

The Bionic Ear Institute is committed to undertaking medical bionics research focussed on neural-prostheses and hearing science.

About us

The Bionic Ear Institute is a leader in the practical application of biotechnology in medicine. The Institute's technological and clinical expertise spans brain and auditory function, the protection and regeneration of damaged nerves, implantable device technology, mathematical modelling and signal processing. The Bionic Ear Institute collaborates extensively with scientists, engineers, clinicians and surgeons to develop a multidisciplinary approach to research outcomes. It has an internationally recognised team of research scientists from areas including biology, physiology, audiology, neuroscience, speech science, engineering, materials science and mathematics.

Our experience and discoveries with the bionic ear have led to developments in the emerging field

of medical bionics and we are now focusing on four key research areas:

- A bionic eye that will provide independence for the blind and will eventually allow them to read large format print
- Nanotechnology-based targeted drug delivery systems for the efficient delivery of therapeutic drugs without adverse side effects
- Intelligent brain implants designed to monitor, diagnose and treat a variety of neurological disorders including epileptic seizures
- High-fidelity bionic ears that will improve speech understanding in noisy environments and unleash the gift of music for deaf patients

Using a multidisciplinary approach, along with proven experience of working from conception to commercialisation, our research aims to deliver technologies to secure better health outcomes for people, reducing the burden of disease and disabilities.

Projects in progress or completed

- The effects of intracochlear electrical stimulation on neural survival and connectivity. Cochlear implant use at an early stage in deaf animals results in the reorganisation of neurons, resembling the organisation of neurons in a hearing brain. This may provide an explanation for the remarkable clinical performance observed among humans implanted with a cochlear implant at a young age.

- Development of new cochlear implant sound processing strategies. The travelling wave strategy has undergone a clinical trial and has produced significant improvements in speech perception scores in noise, which is the largest improvement seen in more than a decade.
- Computational and mathematical models of neural networks to explore information processing in the brain.
- Speech and language development in children: auditory and visual integration.
- Molecular analysis of synaptic plasticity changes in the auditory cortex. Recent findings have provided insights into adaptive, molecular mechanisms recruited by the brain following electrical stimulation in the cochlea.
- Gene therapy for targeted regeneration of auditory neurons after hearing loss.
- Improving the nerve electrode interface of the cochlear implant with drug-eluting conducting polymer coatings. These coatings present a method to promote preservation of neurons without adversely affecting the function of the cochlear. As part of Bionic Vision Australia, a bionic eye is being developed with our research focussing on safety and efficacy.
- ARC Centre of Excellence for Electromaterials Science nano-bionics program.

- The detection and control of epileptic seizures:
 - long-term (days) EEG activity recording methods have been developed which produce better quality data on which to base seizure prediction models.
 - a stimulation paradigm was used to terminate a seizure in a rat model during the Bionic Technologies Australia's Epilepsy control program.

The team

Prof Robert K Shepherd, Director; Jacqueline K Andrew, PhD Student; Rebecca E Argent, Research Assistant; Ayla Barutchu, Research Assistant; Dr Sean M Byrnes, Research Fellow; Prof Graeme M Clark, Senior Research Fellow; Anne Coco, Research Officer; Prof Mark J Cook, Research Associate – Senior Principal; Alison J Evans, Research Assistant; Dr James B Fallon, Research Fellow; Brianna O Flynn, Research Assistant; Dean R Freestone, PhD Student; Michael Giummarra, UROP Student; Dr Fergal Glynn, Research Medical Clinician; Amy J Halliday, Research Assistant; James Mark Harrison, Research Engineer; Alison Marion Hennessy, Audiologist; Dr Richard J M Van Hoesel, Research Fellow; Hamish Innes-Brown, Research Assistant; Prof Dexter R Irvine, Senior Research Fellow; Yogesh S Jeelall, UROP Student; Assoc Prof Robert Kapsa, Senior Research Fellow; Elisabeth L Kennedy, Research Assistant; Magdalena Kita, Research Assistant; Alan Lai, Research Assistant; James

Laird, UROP Student; Thomas G Landry, PhD Student; James P Leuenberger, Honours Student; Ronald Leung, UROP Student; Kylie A Magee, Research Assistant; Jasmine Mar, Research Assistant; Dr Jeremy P Marozeau, Research Fellow; Rodney Eric Millard, Research Engineer; Dr David Nayagam, Research Fellow; Timothy S Nelson, Research Assistant; Prof Stephen J O'Leary, Assistant Director; Assoc Prof Antonio G Paolini, Senior Research Fellow; David W Perry, PhD Student; Dr Lisa N Pettingill, Research Fellow; Dr Anita F Quigley, Research Fellow; Dr Rachael T Richardson, Research Fellow; Prof Roy M Robins-Browne, Research Associate – Senior Principal; Lianne Salerno, Technical Assistant; Mohit N Shivdasani, PhD Student; Dimitra Stathopoulos, Research Assistant; Courtney Suhr, Technical Assistant; Dr Justin C Tan, Research Fellow; Dr Chris Trengove, Research Fellow; Dr Michael Josef Tykocinski, Research Medical Clinician; Meera Ulaganathan, Research Assistant; Andrew Eugene Vandali; Assoc Prof Chris E Williams, Senior Research Fellow; Dr Andrew Wise, Research Fellow; Dr Jin Xu, Research Fellow

Highlights

Inaugural Conference

In November 2008, The Bionic Ear Institute hosted the inaugural conference 'Medical Bionics – a new paradigm for human health'. The event successfully brought together researchers from varied disciplines to support the creation of innovative

health solutions with medical bionic devices.

Jacqueline K Andrew

- Harold Mitchell Student Travelling Fellowship to attend the 45th Inner Ear Biology Workshop in Ferrara, Italy 2008

Dr Sean M Byrnes

- Harold Mitchell Post Doctoral Travelling Fellowship to attend the Computational Neuroscience Meeting, Portland, Oregon 2008

Thomas G Landry

- MiniFab Excellence Award for the most outstanding student poster, Medical Bionics conference, Lorne 2008

David W Perry

- Melbourne Research Scholarship 2008-2011

Mohit N Shivdasani

- Poster Prize at the Medical Bionics conference, Lorne 2008

Dr Ben Wa

Received the 2008 Premiers Award for Health and Medical Research. In conjunction with this award, the Jack and Robert Smorgon Families Award was presented to The Bionic Ear Institute.

Grants

Burkitt A, Shepherd R

Music and voice perception – determining the requirements of future cochlear implant technology. Tattersall's George Adams Foundation, (2008-2009), \$100,000

Innes-Brown H, Barutchu A

Auditory, visual and multisensory processes in children with hearing impairment and learning disabilities. The Corio Foundation, (2008), \$5,000

Auditory, visual and multisensory processes in children with cochlear implants. ANZ Trustees, (2008), \$12,500

Paolini A

Auditory brain implants: strategies for improved hearing. Garnett Passe and Rodney Williams Memorial Foundation, (2007-2010), \$213,075

Pettingill L

Auditory maintenance using cell therapy techniques. Macquarie Group Foundation, (2007-2008), \$150,000

Richardson R

Reversing deafness using nerve growth factors. Stavros Niarchos Foundation, (2006-2009), \$26,600

Reversing deafness using nerve growth factors. John T Reid Charitable Trusts, (2005-2008), Funding Not Disclosed.

Gene transfer of BDNF for survival and reconnection of regenerating auditory neurons. Royal National Institute for the Deaf, (2006-2009), (GBP)150,000

Shepherd R

HHS-N-263-2007-00053-C

The effects of intracochlear electrical stimulation on neural survival and connectivity. US National Institutes of Health. National Institute on Deafness and other Communication Disorders, (2007-2012), USD\$2,940,000

Rescuing primary auditory neurons via cell-based therapy and cochlear implantation. Garnett Passe and Rodney Williams Memorial Foundation, (2006-2008), \$159,132

Shepherd R, Williams C

Bionic eye biocompatibility and efficacy study. John T Reid Charitable Trusts, (2007-2009)

Tan J

Identifying neurotrophin processing as a potential target to treat sensorineural hearing loss. Garnett Passe and Rodney Williams Memorial Foundation, (2007-2010), \$269,853

Williams C

Bionic eye biocompatibility and efficacy project. The Ian Potter Foundation, (2007-2009), \$500,000

Selected presentations**Barutchu A**

– ‘An electrophysiological study of the development of multisensory facilitation in children’, 14th Annual meeting of the Organisation for Human Brain Mapping, Melbourne, Australia, June 2008

Fallon J

– Speaker, ‘Changes in the cochleotopic organisation of primary auditory cortex resulting from chronic deafness and cochlear implantation’, 38th Neural Interfaces Conference, Cleveland, USA, June 2008

– Invited speaker, ‘Changes in the cochleotopic organisation of primary auditory cortex resulting from chronic deafness and cochlear implantation’, QBI Brain Plasticity Symposium, Brisbane, Australia, September 2008

– ‘Factors affecting neural response telemetry recordings’, Association for Research in Otolaryngology 31st Annual Midwinter Meeting, Arizona, USA, February 2008

– Invited speaker, ‘Sensory neural prostheses and brain plasticity’, Medical Bionics Conference, Lorne, Australia, November 2008

Flynn B

– ‘Gene transfer for preserving and reconnecting the auditory pathway after hearing loss’, Medical Bionics Conference, Lorne, Australia, November 2008

Innes-Brown H

– ‘Flash VEP is reduced in children when preceded by an audio visual stimulus’, 14th Annual meeting of the Organisation for Human Brain Mapping, Melbourne, Australia, June 2008

Landry T

- ‘Effects of exogenous neurotrophins in the deaf stimulated cochlea’, Medical Bionics Conference, Lorne, Australia, November 2008
- Invited speaker, ‘Functional effects of exogenous neurotrophins in the deafened cochlea’, 5th Australasian Auditory Neuroscience Workshop, Hobart, Australia, January 2008

Mauger S

- Invited speaker, ‘Frequency specific activation of inferior colliculus neurons through penetrating brainstem microstimulation’, 6th Australasian Auditory Neuroscience Workshop, Hobart, Australia, January 2008
- ‘Inferior colliculus responses to microstimulation using a penetrating auditory brainstem implant’, 10th International Conference on Cochlear Implants, San Diego, USA, April 2008

Nayagam D

- Invited speaker, ‘The tale of the VCLL’, 7th Australasian Auditory Neuroscience Workshop, Hobart, Australia, January 2008

Perry D

- Invited speaker, ‘Research cochlear implant for small laboratory animals’, 8th Australasian Auditory Neuroscience Workshop, Hobart, Australia, January 2008

Richardson R

- Invited speaker, ‘Drug delivery via intelligent polymers: auditory nerve rescue for Bionics Ears’, Medical Bionics Conference, Lorne, Australia, November 2008
- ‘Polypropylene-coated electrodes for the delivery of charge and neurotrophins to cochlear neurons’, Asia Pacific Symposium on Nanobionics, Wollongong, Australia, June 2008

Shepherd R

- ‘Medical bionics and neurotrophin delivery: staring at an intersection of two emerging disciplines’, Asia Pacific Symposium on Nanobionics, Wollongong, Australia, June 2008
- Invited speaker, ‘Neurotrophin delivery for sensorineural hearing loss’, Association for Research in Otolaryngology 31st Annual Midwinter Meeting, Arizona, USA, February 2008

Shivdasani M

- ‘Dual site stimulation in the ventral cochlear nucleus’, 10th International Conference on Cochlear Implants, San Diego, USA, April 2008
- Invited speaker, ‘Dual site stimulation in the ventral cochlear nucleus: insights into penetrating auditory brainstem implant design’, 28th Annual Meeting of the Australian Neuroscience Society, Hobart, Australia, January 2008

Taft D

- ‘A frequency position function for cochlear implants’, Association for Research in Otolaryngology 31st Annual Midwinter Meeting, Arizona, USA, February 2008
- ‘Travelling wave based group delays for cochlear implant speech processing’, INTERSPEECH 2008, Brisbane, Australia, September 2008

Tan J

- ‘Cochlear implants stimulate activity-dependent CREB pathway in the deaf auditory cortex’, Association for Research in Otolaryngology 31st Annual Midwinter Meeting, Arizona, USA, February 2008

Trengove C

- ‘Population based limit cycle oscillations in a compositional system of synfire chains’, Neurons and Language Symposium, Israel, June 2008

Vandali A

- Speaker, ‘A pitch on the coding of melody in cochlear implants’, 2nd International Symposium on Cochlear Implants and Music, Zurich, February 2008

Wise A

- ‘Factors affecting neural response telemetry recordings’, 28th Annual Meeting of the Australian Neuroscience Society, Hobart, Australia, January 2008

Collaborations

- Centre for Eye Research Australia
- CSIRO Molecular and Health Technologies
- CSIRO Textile and Fibre Technology
- Living Cell Technologies Ltd
- NICTA
- St. Vincent's
- University of Melbourne, School of Engineering
- University of NSW
- University of Wollongong

Publications

Backhouse S, Coleman B, Shepherd RK 2008, 'Surgical access to the mammalian cochlea for cell-based therapies', *Experimental Neurology*, 214, 2, 193-200

Fallon JB, Irvine D, Shepherd RK 2008, 'Cochlear implants and brain plasticity', *Hearing Research*, 238, 1-2, 110-117

Guipponi M, Toh MY, Tan J, Park D, Hanson K, Ballana E, Kwong D, Cannon PZ, Wu Q, Gout A, Delorenzi M, Speed TP, Smith RJ, Dahl HH, Petersen M, Teasdale RD, X. E, Park WJ, Scott HS 2008, 'An integrated genetic and functional analysis of the role of type II transmembrane serine proteases (TMPRSSs) in hearing loss', *Human Mutation*, 29, 1, 130-41

Heffer LF, Fallon JB 2008, 'A novel stimulus artifact removal technique for high-rate electrical stimulation', *Journal of Neuroscience Methods*, 170, 277-84

James DP, Eastwood H, Richardson RT, O'Leary SJ 2008, 'Effects of round window dexamethasone on residual hearing in a guinea pig model of cochlear implantation', *Audiology and Neurotology*, 13, 2, 86-96

Malmierca MS, Storm-Mathisen J, Cant NB, Irvine D 2008, 'From cochlear to cortex: a tribute to Kirsten Kjelsberg Osen', *Neuroscience*, 154, 1, 1-9

Moore DR, Shepherd RK 2008, 'The auditory brain – a tribute to Dexter R.F. Irvine', *Hearing Research*, 238, 1-2, 1-2

Pettingill L, Minter R, Shepherd RK 2008, 'Schwann cells genetically modified to express neurotrophins promote spiral ganglion neuron survival in vitro', *Neuroscience*, 152, 3, 821-828

Richardson RT, Wise AK, Andrew JK, O'Leary SJ 2008, 'Novel drug delivery systems for inner ear protection and regeneration after hearing loss', *Expert Opinion on Drug Delivery*, 5, 10, 1059-76

Shepherd RK, Epp S, Coco A 2008, 'Neurotrophins and electrical stimulation for protection and repair of spiral ganglion neurons following sensorineural hearing loss', *Hearing Research*, 242, 1-2, 100-109

Shivdasani MN, Mauger SJ, Rathbone G, Paolini AG 2008, 'Inferior colliculus responses to multichannel microstimulation of the ventral cochlear nucleus: implications for auditory brainstem implants', *Journal of Neurophysiology*, 99, 1, 1-13

Tan J, Widjaja S, Shepherd RK 2008, 'Cochlear implants stimulate activity-dependent CREB pathway in the deaf auditory cortex: implications for molecular plasticity induced by neural prosthetic devices', *Cerebral Cortex*, 18, 8, 1799-813

Wei BP, Robbins-Browne R, Shepherd RK, Clark GM, O'Leary SJ 2008, 'Can we prevent cochlear implant recipients from developing pneumococcal meningitis?', *Clinical Infectious Diseases*, 46, 1, e1-e7

Wong LLN, Vandali AE, Ciocca V, Luk B, Ip VWK, Murray B, Yu HC, Chung I 2008, 'New cochlear implant coding strategy for tonal language speakers', *International Journal of Audiology*, 47, 6, 337-47

Yousoufian M, Couchman K, Shivdasani MN, Walmsley B, Paolini AG 2008, 'Maturation of auditory brainstem projections and calyces in the congenitally deaf (dn/dn) mouse', *Journal of Comparative Neurology*, 506, 3, 442-51