation of gene therapy, the effects of neurotrophin gene therapy were found to be long lasting. Neurotrophin gene expression, nerve survival and regenerated nerve fibres were all significantly sustained for at least 11 weeks after gene therapy, a timeline that could be equivalent to many years in humans. Furthermore, the numbers of surviving neurons were comparable to normal hearing cochlea when gene therapy was implemented one week after hearing loss. These results suggest overall stability of protected neurons and their regenerated fibres.

### Neurotrophin gene therapy after long-term hearing loss

The number of cells altered by gene therapy in the organ of Corti diminished as the period between deafness and gene therapy increased. This was found to be due to the progressive degeneration of the organ of Corti that occurs after the onset of hearing loss. As a consequence, the ability of neurotrophin gene therapy to protect neurons also decreased after increasing periods of deafness due to lower expression levels. Hence there is a critical window of opportunity after hearing loss during which neurotrophin gene therapy for neuronal survival could be considered. Interestingly, gene expression was still possible in the highly degenerated organ of Corti, albeit with severely reduced numbers of cells.

### Safety of gene therapy in the cochlea

Two aspects of safety that we investigated were the tissue response of the cochlea to gene therapy and the effect of gene therapy on hearing thresholds. There was minor fibrous tissue formation in the cochlea after gene therapy. A similar response is often seen after cochlear implantation or other surgical approaches to the cochlea suggesting that gene therapy does not induce a tissue response or immune reaction above or beyond that generated by the surgical approach. There was some decrease in hearing sensitivity in the high frequency region of the cochlea, proximal to the site of gene therapy, which in a clinical setting is usually already significantly damaged prior to intervention. Importantly, the low frequency region in which people often have some residual hearing remained unaffected.

### Atoh1 gene therapy

We are examining the effectiveness of gene therapy using Atoh1 to regenerate the sensory hair cells of the cochlea. In preliminary trials, we observed that supporting cells in the organ of Corti acquired characteristics of hair cells (such as expression of the myosin 7a gene) in both normal hearing and profoundly deaf in vivo models. We intend to examine how these new “hair cells” influence the growth of hearing nerves in the deafened cochlea.

This research is funded by The Garnett Passe and Rodney Williams Memorial Foundation and Action on Hearing Loss. The team includes Dr Rachael Richardson, Dr Andrew Wise, Prof Rob Shepherd, Mr Patrick Atkinson, Ms Brianna Flynn, Prof Stephen O’Leary (University of Melbourne), and Prof Cliff Hume (University of Washington).
As part of the Bionic Vision Australia (BVA) consortium the Bionics Institute has designed, manufactured and rigorously tested Australia’s first prototype bionic eye. This innovation is the first major step towards restoring sight for thousands of people with inherited eye disease.
In collaboration with our research partners, ongoing studies over the past year have been evaluating the merits of two possible locations within the eye for the placement of the wide-view and high-acuity devices.

The wide-view device for bionic vision, placed in the suprachoroidal space (between the first two layers of the eye, namely the sclera and choroid, and behind the retina) and covering a large portion of the back of the eye, will result in a large field of vision for patients. The prototype wide-view device has been developed by the Bionics Institute using silicone with platinum electrodes for stimulation. The surgical techniques involved with this approach have been extensively tested, and the device position has been found to be stable over long-term implantation.

The ability of the device to generate visual percepts in the brain has been evaluated with respect to its position within the suprachoroidal space. Long-term implant safety has been tested with passively implanted devices and studies have demonstrated successful stimulation of the retina at the end of the chronic implantation period. The biocompatibility of the implant has been evaluated and we have demonstrated a normal retina after three months of implantation. Long-term stimulation of the device was also shown to be safe.

For the high-acuity device, the epiretinal placement (through the front of the eye directly on the surface of the retina) is looking promising. Experiments have been proceeding over the past 12 months looking at the safety and efficacy of a device made from conductive diamond electrodes. As with the wide-view device the external shape of the implant (or ‘form factor’) is of crucial importance for its long term stability. Bionics Institute staff in collaboration with the Melbourne Materials Institute (University of Melbourne) and surgeons from the Centre for Eye Research Australia (CERA) have been refining the shape of the device.
Gearing up for Patient Tests

Over the past 12 months staff at the Bionics Institute, in collaboration with our surgical partners from CERA and the Royal Victorian Eye and Ear Hospital (RVEEH) have been preparing for the implantation of three clinical grade prototype wide-view suprachoroidal arrays developed and manufactured by the Bionics Institute for human use. We continue to test the mechanical stability of this device in chronic in vivo studies. The stability of the stimulating electrode array is a critical factor (and has been shown to be well tolerated), but we must also ensure that the system as a whole remains stable and safe for the entire implant period.

In addition to anatomical fitting, the leadwire components of the prototype device have been undergoing continuous mechanical fatigue testing. A healthy-sighted person has between 100,000 and 150,000 eye movements (termed saccades) per day, of which 90% are micro-saccades with an eye rotation of 5° or less, and the remaining 10% of movements (macro-saccades) are between 5° and 30° rotation. The first round of patient tests will see patients implanted for an 18 month period. The leadwire components of the early prototype device have now been running under accelerated conditions for over eight months, which equates to greater than 28 years of micro-saccades and nine years of macro-saccades, demonstrating the robustness of the technology.

To aid in the delivery of the implant to the intended location in the eye, custom-made

Safety of bionic eye removal and replacement

Over the past year, in collaboration with our surgical partners from CERA, we have been experimenting with and improving the design of the wide-view device to maximise its safety and efficacy. The effect of removal or replacement of the bionic eye are key issues that need to be addressed in order to be confident that the implanted bionic eye will be safe for human use. Implants of any kind may need to be removed or replaced under certain circumstances. Recently, we have made excellent progress in determining the feasibility and safety of removing and replacing implanted devices and the long-term effects these two processes may have on the adjacent tissue. Analysis has shown that implants can be safely removed and replaced.

Chronic Safety Studies

We are conducting studies to assess the safety and efficacy of long-term electrical stimulation of the retina using the wide-view suprachoroidally implanted device. Implants were continuously stimulated at clinically relevant current levels for several months. The electrodes remained stable and the surrounding tissue remained healthy at the completion of the implantation period. The neural responses to various modes of stimulation were also assessed and these data will inform the development of future stimulation strategies. Assessments have shown that implants have been well tolerated in the suprachoroidal space with an absence of infections or electrically induced damage.

Wide-View Studies (Platinum Electrodes)

Optimised electrical stimulation for a wide-view device that is safe and effective

Through numerous preclinical studies, using recordings from the visual cortex of the brain, we have assessed the efficacy of electrical stimulation with a suprachoroidal wide-view device. Through this we have optimised the stimulus parameters that lead to the most effective response. We have found that monopolar stimulation, which refers to the configuration of the stimulating electrode and the return electrode, is the most effective in terms of requiring the lowest levels of charge to produce a localised response. We also found that unlike cochlear implants, short pulses (less than 100µsec in duration) are not useful for retinal stimulation while pulses of 500µsec and longer duration can achieve consistent and reproducible brain responses. Finally, we have found that stimulation of lines and groups of electrodes simultaneously is more effective and requires less power than stimulating single electrodes in a sequential manner. This leads to the notion that the retina and brain may be more responsive to progressive stimulation of lines and edges rather than single points (like pixels of a computer display).

Activation patterns in the visual brain in response to stimulation of the suprachoroidal wide-view device. Three different modes of stimulation were used and found to produce similar patterns of activation in the brain.
surgical tooling was developed and designed to simultaneously protect the device from the rigors of surgical implantation and minimise surgical trauma to the recipient. Institute engineers and research staff worked closely with the CERA surgeons to ensure all custom and standard tooling met the strict regulatory standards required for clinical use.

Marking a milestone for the Bionics Institute and its staff was the handover to the CERA and RVEEH surgical team of all materials, surgical tooling and devices for the patient tests. In research and development terms this also marks a major shift in our research focus of the past three years that has led up to this point, and we are now looking forward to the follow up work that will need to be done when the first clinical data become available.

BVA’s prototype bionic eye, developed by the Institute, has now been successfully implanted in three patients at the Royal Victorian Eye and Ear Hospital and the psychophysics team, led by the Bionics Institute, is currently in the process of performing visual perception testing.
Visual
psychophysics

Visual psychophysics is the field of study that describes the visual percepts experienced by bionic eye patients when residual nerves in the retina are stimulated electrically, i.e., the relationship between the perceptual psychology and the physics of stimulation.

The neuroBi stimulator

Psychophysics measures the relationship between physical stimuli and sensory perception. In the case of a bionic eye, electrical stimulation of the retina produces visual percepts known as phosphenes. The visual psychophysics test system has been designed to investigate how the characteristics of these phosphenes (e.g., brightness, size, shape, location) vary with changes in stimulation parameters. A major component of the system is the neuroBi, a highly flexible, external neural stimulator developed at the Institute to deliver controlled electrical stimulation to implanted electrodes. Custom software has also been developed that will be used by clinicians and researchers to control stimulus delivery and record patient responses.

Validation of the psychophysics setup

In collaboration with clinicians from CERA, validation tests have been successfully performed using the psychophysics system with normally sighted subjects. By stimulating a very fine fibre electrode placed under the eyelid, phosphenes were produced that consisted of flashes of light in the periphery of the visual field. The characteristics of these phosphenes were then explored using the capabilities of the psychophysics test system.

Phosphenes shape, size, and location

Recently, psychophysics testing has commenced in the first recipient of the surachoroidal electrode array. The phosphenes produced are more complex than expected, containing light, dark, and grey regions, and evolving over time. It is likely that these percepts include the effects of ON and OFF neurons that detect the onset and offset of stimuli, and other specialised processing such as edge detection in the visual system. Phosphenes produced by electrodes close to the fovea – the specialised, central part of the retina responsible for fine detailed vision - are more complex in their morphology than phosphenes that are produced by more peripheral electrodes.

Further psychophysics testing over the next 12 months will provide BVA researchers with a basis for future vision processing studies in patients using a totally implantable wide-view device that will be an aid to navigation.
High-Acuity Studies (Diamond Electrodes)

Optimised surgery and electrical stimulation for a high-acuity device

Preliminary preclinical in vivo surgical trials of the placement of a high acuity device are looking promising. These high resolution electrodes have been designed and manufactured by BVA partners at Melbourne Materials Institute, University of Melbourne. Our contribution includes providing the appropriate form factor and leadwire assembly required for surgical application. Surgeons at CERA have been able to successfully attach a device made entirely of conductive diamond electrodes and silicone to the inner surface of the retina using a retinal ‘tack’. We have shown diamond electrodes to be very stable during continuous stimulation in vitro in saline. Preliminary in vivo stimulation results are also looking promising. We have found that charge levels required for brain activation are similar to those found with the wide-view suprachoroidal device.

The Bionics Institute team includes A/Prof Chris Williams, Dr David Nayagam, Dr Mohit Shivdasani, Dr James Fallon, Dr Jin Xu, Mr Joel Villalobos, Ms Rosemary Cicione, Mr Sam John, Mr Ronald Leung, Ms Melanie Gault, Mr Austin Mueller, Mr David Perry, Mrs Alexia Saunders, Ms Michelle McPhedran, Mr Nick Sinclair, Mr Kyle Slater, Mr Thushara Perera, Mr Rodney Millard, Mr Mark Harrison, Mr Owen Burns, Ms Ceara McGowan, Ms Vanessa Maxim, Ms Helen Feng, Prof Peter Seilgman, Prof Peter Blamey, Prof Hugh McDermott and Prof Rob Shepherd.

Our collaborators include: Dr Penny Allen, Dr Mark McCombe, Dr Jonathan Yeoh (Royal Victorian Eye and Ear Hospital); Dr Chi Luu, Dr Lauren Aytton, Dr Peter Dimitrov, Ms Mary Varsamides, Prof Robyn Guymer and Mr Nick Opie (CERA); A/Prof Richard Williams (Department of Pathology, University of Melbourne); A/Prof Penny McKelvie and Ms Meri Basa (St Vincent’s Hospital Melbourne); Dr Hamish Meffin (NICTA); Mr Chris Doeds, Ms Cherry Ho and A/Prof Gregg Suanning (University of NSW); Prof John Morley (University of Western Sydney); Dr Kumar Ganesan, Dr David Garret, Dr Kate Fox, Ms Samantha Lichter and Prof Steven Prawer (Melbourne Materials Institute), Prof Michael Ibbotson and Dr Brendan O’Brien (National Vision Research Institute); Prof Anthony Burkitt and Ms Tamara Brown (Bionic Vision Australia).

Funding for our bionic eye research comes from Bionic Vision Australia’s Special Research Initiative “Research in Bionic Vision Science and Technology” grant from the Australian Research Council and the Bertalli Family Foundation.

The electrode array in the first prototype bionic eye has 20 electrodes in a hexagonal pattern (electrodes 1-20), partially surrounded by a guard ring (electrode 21), with three remote electrodes (22, 23, 24). During stimulation, a biphasic current flows between an active electrode (1-20) and a return electrode or electrodes. The circular electrodes are spaced 1mm centre-to-centre. Most electrodes are 600μm, with 3 smaller electrodes (9, 17, 19) being 400μm in diameter.
Applying 25 years of knowledge in the development of medical devices, the Bionics Institute hopes to provide relief to people with intractable neurological and psychiatric conditions with a range of brain stimulation devices. The number of people whose health we can improve is many times that of the bionic ear.
Epilepsy is a chronic disorder of the brain that results in recurrent and unpredictable seizures that adversely affect patients’ lives. Within the general population, about 1 per cent of people are affected by epilepsy, and of these up to one third cannot gain control of the condition through medication or other means. The uncertainty of when seizures may occur can lead to a withdrawal from everyday activities and a reduction in quality of life. The surgical removal of the region of brain suspected to be the cause of the seizures is the last and most extreme option that is offered to these patients. Surgery is highly invasive, non-reversible, and carries no guarantees of success. The Bionics Institute is developing Neurobionic technologies that offer a new approach for controlling these seizures, ideally returning to epilepsy patients the freedom and safety that most of us take for granted.

Anticipation of epileptic seizures using a probing stimulus

In patients with focal or localised epilepsy, seizure occurrence often appears to be random. However, there is evidence that the brain undergoes subtle changes prior to seizures. This evidence was initially anecdotal, with patients and their family and friends reporting strange feelings or behaviour in the minutes or hours prior to seizures. More recently, researchers using a variety of medical imaging techniques have observed changes in the form of hyper-activity in the brain’s dynamics prior to seizures.

Our goal is to develop an implantable therapeutic device for epilepsy that includes effective anticipation of an impending seizure. Anticipation will allow for an intervention period within which a preventative therapy (electrical stimulation or focal drug delivery) can be administered to prevent the seizure from occurring. Over the last year, we have demonstrated that our method of seizure anticipation is effective and safe. With further development we hope our method will eventually be applied more widely.

The technique we are developing and evaluating involves measuring cortical excitability. It is hypothesised that hyper-excitability (hyper-activity) is a precursor to seizures. In order to test this hypothesis, our team has developed a system for tracking neural excitability over time with electrodes implanted directly in the brain.

At St Vincent’s Hospital Melbourne, where patients with epilepsy undergo pre-operative studies conducted in collaboration with Institute researchers, an array of electrodes implanted directly on the brain has allowed the investigation of novel excitability measurements. Our active approach of using electrical stimulation for monitoring brain hyper-excitability is a paradigm shift from conventional passive measurement techniques. This approach has the potential to lead to clinically applicable outcomes in the near future. Seizure anticipation provides a window for therapeutic intervention, thereby possibly preventing these life-threatening attacks.

This research is funded by the Australian Research Council (Linkage Project), LEW Carty Charitable Fund, Jack and Robert Smorgon Families Foundation and The Jack Brockhoff Foundation. The team includes Dr Dean Freestone, Dr Alan Lai, Mr Tim Nelson, Prof Hugh McDermott, Prof Peter Blamey, Prof Mark Cook (St Vincent’s Hospital Melbourne), A/Prof David Grayden (University of Melbourne), Prof Anthony Burkitt (University of Melbourne), Prof Dragan Nesic (University of Melbourne), Ms Linda Seiderer (University of Melbourne), and Mr Simon Vogrin, A/Prof Wendyl D’Souza and A/Prof Michael Murphy (St Vincent’s Hospital Melbourne).

Treating Intractable Epilepsy
Development of an ambulatory epilepsy treatment device

In the last few years, data have been collected from seven patients prior to undergoing surgery for focal epilepsy. Experimental paradigms for prediction, detection, and suppression of seizures have been evaluated in these patients, but the results are inconclusive due to the limited number of patients and the available time with each.

To enable data collection from a much larger group of patients we have designed and constructed three portable devices that will be available for use in three of Melbourne’s major hospitals in the coming year. These devices have been designed to be used in patients prior to surgical treatment of their epilepsy. The devices will provide seizure anticipation, detection, and stimulation functions via a connection to electrode arrays implanted on the surface of the brain. In anticipation of the large volume of data that will be collected from these portable devices, we have been developing computer systems capable of automatically labelling seizure activity in EEG recordings.

In parallel with the development of these portable devices, we have been verifying the effectiveness of the seizure detection and suppression algorithms. An algorithm has been developed that uses each newly acquired seizure to update the criteria that determine what is and is not classified as an epileptic discharge. The performance of this algorithm was superior to that of commercially available detection software that was applied to the same dataset.

This research is funded by the NH&MRC, Jack and Robert Smorgon Families Foundation, Annie Banks Trust, and the Pierce Armstrong Foundation. The team includes Mr Kyle Slater, Mr Tim Nelson, Dr Alan Lai, Dr Dean Freestone, Prof Peter Blamey, Prof Hugh McDermott, A/Prof Chris Williams, Prof Mark Cook (St Vincent’s Hospital Melbourne), Prof Anthony Burkitt (University of Melbourne) and A/Prof David Grayden (University of Melbourne).

Deep brain stimulation for movement disorders, psychiatric disorders, and pain alleviation

Deep Brain Stimulation

Deep brain stimulation (DBS) is emerging as a safe and effective treatment for people with a range of serious disorders that do not respond adequately to established therapies. Over the next few years, together with collaborators and clinical partners, the Institute aims to develop a complete DBS system to treat disorders of the central nervous system for which no other effective therapies are available, including movement disorders (e.g. Parkinson Disease and essential tremor), certain severe psychiatric conditions (e.g. obsessive-compulsive disorder and chronic depression), and severe chronic pain.

DBS delivers electrical pulses via implanted electrodes to selected brain structures. Although the neurophysiological mechanisms underlying effective DBS treatment are not understood in detail at present, previous research has shown that precise electrode positioning and optimised selection of the stimulation parameters are important to obtain the greatest benefit with minimal side-effects for each patient.

Optimising stimulation parameters and improving clinical benefit

We are conducting a series of studies with existing DBS users to optimise the electrical settings of the devices. Participants in the initial study have been adults diagnosed with essential tremor, a disabling movement disorder that is frequently difficult to treat. For each DBS recipient, we have determined the electrical parameter values that produce the best outcomes in terms of symptom reduction while avoiding or minimising any problems related to the stimulation. The results of this initial study are currently being analysed. Parameters that are being investigated include the intensity and pulse rate of stimulation, and the selection of the active electrodes. The effects of adjusting these parameters were assessed by a combination of subjective measures (such as questionnaires and observations) and objective measures. The latter includes measures of limb movement and acoustic voice characteristics. Evaluating the effects of DBS on voice quality is an innovative strategy, because although clinical experience suggests that excessive stimulation can sometimes adversely affect speech production, we are unaware of any published studies reporting on a systematic investigation of this outcome.

We have also obtained extensive measurements from patients with Parkinson’s disease who use an existing DBS stimulator. These data are being analysed in collaboration with one of the Institute's Honorary Clinical Research Fellows from the Royal Melbourne Hospital.

The results of these studies will provide an essential database for developing the most effective treatment strategies for each DBS user. They will also contribute to a greater understanding of how and why positive therapeutic results may be obtained with DBS more generally. Our work will establish an evidence-based relationship between the brain stimulation parameters that are under control of the device and patient outcomes. Knowing this relationship will ensure that the design of our innovative implantable stimulator for DBS will be based on strong objective data.

The next stages of our research are: (i) the development and testing of prototype electrode arrays and innovative tools for the precise and safe positioning of electrodes in appropriately targeted regions of the brain; and (ii) development of innovative stimulation techniques that maximise therapeutic effectiveness while minimising potential adverse side-effects.
Over the past year we have built the team of engineers and clinicians that together will devise these innovative electrodes, implantation systems, and stimulators.

**Treating Obsessive-compulsive disorder**

In a collaborative study together with a team of our Honorary Clinical Research Fellows, we plan to treat a small group of subjects with refractory obsessive-compulsive disorder (OCD). This disorder is characterised by disabling thoughts and behaviours that can be difficult to manage or eradicate. Conventional treatments rarely alleviate symptoms completely, and about 30 per cent of patients remain refractory to treatment. A small group of subjects will be implanted with commercially available DBS devices and outcomes will be assessed using established subjective and objective measures. The study will include systematic adjustments of the DBS device to determine optimal stimulation parameter settings for each participant. In addition, these patients will undergo state-of-the-art imaging techniques to better elucidate the mechanism of action of both the condition and the DBS treatment. Results from this study will contribute to the design of innovative electrodes and optimised stimulators for future DBS devices.

This research is funded by the Colonial Foundation, Helen Macpherson Smith Trust, Rebecca L. Cooper Medical Research Fund, and the St Vincent’s Hospital Melbourne Research Endowment Fund. The team includes Prof Hugh McDermott, Prof Colette McKay, Prof Rob Shepherd, A/Prof Chris Williams, Dr Leigh McKinlay, Mr Joel Villalobos, Mrs Alexia Saunders, Mr Kyle Slater, and Mr Thushara Perera. The Honorary Clinical Research Fellows involved are Dr Richard Peppard (Precision Neurosurgery), Prof Richard Bittar (Precision Neurosurgery), Dr Adam Vogel (University of Melbourne), Dr Andrew Evans (Flemington Neurology), Dr Wes Thevathasan (Royal Melbourne Hospital), Prof David Castle (St Vincent’s Mental Health), A/Prof James O’Ler (Austin Health), Dr Peter Bosanac (St Vincent’s Mental Health), Mr Peter McNeill (St Vincent’s Hospital Melbourne), Prof Susan Rossell (Swinburne University) and Prof Mark Cook (St Vincent’s Hospital Melbourne).

There are treatments available but they have a number of problems including infection, urinary retention, and incomplete benefit. The Bionics Institute is bringing its expertise in electrode development and design, as well as our knowledge of stimulation strategies that produce the best outcomes, to a collaborative project led by Charles Sturt University and including the University of Melbourne and Neosphincter Technologies Pty Ltd. This project is aimed at developing a new treatment for severe stress urinary incontinence and will perform preclinical studies aimed at proof of concept for an implantable device. The role of the Institute in this project is to design, construct, and supply electrodes and stimulators.

This research is funded by the Australian Research Council (Linkage Project). The team includes Prof Peter Blamey, Mr Joel Villalobos, Mr Mark Harrison, A/Prof Glenn Edwards (Charles Sturt University), A/Prof James Brock (University of Melbourne), Dr Christine Hirst (Neosphincter Pty Ltd), and Dr Helen O’Connell (Royal Melbourne Hospital).

**Treating urinary incontinence**

Stress urinary incontinence refers to a weakening of the muscles that support the bladder, and related structures, so that any extra muscular pressure (such as occurs when laughing, coughing or sneezing) causes urine to be released. This type of incontinence is most common in women and the elderly, and in severe cases can cause considerable distress and disruption to peoples’ lives.

“Our work will establish an evidence-based relationship between the brain stimulation parameters that are under control of the device and patient outcomes. Knowing this relationship will ensure that the design of our innovative implantable stimulator for DBS will be based on strong objective data.”
Commercialising our Research

The Institute is 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 industry development and new skills.

Due to the scale, scope and multidisciplinary approach needed to achieve these goals, a high level of scientific, operational and commercial acumen across a number of laboratories, hospitals and industry partners is required. The Bionics Institute has the relationships, policies, structures and right people in place to effectively manage this constant ‘innovation loop’ between researchers, clinicians and industry.

Our staff work closely with our collaborators, partners and other stakeholders to develop strong relationships. We negotiate formal arrangements where required to ensure clarity of roles and responsibilities, intellectual property (IP) title and a well-defined commercial pathway.

Over the last year, the Institute has made substantial progress towards achieving its strategic commercial objectives. These objectives include a greater emphasis on growing investment and commercial funding for research, and achieving commercial and clinical outcomes from the Institute’s translational and basic research activities in each of the three key programs: Neurobionics, Bionic Hearing, and Bionic Vision.

The Institute has a commercial pathway for each of its research programs

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<tr>
<th>Biology</th>
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<td>Bionic Ear Institute research since 1986</td>
<td>Preclinical studies led by Rob Shepherd</td>
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<td>Bionic Vision Australia $42m 2010–2013</td>
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<td>Cochlear</td>
<td>Bionic Vision Technologies</td>
<td>Bionic Enterprises</td>
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Intellectual Property and Commercialisation

Commercialising our Research
**Neurobionics**

The goal of the Institute's Neurobionics program is to translate cochlear implant and other technologies into complete clinical solutions for chronic conditions of the central nervous system (CNS) that otherwise have no treatments. Bionic Enterprises, a newly established business arm of the Institute, will provide the commercial pathway for this program by taking neurobionic devices for the treatment of epilepsy and a deep brain stimulation implant to treat other CNS disorders into early clinical trials within the next five years.

The Institute now has seven patent applications in the Neurobionics field, including filings in the epilepsy and more general neurostimulation areas.

**Bionic Vision**

Together with our clinical partners, the Institute has played a pivotal role in the development, regulatory approval and clinical translation of the early prototype device in the Bionic Vision program. As a core party of Bionic Vision Australia (BVA), the Institute will continue to provide research, intellectual property and commercial expertise in order to achieve BVA's aims to provide proof of concept for two bionic eye products – the wide-view and the high-acuity devices. The Institute has filed thirteen bionic eye patent applications in this area alone.

**Bionic Hearing**

The Institute continues to build further on the strong base of collaboration and partnership with Cochlear Ltd. Several contracts, spanning a range of hearing-related manufacturing and R&D projects have either been completed, are underway or under discussion. Cochlear Ltd has sold over 250,000 cochlear implants.

The Institute has 28 individual patent applications in the Bionic Hearing field.

**PolyActiva Pty Ltd**

The spin-off company PolyActiva Pty Ltd was established in February 2009 to commercialise a drug-polymer conjugate technology that arose from Bionic Technologies Australia. PolyActiva has been successful in raising substantial capital towards developing new ocular implant technology for global markets. PolyActiva is one of four companies either spun out and/or incubated by the Institute since 2000. The others are Wolfson Dynamic Hearing, Blamey & Saunders Hearing, and Bionic Enterprises.

**Patent applications and commercial pathways**

An increased rate of new inventions and patent applications has been established across all program areas, with the assistance of FB Rice as our patent attorneys. Over the past year, the number of patent families have increased from 15 to 20 with the total number of patent applications increasing from 37 to 55.
**Bionic Enterprises**

Bionic Enterprises (BE), an initiative of the Bionics Institute, is a company that will integrate innovative technologies and reduce the cost of medical device development. The company will access a broad range of existing intellectual property, technology and manufacturing know-how to produce a versatile medical bionics platform with multiple applications. Linda Peterson has been appointed CEO, Peter Blamey as CTO and Tim Griffiths is the sole Director.

The company will take each device through preclinical studies and early development to a working implantable prototype. Each of these application-specific devices will then be taken through clinical trials and into global markets by subsidiary companies. BE aims to bring six neurobionic devices to early stage clinical trial within the next 3 to 5 years. These are:

1. A device for the diagnosis and treatment of epilepsy in a hospital setting
2. A pain alleviation device for short-term use with palliative care patients
3. A pain alleviation device for long-term use
4. An implantable deep brain stimulation (DBS) device for the treatment of movement disorders
5. An implantable DBS device for the treatment of obsessive-compulsive disorder
6. An implantable device for the detection and suppression of epileptic seizures

Each of the conditions listed above has a clearly identified clinical need and a sizeable target market in Australia, America and Europe. There are also emerging markets in China and India.
As part of its commitment to training the next generation of researchers, staff at the Bionics Institute continued to supervise a number of students in 2011-2012. More information about student projects can be found on our website: www.bionicsinstitute.org

**PhD Students**

A number of students are undertaking their PhD studies at the Bionics Institute in collaboration with enrolling Universities. Students enrolled in 2011–2012 include:

- **Patrick Atkinson** – Gene therapy for the preservation and regeneration of spiral ganglion neurons and hair cells after deafness  
  Dept of Otolaryngology, The University of Melbourne. Supervisors: Dr Rachael Richardson; Dr Andrew Wise; Dr Bryony Nayagam (Garnett Passe and Rodney Williams Memorial Foundation Research Scholarship).

- **Yuri Benovitski** – New methods for evaluating performance of neuroprostheses  
  School of Engineering and Mathematical Sciences, Latrobe University. Supervisors: Prof Peter Blamey; Dr James Fallon; Mr Graeme Rathbone; Dr David Tay (Latrobe University Postgraduate Research Scholarship).

- **Rosemary Cicione** – Bionic eye: Neuronal modelling for the human visual system  
  School of Engineering and Mathematical Sciences, La Trobe University. Supervisors: A/Prof Chris Williams; Dr Mohit Shivdasani; Mr Graeme Rathbone (La Trobe University Postgraduate Research Scholarship).

- **Sam John** – Bionic eye: Effects of varying temporal properties of electrical stimulation using suprachoroidal visual prostheses  
  School of Engineering and Mathematical Sciences, La Trobe University. Supervisors: A/Prof Chris Williams; Mr Graeme Rathbone; Dr James Fallon (La Trobe University Postgraduate Research Scholarship).

- **Ronald Leung** – The removability and replacement of a bionic eye  
  Department of Pathology, The University of Melbourne. Supervisors: Prof Rob Shepherd; A/Prof Richard Williams; A/Prof Chris Williams; Dr David Nayagam (Australian Postgraduate Award (Industry)).

- **Mohammad Maarefvand** – Improving music perception in bimodal cochlear implant users  
  Dept of Otolaryngology, The University of Melbourne. Supervisors: Prof Peter Blamey; Dr Jeremy Morozeau; Dr Julia Sarant.

- **David Perry** – Plastic reorganisation of the central auditory pathway with cochlear implant use  
  Dept of Otolaryngology, The University of Melbourne. Supervisors: Dr James Fallon; Prof Rob Shepherd; Prof Hugh McDermott (Melbourne Research Scholarship).

- **Philipp Senn** – Peripheral nerve stimulation for the treatment of chronic neuropathic pain  
  Dept of Chemical & Biomolecular Engineering, The University of Melbourne. Supervisors: Prof Rob Shepherd; Dr James Fallon; Prof Frank Caruso.

- **Kyle Slater** – A novel system for the treatment of epilepsy and other neurological disorders  
  Department of Electrical and Electronic Engineering, The University of Melbourne. Supervisors: Prof Hugh McDermott; Prof Mark Cook; Prof Stan Skafidas; A/Prof David Grayden

- **Joel Villalobos** – Bionic eye: Electrode tissue interface and chronic implantation  
  Dept of Otolaryngology, The University of Melbourne. Supervisors: A/Prof Chris Williams; Dr James Fallon; Dr Hamish Meffin (Endeavour International Postgraduate Research Scholarship/Melbourne International Research Scholarship; National ICT Australia Scholarship (top-up); Fundacion GCC scholarship Mexico).
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Richard Balson – Adaptive electrical stimulation of the brain for the treatment of epilepsy
Dept of Electrical and Electronic Engineering, The University of Melbourne. Supervisors: A/Prof David Grayden; Prof Tony Burkitt; Prof Mark Cook; Prof Peter Blamey (Australian Postgraduate Award (Industry)).

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Dept of Otolaryngology, The University of Melbourne. Supervisors: Prof Peter Blamey; Dr Jeremy Marozeau; Dr Julia Sarant.
For our devices to provide the best possible health outcomes and to bring them to market in the most time-effective fashion we have established links with eminent clinicians from Melbourne’s major hospitals and several interstate and overseas institutions. These Honorary Clinical Research Fellows provide a strong clinical base to our scientific and engineering expertise.

The Chairman of the Institute’s Honorary Clinical Research Fellows is Professor Mark Cook, neurologist and epilepsy expert, Chair of Medicine at the University of Melbourne and Director of Neurosciences at St Vincent’s Hospital Melbourne.

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<tr>
<td>Prof Richard Bittar</td>
<td>Royal Melbourne Hospital, Precision Neurosurgery</td>
</tr>
<tr>
<td>A/Prof Robert Briggs</td>
<td>University of Melbourne, Royal Victorian Eye and Ear Hospital, Royal Melbourne Hospital</td>
</tr>
<tr>
<td>Dr Kristian Bulluss</td>
<td>St Vincent’s Hospital Melbourne</td>
</tr>
<tr>
<td>Prof David Castle</td>
<td>St Vincent’s Hospital Melbourne (Mental Health)</td>
</tr>
<tr>
<td>Dr Wendyl D’Souza</td>
<td>St Vincent’s Hospital Melbourne</td>
</tr>
<tr>
<td>Dr Marcus Dahm</td>
<td>The Royal Children’s Hospital Melbourne</td>
</tr>
<tr>
<td>Prof Damiaan Denys</td>
<td>University of Amsterdam, Netherlands</td>
</tr>
<tr>
<td>Prof Richard Dowell</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>Dr Andrew Evans</td>
<td>Flemington Neurology</td>
</tr>
<tr>
<td>Prof Robyn Gwymer</td>
<td>Royal Victorian Eye and Ear Hospital</td>
</tr>
<tr>
<td>Prof Andres Lozano</td>
<td>University of Toronto, Canada</td>
</tr>
<tr>
<td>A/Prof Michael Murphy</td>
<td>St Vincent’s Hospital Melbourne</td>
</tr>
<tr>
<td>Prof Terence O’Brien</td>
<td>Royal Melbourne Hospital</td>
</tr>
<tr>
<td>Dr Helen O’Connell</td>
<td>Royal Melbourne Hospital</td>
</tr>
<tr>
<td>Prof Stephen O’Leary</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>Prof James Olver</td>
<td>Austin Hospital, University of Melbourne</td>
</tr>
<tr>
<td>Dr Richard Peppard</td>
<td>St Vincent’s Hospital Melbourne, Precision Neurosurgery</td>
</tr>
<tr>
<td>A/Prof Gary Rance</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>Prof Jeffrey Rosenfeld</td>
<td>Alfred Hospital, Monash University</td>
</tr>
<tr>
<td>Prof Susan Rossell</td>
<td>Swinburne University</td>
</tr>
<tr>
<td>Prof Simon Shorvon</td>
<td>University College London, UK</td>
</tr>
<tr>
<td>Dr Richard Sullivan</td>
<td>Peter MacCallum Cancer Centre, Precision Spine and Pain Clinic</td>
</tr>
<tr>
<td>Dr Wesley Thevathasan</td>
<td>Royal Melbourne Hospital</td>
</tr>
<tr>
<td>Dr Michael Tykocinski</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>Dr Adam Vogel</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>Dr Ben Wei</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>Dr Robert Wilke</td>
<td>University of New South Wales</td>
</tr>
<tr>
<td>Prof Jonathon Yeoh</td>
<td>New Vision Clinics</td>
</tr>
</tbody>
</table>
### Book Chapters


### Journal Articles


## Journal Articles

### In Press


3rd International Conference on Neuroprosthetic Devices – Sydney, Australia – November 2011
Wise A. Drug delivery to the cochlea. Invited presentation

2011 UWS Sensory Neuroscience Symposium - University of Western Sydney - November 2011
Shivdasani M. Suprachoroidal electrical stimulation of the retina – lessons learnt from acute experiments. Invited presentation

2nd International Conference on Medical Bionics – Phillip Island, Australia – November 2011


Blamey P. Pathway to market for medical bionics devices.


Fallon J, Irvine D. Brain plasticity and its role in medical bionics.

Innes-Brown H, Marozeau J, Blamey P. The effect of visual cues on musical stream segregation in listeners with impaired hearing.


Marozeau J, Innes-Brown H, Blamey P. Improving music perception in cochlear implant recipients by enhancing auditory stream cues.

Merozeau J, Maarefvand M, Blamey P. Some cochlear implant recipients can perceive music better than normal hearing listeners: A case study.

McDermott H. Improved sound processing for users of auditory implants. Invited presentation

Pettingill LN, Wise AK, Geaney MS and Shepherd RK. Enhanced auditory neuron survival following cell-based BDNF treatment in the deaf guinea pig.


Annual Conference of the Chinese Audiology and ENT Societies. Tianjin, China, October 2011
McKay CM. Advances in cochlear implants and central auditory implants. Invited presentation

Inner Ear Biology – Lisbon, Portugal – September 2011

Conference Presentations

Conference on Implantable Auditory Prostheses, Pacific Grove, USA – July 2011
Fallon J. Plasticity of the primary auditory cortex: Effects of long-term deafness and chronic intracochlear stimulation.


Merozeau J, Maarefvand M, Blamey P. Some cochlear implant recipients can perceive music better than normal hearing listeners: A case study.

McDermott H. Improved sound processing for users of auditory implants. Invited presentation

Pettingill LN, Wise AK, Geaney MS and Shepherd RK. Enhanced auditory neuron survival following cell-based BDNF treatment in the deaf guinea pig.


Annual Conference of the Chinese Audiology and ENT Societies. Tianjin, China, October 2011
McKay CM. Advances in cochlear implants and central auditory implants. Invited presentation

Inner Ear Biology – Lisbon, Portugal – September 2011

Seligman P. A hybrid current/voltage driven stimulator for prosthetic devices.


Sergee E, Meffin H, Tayahori B, Burkitt A, Graydent D, Shivdasani M, Williams C. The reduction of thresholds when stimulating the retina with electrodes simultaneously is explained by current spread.


Slater K, Sinclair N, McDermott H, Blamey P. An arbitrarily configurable, high compliance voltage neural stimulator with scalable architecture.


Vasnavsky A, Grayden D, McDermott H. Physiologically-based neural models of the cochlea can predict psychophysical measures of loudness perception.


Wise A, Pettingill L. Drug delivery to the inner ear.

Australian Neuroscience Society Conference, Gold Coast, Australia, Jan 2012

Atkinson P, Wise AK, Flynn BO, Nayagam BA, Hume CR, O’Leary SJ, Shepherd RK, Richardson, RT. Gene therapy after hearing loss for long-term neural protection. winner of the Sir Grafton Elliot-Smith Award for best student poster

Fallon J, Irvine DFR, Irving S, Shepherd RK. Chronic multi-unit recording from cat auditory cortex.


Thirty-Fourth Annual Midwinter Research Meeting of the Association for Research in Otalaryngology, San Diego, CA., Feb 2012


Benovitski YB, Fallon JB, Blamey PJ, Rathbone GD. A new method for determining frequency discrimination in cats with different hearing profiles. invited speaker

Fallon JB, Irvine DFR, Irving S, Shepherd, RK. Chronic multi-unit recording from cat auditory cortex.

White MW, Heffer LF, Fallon JB, Sly DJ, Shepherd RK, O’Leary SJ. The slopes of auditory nerve input-output functions decrease as stimulus pulse rate is increased – for spike-rates less than 100 spikes/second.

11th Congrès Français d’Acoustique, Nantes, France, April 2012

Marozeau JM, Innes-Brown H. Creating new musical rules for listeners with a cochlear implant.

ARVO, 2012, Fort Lauderdale, Florida, May 2012

John S. Cortical responses to repetitive electrical stimulation of the retina using suprachoroidal visual prostheses.

Nayagam D. A pre-clinical model for chronic electrical stimulation of the retina via suprachoroidal electrodes.

Shivdasani M. Spatiotemporal interactions using paired electrical stimulation of the retina with a clinical grade implant.

AusMedTech Sydney, May 2012

Shepherd R. Building a Bionic Eye. invited speaker

TEDx, Woollongong, May 2012

Shepherd R. Building a Bionic Eye. invited speaker

ASMR Victorian Student Research Symposium Melbourne, Australia, June 2012


40th Neural Interfaces Conference, Salt Lake City, Utah, June 2012


Supporting our Research

The corporate and support services of the Institute provide timely, accurate and quality assistance to our researchers, enabling them to maximise their potential to create solutions that will improve the quality of life for people with profound disabilities and chronic diseases.
Business Planning

Planning and business reviews are regularly undertaken by the team. The aim is to provide accurate forecasts to the Executive and Board of the potential resource needs of the organisation over the near and longer terms. Through a defined growth phase, particularly within the neurobionics research program, it is critical that we anticipate and plan for the resources required.

Human Resources and Organisational Development

Human Resources continue to focus on the important function of co-ordinating and managing the retention and expansion of our team in order to maintain a high level of research skills and administrative support. We particularly work on attracting bright and capable students to the Institute to foster their interest and skills in the development of medical bionic devices with the hope that we retain or collaborate with them in the future.

Occupational Health and Safety

Managing and promoting safe practices in our growing workplace is a major goal. The OH&S Advisory Committee, which represents all areas of the Institute, meets regularly to ensure that the health and safety of our staff, students and visitors are paramount.

The Calvert-Jones Library

The Library provides a personalised reference service for staff and students using the Bionics Institute library collection and external sources. The Institute collection includes books, reports, conference proceedings and journals, and covers disciplines such as biomedical engineering, neuroscience and audiology.

The Intranet (BLink) and Research Portal were launched in December 2011, with the library playing a key role in management and training in SharePoint.

Research Office

A large portion of researchers’ funds comes from competitive, peer-reviewed grant applications to funding bodies such as the National Health and Medical Research Council (NH&MRC). The Institute’s Research Office provides support to our scientists and engineers by assisting with the preparation and submission of these grant applications. Additionally, the office manages the ongoing administration of all grants which includes scientific and financial reporting.

The office is also responsible for laboratory coordination, managing licences and compliance matters related to research and completing government surveys related to research activities. During the past year this included compiling the documentation required for continued accreditation as an NH&MRC administering institution.

Information Technology

The IT team continued to provide reliable, innovative and dynamic technologies to support our research effort. Over the past 12 months the group implemented IT infrastructure and data storage upgrades to accommodate the increase in research data generated within the Institute.

Public Relations and Fundraising

Building the Bionics Institute brand through public relations and fundraising activities has been a major focus of this year. Substantial media exposure has helped generate further interest in the Institute and its work. This in turn directly correlated with an increase in fundraising revenue.

Finance

The finance team provided valuable support to the organisation through financial and regulatory systems, procedures, policies and guidance, as well as risk management. The finance team are highly regarded for their rigor and are central to the decision making process.

Governance and Risk Management

The Institute is committed to ensuring that the Board is provided with relevant information so it can exercise its governance responsibilities. The corporate team ensures that appropriate operational practices, policies and procedures are in place that underpin the effective and efficient governance of the Institute.

The corporate team ensures that risk management is an integral part of the Institute’s operations and that reporting mechanisms are in place to review, confirm, change and report on compliance to the Board.

By having effective governance and operational mechanisms, the Institute ensures appropriate stewardship over the organisation’s assets.

I would like to thank the corporate staff for their efforts over a particularly busy year; as administrators they are as passionate about the Institute’s work and vision as our researchers.

Tim Griffiths
General Manager & Company Secretary
Board Members

Mr Gerald Edward Moriarty AM, BEng (Hons), FTSE, FIEAust, FAICD
Chairman

Mr Jack Smorgon AO
Advanced Management Diploma
Vice-Chairman (until November 2011)

Mr John Bryson
BEng (Mech), MBA (Melb), Visiting Fellow MIT – Sloan Business School (1999), Harvard University – Executive Courses (1999), MAICD

Professor James McCluskey
BMedSci, MBBS, MD, FRACP, FRCPA, FAA

Executive Officers

Professor Robert Shepherd
BSc, DipEd, PhD
Director

Professor Peter Blamey
BSc (Hons), PhD
Deputy Director (IP and Commercialisation)
**Director**
Professor Robert Shepherd  
BSc DipEd PhD

**Deputy Director (IP & Commercialisation)**
Professor Peter Blamey  
BSc(Hons) PhD GAICD

**Deputy Director (Research)**
Professor Hugh McDermott  
BAppSc PhD

**General Manager and Company Secretary**
Mr Tim Griffiths  
BBus GradCertExport  
GradDip (MarLogMgt) MBT

**Chief Financial Officer**
Mr Peter Gover  
BCompt(Hons) CA CPA ICAA

**Executive Manager**
Ms Linda Peterson  
BSc GradCertBusAdm

**Senior Scientific Mentors**
Professor Dexter Irvine  
BA(Hons) PhD FASSA  
Professor Peter Seligman  
BEng PhD

**Professorial Research Fellows**
Professor Colette McKay  
BSc(Hons) GradDip Audiology PhD

**Research Fellows**
A/Prof Chis Williams  
BSc MSc(Hons) PhD

**Research Engineers**
Mr Owen Burns  
BEng

**Research Support Officer to the Deputy Directors**
Dr Leigh McKinlay  
BSc(Hons) PhD

<table>
<thead>
<tr>
<th>Position</th>
<th>Name</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>Professor Robert Shepherd</td>
<td>BSc DipEd PhD</td>
</tr>
<tr>
<td>Deputy Director (IP &amp; Commercialisation)</td>
<td>Professor Peter Blamey</td>
<td>BSc(Hons) PhD GAICD</td>
</tr>
<tr>
<td>Deputy Director (Research)</td>
<td>Professor Hugh McDermott</td>
<td>BAppSc PhD</td>
</tr>
<tr>
<td>General Manager and Company Secretary</td>
<td>Mr Tim Griffiths</td>
<td>BBus GradCertExport GradDip (MarLogMgt) MBT</td>
</tr>
<tr>
<td>Chief Financial Officer</td>
<td>Mr Peter Gover</td>
<td>BCompt(Hons) CA CPA ICAA</td>
</tr>
<tr>
<td>Executive Manager</td>
<td>Ms Linda Peterson</td>
<td>BSc GradCertBusAdm</td>
</tr>
<tr>
<td>Senior Scientific Mentors</td>
<td>Professor Dexter Irvine</td>
<td>BA(Hons) PhD FASSA</td>
</tr>
<tr>
<td></td>
<td>Professor Peter Seligman</td>
<td>BEng PhD</td>
</tr>
<tr>
<td>Professorial Research Fellows</td>
<td>Professor Colette McKay</td>
<td>BSc(Hons) GradDip Audiology PhD</td>
</tr>
<tr>
<td>Research Fellows</td>
<td>A/Prof Chis Williams</td>
<td>BSc MSc(Hons) PhD</td>
</tr>
<tr>
<td>Research Engineers</td>
<td>Mr Owen Burns</td>
<td>BEng</td>
</tr>
<tr>
<td>Research Support Officer to the Deputy Directors</td>
<td>Dr Leigh McKinlay</td>
<td>BSc(Hons) PhD</td>
</tr>
<tr>
<td>Visiting Research Fellows</td>
<td>Professor Remy Pujol</td>
<td>PhD Emeritus Professor University of Montpellier</td>
</tr>
<tr>
<td>Visiting Researchers</td>
<td>Dr Diane Lazard</td>
<td>ENT surgeon Paris, France</td>
</tr>
<tr>
<td>Research Grants and Student Co-ordinator</td>
<td>Ms Anne Coco</td>
<td>BSc(Hons)</td>
</tr>
</tbody>
</table>

Mr Tim Nelson  
BSc BEng (Hons)  
(From December 2011)

Mr Thushara Perera  
BEng MBiomedEng(Hons)  
(From March 2012)

Mr Nicholas Sinclair  
BEng(Hons) BSc

Mr Kyle Slater  
BEng BSc  
(From December 2011)

Mr Andrew Vandali  
BEng

Mr Joel Villalobos  
BScElecSystemsEng  
(From March 2012)

Dr James Fallon  
BEng(Hons) BSc PhD

Dr Tom Francart  
MSc PhD  
(until April 2012)

Dr Sam Irving  
MNeuosci PhD

Dr Jeremy Marozeau  
BSc MSc PhD

Dr David Nayagam  
BSc/Eng(Hons) PhD

Dr Lisa Pettingill  
BSc(Hons) PhD

Dr Rachael Richardson  
BSc(Hons) PhD

Dr Mohit Shivdasani  
MEng(BioMed) PhD

Dr Justin Tan  
BSc(Hons) DipEd MSc PhD

Dr Andrew Wise  
BSc(Hons) PhD

Dr Jin Xu  
MD MMed DipRad MIR

Dr Mark Zanin  
BSc(Hons) PhD  
(until January 2012)

Ms Anne Coco  
BSc(Hons)
Laboratory Co-ordinator
Ms Rebecca Argent
BSc

Research Assistants
Ms Nicole Critch
Dip Animal Tech
Ms Alison Evans
BSc (Hons)
Ms Brianna Flynn
BSc (Hons)
DiplLabTech(BioTech)
Mr Hamish Innes-Brown
BCogSc(Hons)
Dr Alan Lai
MEngSc(BiomedEng) PhD
Ms Ceara McGowan
BBiomedSc(Hons)
(from July 2011)
Ms Michelle McPhedran
BBioSc
Ms Amy Morley
BSc(Hons) MSc
Mrs Alexia Saunders (nee Freemantle)
BAppSc(Hons)

Technical Assistant
Ms Vanessa Maxim
BBehavSc AdDipEngTech
(from October 2011)

PhD Students
Patrick Atkinson
PhD (Uni of Melb)
Richard Balson
PhD (Uni of Melb)
Yuri Benovitski
PhD (LaTrobe Uni)
Rosemary Cicione
PhD (LaTrobe Uni)
Sam John
PhD (LaTrobe Uni)
Ronald Leung
PhD (Uni of Melb)
Mohammad Maarefvand
PhD (Uni of Melb)
David Perry
PhD (Uni of Melb)
Philipp Senn
PhD (Uni of Melb)
Kyle Slater
PhD (Uni of Melb)
Joel Villalobos
PhD (Uni of Melb)

International Students
Nicholas Vannson
MAudio candidate (Uni of Montpellier)
Marion David
MACoustics-Eng candidate (Uni of Poitiers)
Austin Mueller
MSciEng candidate (Swiss Federal Institute of Technology, Lausanne)
Melanie Gault
Internship, Whitaker International Fellow, (Vanderbilt Uni, USA)

Undergraduate Students
Luke McGeorge
BEng candidate (LaTrobe Uni)
Samantha Hall
BEng candidate (LaTrobe Uni)
Rowan Habel
BBiomedEng candidate (Uni of Melb)
Jess Mewing
BBiomedEng candidate (Uni of Melb)

Information Technology Manager
Mr Stas Surowiecki
DipNetEng & MCP

Information Technology Officer
Mr Andrew Purnama
BAppSci (IT)

Human Resources Manager
Ms Susanne Clarke
BA(Psych)

Public Relations & Fundraising Manager
Mrs Glenis Cook
(until September 2011)
Mr Robert Hilkes
BA GradDipPR
(from September 2011)

Research Communications Officer
Dr Janine Clarey
BSc(Hons) PhD

Executive Assistant to the Director
Ms Berenice Hale

Administrative Staff
Ms Olivera Krstevski
BEC CA
Mr Anthony McGregor
BComm
Ms Rosie Marsicovetere
Adv Dip Accounting

Trusts and Foundations Officer

Information Resources Officer
Ms Aimee Clague
B InfoMgt

Receptionist
Mrs Karen Campitelli

Honorary Institute Fellow
Dr Lindsay Aitkin

Principal Honorary Research Fellows
Professor Anthony Burkitt
A/Prof David Grayden
A/Prof Jim Patrick
Professor Stephen Prawer
Professor David Ryugo
Professor Gordon Wallace

Honorary Research Fellows
Dr Tong Yit Chow
Dr Tom Francart
Dr Bryony Nayagam
Mr Graeme Rathbone
Dr Natalie Rickard
Summarised Financial Report

**Income**
- Federal Government 45%
- Other Income 9%
- Investment Income 14%
- Victorian State Government 5%
- Contract and commercialisation 5%
- Non-government grants and donations 10%
- Overseas grants and fellowships 14%

**Expenses**
- Administration 13%
- Building & facilities 4%
- Business development 3%
- Fundraising 2%
- Research support 9%
- Direct research 70%
## Summarised Financial Report

### The year at a glance

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. This accounting standard on contributions requires that the Institute recognise contributions when the entity obtains control of the contribution. The current interpretation of this standard requires that grants be recognised as income when the Institute receives the applicable funds. This is irrespective of when the funds are consumed, or whether the Institute has met its obligations in accordance with applicable agreements.

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

### CONSOLIDATED INCOME STATEMENT

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REVENUE FOR ORDINARY ACTIVITIES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant Income</td>
<td>5,269,294</td>
<td>3,843,209</td>
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<tr>
<td>Fundraising activities</td>
<td>232,241</td>
<td>211,961</td>
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<tr>
<td>Contract research and commercialisation income</td>
<td>364,266</td>
<td>261,414</td>
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<tr>
<td>Investment &amp; interest income</td>
<td>1,025,658</td>
<td>1,030,805</td>
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<tr>
<td>Realised foreign exchange gains</td>
<td>-</td>
<td>32,611</td>
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<tr>
<td>Other revenue</td>
<td>659,404</td>
<td>177,232</td>
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<tr>
<td><strong>Total revenue for ordinary activities</strong></td>
<td>7,550,863</td>
<td>5,557,232</td>
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<table>
<thead>
<tr>
<th></th>
<th>2012</th>
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<tbody>
<tr>
<td><strong>EXPENDITURE ON RESEARCH ACTIVITIES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee benefits expense</td>
<td>(4,867,844)</td>
<td>(4,151,768)</td>
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<tr>
<td>Consultant fees</td>
<td>(138,343 )</td>
<td>(146,617  )</td>
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<tr>
<td>Conference events expenses</td>
<td>(164,125)</td>
<td>-</td>
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<tr>
<td>Property and facilities expenses</td>
<td>(262,102)</td>
<td>(265,037)</td>
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<tr>
<td>Depreciation and amortisation expense</td>
<td>(581,432)</td>
<td>(492,072)</td>
</tr>
<tr>
<td>Fundraising activities</td>
<td>(51,901)</td>
<td>(39,791)</td>
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<tr>
<td>Research consumables</td>
<td>(1,049,620)</td>
<td>(543,123)</td>
</tr>
<tr>
<td>Research contributions to collaborators</td>
<td>(60,000)</td>
<td>(41,132)</td>
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<tr>
<td>Intellectual property and legal expenses</td>
<td>(145,435)</td>
<td>(144,720)</td>
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<tr>
<td>Interest paid</td>
<td>(1,246)</td>
<td>(1,763)</td>
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<tr>
<td>Other expenses from continuing operations</td>
<td>(477,646)</td>
<td>(394,387)</td>
</tr>
<tr>
<td><strong>Total expenditure on ordinary activities</strong></td>
<td>(7,799,694)</td>
<td>(6,220,410)</td>
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<table>
<thead>
<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td><strong>DEFICIT ON ORDINARY ACTIVITIES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Loss)/gain on sale of available-for-sale financial assets</td>
<td>(83,298)</td>
<td>413,888</td>
</tr>
<tr>
<td>Unrealised foreign exchange (loss)/gain</td>
<td>(182,019)</td>
<td>186,119</td>
</tr>
<tr>
<td>Impairment write down of available-for-sale financial assets</td>
<td>-</td>
<td>(71,602)</td>
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<tr>
<td><strong>NET (DEFICIT)</strong></td>
<td>(514,148)</td>
<td>(134,773)</td>
</tr>
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</table>
# Summarised Financial Report

## Consolidated Statement of Financial Position

for the year ended 30 June 2012

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
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<tr>
<td><strong>Current Assets</strong></td>
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</tr>
<tr>
<td>Cash assets</td>
<td>4,627,920</td>
<td>5,609,121</td>
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<tr>
<td>Receivables</td>
<td>1,706,531</td>
<td>1,856,856</td>
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<tr>
<td>Prepayments</td>
<td>42,271</td>
<td>38,765</td>
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<tr>
<td>Other financial assets</td>
<td>87,456</td>
<td>186,118</td>
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<tr>
<td><strong>Total Current Assets</strong></td>
<td>6,464,178</td>
<td>7,690,860</td>
</tr>
<tr>
<td><strong>Non-Current Assets</strong></td>
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</tr>
<tr>
<td>Other financial assets</td>
<td>9,114,390</td>
<td>9,904,876</td>
</tr>
<tr>
<td>Property, plant and equipment</td>
<td>3,305,569</td>
<td>3,178,994</td>
</tr>
<tr>
<td><strong>Total Non-Current Assets</strong></td>
<td>12,419,959</td>
<td>13,083,870</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>18,884,137</td>
<td>20,774,730</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Liabilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payables</td>
<td>599,574</td>
<td>602,189</td>
</tr>
<tr>
<td>Deferred Income / Grant income received in advance</td>
<td>1,777,676</td>
<td>2,341,062</td>
</tr>
<tr>
<td>Other financial liabilities</td>
<td></td>
<td>617</td>
</tr>
<tr>
<td>Provisions</td>
<td>858,268</td>
<td>760,119</td>
</tr>
<tr>
<td><strong>Total Current Liabilities</strong></td>
<td>3,235,518</td>
<td>3,703,987</td>
</tr>
<tr>
<td><strong>Non-Current Liabilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provisions</td>
<td>207,843</td>
<td>302,945</td>
</tr>
<tr>
<td><strong>Total Non-Current Liabilities</strong></td>
<td>207,843</td>
<td>302,945</td>
</tr>
<tr>
<td><strong>Total Liabilities</strong></td>
<td>3,443,361</td>
<td>4,006,932</td>
</tr>
<tr>
<td><strong>Net Assets</strong></td>
<td>15,440,776</td>
<td>16,767,798</td>
</tr>
</tbody>
</table>

## Institute Funds

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endowment fund for Executive Director</td>
<td>3,050,329</td>
<td>3,843,220</td>
</tr>
<tr>
<td>Net unrealised gains reserve</td>
<td>1,238,068</td>
<td>2,050,943</td>
</tr>
<tr>
<td>Retained earnings</td>
<td>11,152,379</td>
<td>10,873,635</td>
</tr>
<tr>
<td><strong>Total Institute Funds</strong></td>
<td>15,440,776</td>
<td>16,767,798</td>
</tr>
</tbody>
</table>
Support the Bionics Institute

The bionic ear is one of Australia’s great medical contributions, and a prototype bionic eye is already being tested with patients. Over the next five years the Bionics Institute will deliver a range of neurobionic devices aimed at providing relief for people with otherwise untreatable forms of neurological and psychiatric disorders from Parkinson’s disease, and essential tremor to obsessive-compulsive disorder and major depression.

If you wish to make a donation to a specific research program, we would be happy to discuss with you.

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 honour 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.

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.

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

The Bionics Institute acknowledges and thanks its generous supporters.

$50,000 and over
Bertalli Family Foundation
Colonial Foundation
Jack & Robert Smorgon Families Foundation
The Australian Ballet
The Garnett Passe and Rodney Williams Memorial Foundation
Victorian Lions Foundation Inc

$10,000 - $49,999
Annie Danks Trust
Deafness Foundation (Victoria)
Harold Mitchell Foundation
Pierce Armstrong Trust
Prescott Family Foundation
Rebecca L Cooper Medical Research Foundation
Ritchies SUPA IGA & Colgate -Palmolive
Robert C Bullley Charitable Trust
The Calvert-Jones Foundation
The Marian & E.H. Flack Trust
Woodards Group

$5,000 - $9,999
Mr & Mrs G Moriarty
Mr John B Reid AO

$1000 - $4,999
Heymanson Family Foundation
Macquarie Group Foundation
Mr & Mrs Michael Robinson AO
Mr & Mrs P Thomas
Mr Ian Young
Mr James Hassell
Mr Matthew Mafrici
Mr Stephen Penman
Mr Wes & Mrs Jane Dunn
Mrs Katrina Tull
Mrs Meg Bentley
Mrs Yvonne Sullivan
Nell & Hermon Slade Trust
The William Angliss Charitable Fund
Zdraveski Trust

$300–$999
C.J. Sinclair & Associates
Dr K S Crowley
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Mr A & Mrs R Bradey
Mr E & Mrs D Bourke
Mr Ivor Johnson
Mr John & Mrs Jenny Younger
Mr Julian Fader
Mr Mark & Mrs Linda Anderson
Mr Maurice Newman
Mr Robert & Mrs Beverley Squire
Mr V J Bertram
Mrs Inez Glanger
Mrs Laurie Gwillim
Mrs Pamela DeSauty
Mrs Pauline Powell OAM
Ms Clio Hertzberg
Ms Val Gallahawk
We also express our appreciation to other individuals and companies, particularly monthly givers, who donated and supported us throughout the year.

**Corporate Partners**

Colgate - Palmotive  
HEARworks Pty Ltd  
Macquarie Group Limited  
Ritchies SUPA IGA  
The Australian Ballet  
Woodards Group

**Community Partners**

Victorian Lions Foundation Inc

**Ambassadors**

Our Ambassador programs would not be possible without our dedicated volunteers and we warmly thank them all for their continued participation.

**Government Support**

The Bionics Institute acknowledges the funding support from the Federal Government for the purposes of establishing the Centre for Medical Bionics and Hearing Science.

The Bionics Institute acknowledges the support it receives from the Victorian Government through its Operational Infrastructure Support Program.