Innovation in medicine: medical bionics as a case study

Professor Rob Shepherd
Director, Bionic Ear Institute
Professor of Medical Bionics, The University of Melbourne
An independent medical research institute located in a hospital setting

Three research frontiers:

Bionic Hearing          Neurobionics          Bionic Vision
Interface between body & electronic devices:

Biology + Electronics = Bionics
Interface between body & electronic devices:

**Biology + Electronics = Bionics**

- Approved devices:
  - Heart pacemakers
  - Spinal cord stimulators (pain relief)
  - Cochlear implants (hearing)
  - Deep Brain Stimulators (Parkinson’s disease)
  - Phrenic nerve stimulation (assisted breathing)
  - Sacral nerve stimulation (bladder control)
Interface between body 
& electronic devices:

Bio(logy) + Electr(onics) = Bionics

• Approved devices:
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• Bionics devices in clinical trial 
or basic research & development:
  – Functional electrical stimulation (standing and gait)
  – Brain Computer Interfaces (control of robotic limbs)
  – Deep Brain Stimulation (severe psychiatric 
    conditions & severe chronic pain)
  – Vestibular prostheses (balance)
  – Retinal prostheses (vision)
  – Cortical prostheses (epilepsy detection & suppression)
Medical Bionics: two examples

Deep Brain Stimulation for movement disorders

Cochlear implant for severe-profound deafness
Deep Brain Stimulation for movement disorders

Cochlear implants for severe-profound deafness

Profound Deafness – Surgeon’s Opinion 1967

4th April, 1967.

Mr. S. Kearton,
66 Springfield Road,
BOX HILL.

Dear Mr. Kearton,

Thank you very much for going along to the Acoustic Laboratory and having their somewhat more sophisticated tests.

It does appear that you have a complete bilateral sensori-neural hearing loss and that no surgical or any other attack would be of any avail to you. I would agree entirely with this that you rejoin the Australian Association for Better Hearing and I have enclosed a form for you to fill out to this end. It was disappointing that nothing surgical can help, but I’m sure with your perseverance and continued attack on it with the ability that you have got then you will make the most of a pretty bad lot.

Yours sincerely,

[Signature]

It does appear that you have a complete bilateral sensori-neural hearing loss and that no surgical or any other attack would be of any avail to you ...

...but I’m sure with your perseverance and continued attack on it with the ability that you have got then you will make the most of a pretty bad lot.
Multichannel cochlear implant (circa 1970)

- Underlying cochlear anatomy & physiology well understood
- Proof of principle clinical trials generated widespread interest
- Low power integrated circuits suitable for implantation were becoming available
- Demonstrable clinical need: 120,000 profoundly deaf patients in Australia and 50 million worldwide
- No competing technologies
Graeme Clark assembled a small **multidisciplinary** team in the Department of Otolaryngology, University of Melbourne circa 1976.
Climate of Research Opinion – 1960s

“Direct stimulation of the auditory nerve fibres with resultant perception of speech is not feasible”

Lawrence (1964)

“Direct stimulation of the cochlear nerve will from time to time be discovered. There is no indication that it will ever succeed in enabling a patient to readily hear speech”

Fowler (1968)
The University of Melbourne
Multi-channel Cochlear Implant 1978
Cochlear Implant
Cochlear Implants: the path to success

- Excellent **multidisciplinary** R & D
- Champions in research, commerce and government
- A project that inspired people
- Large population of potential patients
- No therapeutic competition
- Ignored the many doubters
- Luck and hard work
- High level political support
Cochlear Ltd:
- 2,400 highly skilled employees
- 70% of the world market in cochlear implants
- manufacturer of the world’s most sophisticated medical bionics device
- 2010-2011 profit $180m
- 30 years old
The bionic eye electrodes will be implanted behind the retina and stimulate the optic nerve.
Imagine your eyesight is failing

... in 5 years you will be legally blind

... in 10 years you will have no useful vision

... in 20 years your children’s eyesight will begin to fail!
Diseases:
- RP
- AMD
The bionic eye electrodes will be implanted behind the retina and stimulate the optic nerve.
Phase 1 - 100 electrodes!

High-density Pt electrodes on a medical grade silicone carrier
Phase 1 - 100 electrodes!

High-density Pt electrodes on a medical grade silicone carrier
Mechanical stability!

Villalobos et al., 2012
Biocompatible!

Nayagam et al., 2012

Electrode cavity

3 months implantation
Phase 2 - 1000 electrodes!

Dr Kumaravelu Ganesan & Prof Steven Prawer
Phase 2 - 1000 electrodes!

Diamond electronics capsule and diamond array

Power and data lead

Dr David Garrett
Phase 2 - 1000 electrodes!

Dr David Garrett

Dr Kate Fox & Dr Penny Allen
Don’t forget the cables!
Don’t forget the cables!
Expertise required to develop implantable devices:

**Engineering:**
- Biomedical engineering
- Mechanical engineering
- Electronic engineering
- Chemical engineering
- Software engineering

**Science:**
- Physics
- Biological sciences
- Neuroscience

**Clinical science:**
- Appropriate physicians/surgeons
- Psychologists

**Social Sciences:**
- Ethicists

The bionic eye electrodes will be implanted behind the retina and stimulate the optic nerve.
Smarter devices for patients
Smarter devices for patients

Brain plasticity
Bionics Institute
& Medical Bionics
Department Team

www.bionicsinstitute.org
Our Collaborators

Research
- The University of Melbourne
- NICTA
- Centre for Eye Research Australia
- ARC Centre of Excellence for Electromaterials Science
- UNSW
- CSIRO
- Swinburne University of Technology

Clinical
- St Vincent's Health
- Eye & Ear Hospital

Commercial
- Bionic enterprises
- Cochlear
- HEAR
- LCT

Funding
- Australian Government
- National Health and Medical Research Council
- Australian Government
- National Institute on Deafness and Other Communication Disorders

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