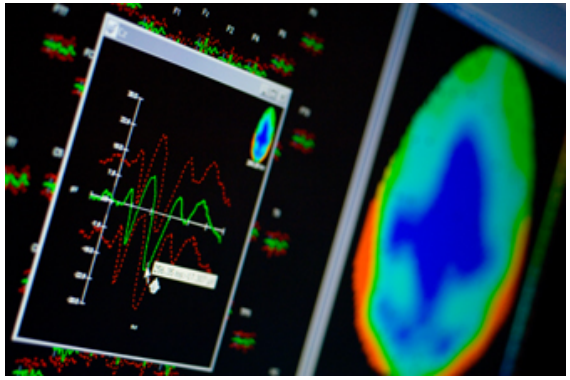
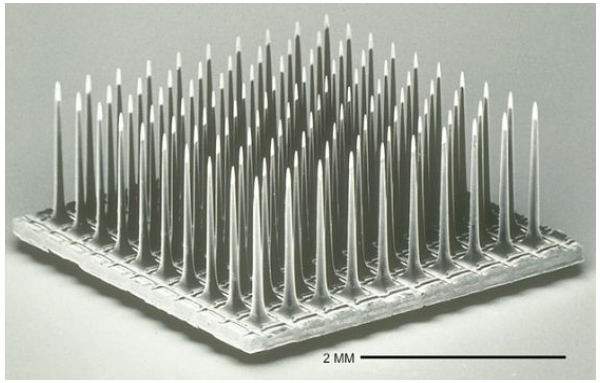
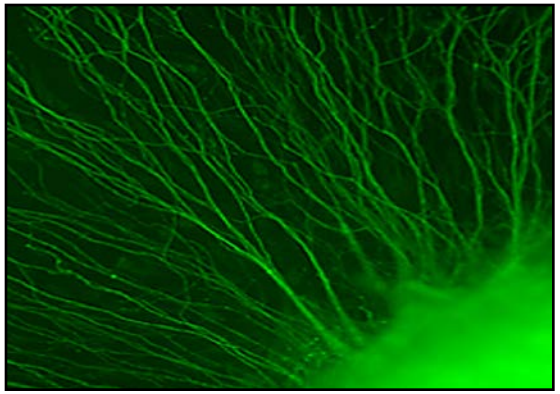
Innovation in medicine: medical bionics as a case study

Professor Rob Shepherd
Director, Bionic Ear Institute
Professor of Medical Bionics, The University of Melbourne





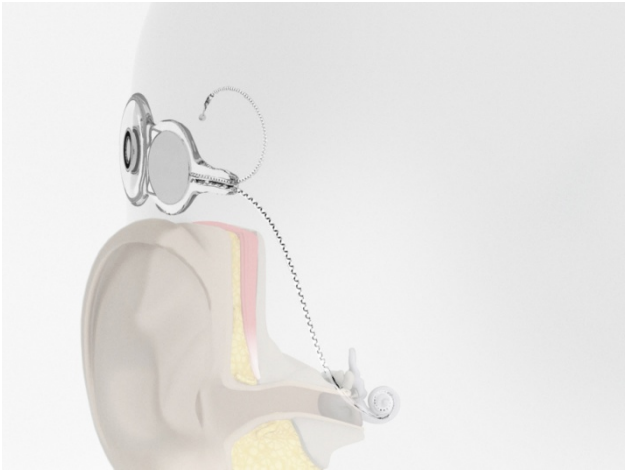


Bionics institute

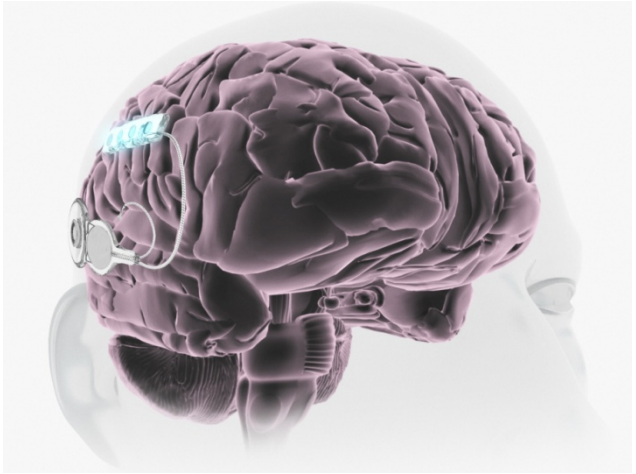
An independent medical research institute located in a hospital setting

Three research frontiers:

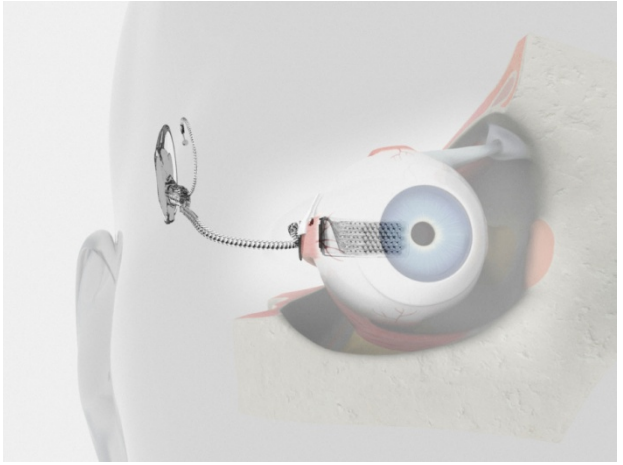
Bionic Hearing



Neurobionics



Bionic Vision

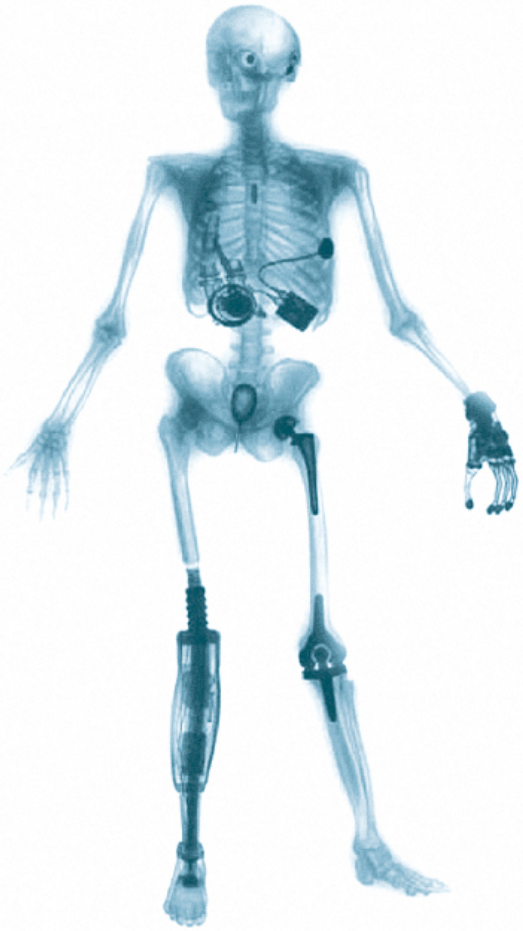


THE UNIVERSITY OF MELBOURNE

Bionics institute

Interface between body & electronic devices:

Biology + Electronics = Bionics



THE UNIVERSITY OF MELBOURNE

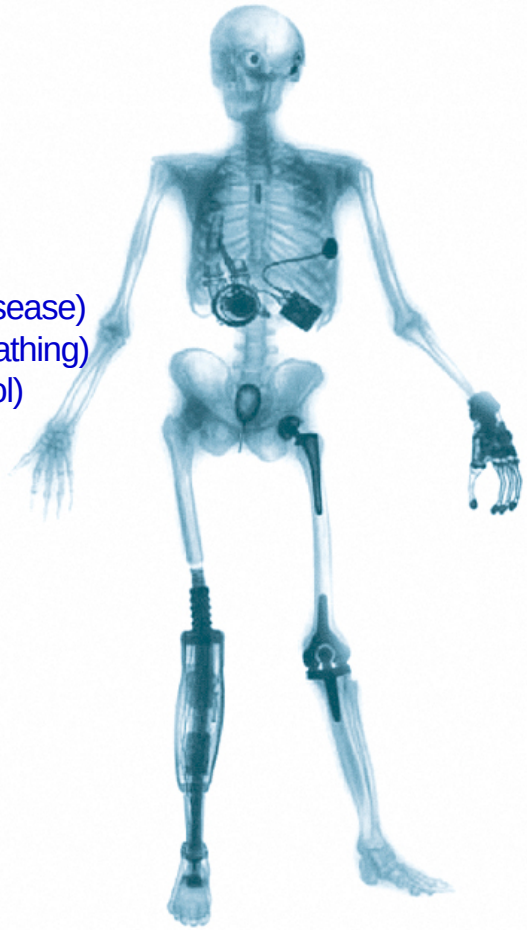
Bionics institute

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)

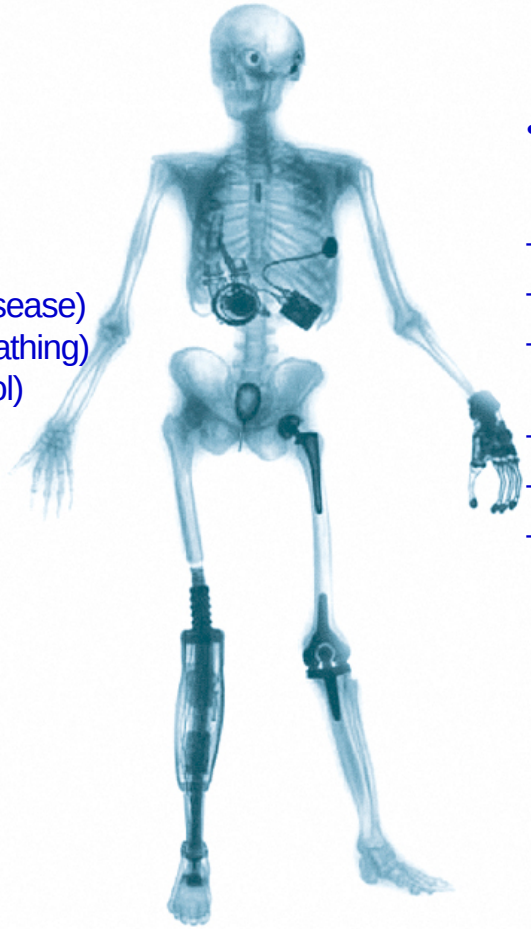


THE UNIVERSITY OF MELBOURNE

Bionics institute

Interface between body & electronic devices:

Bio(logy) + Electr(onics) = 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)

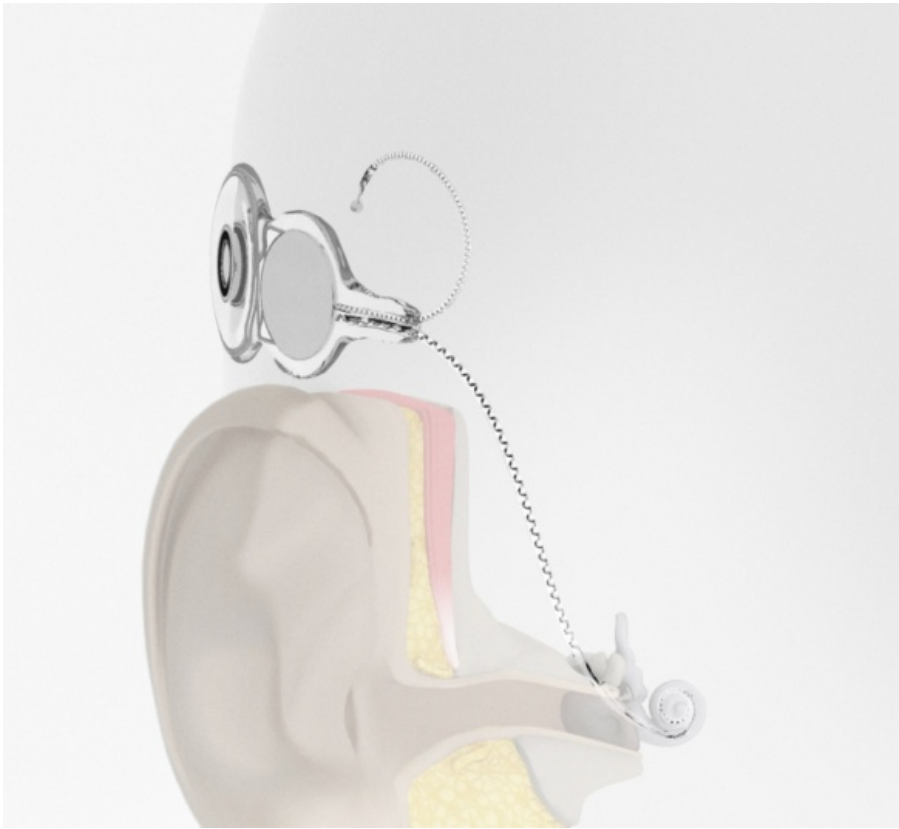
- **Bionics devices in clinical trial or basic research & development:**

– 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



THE UNIVERSITY OF MELBOURNE

Bionics institute

Deep Brain Stimulation for movement disorders

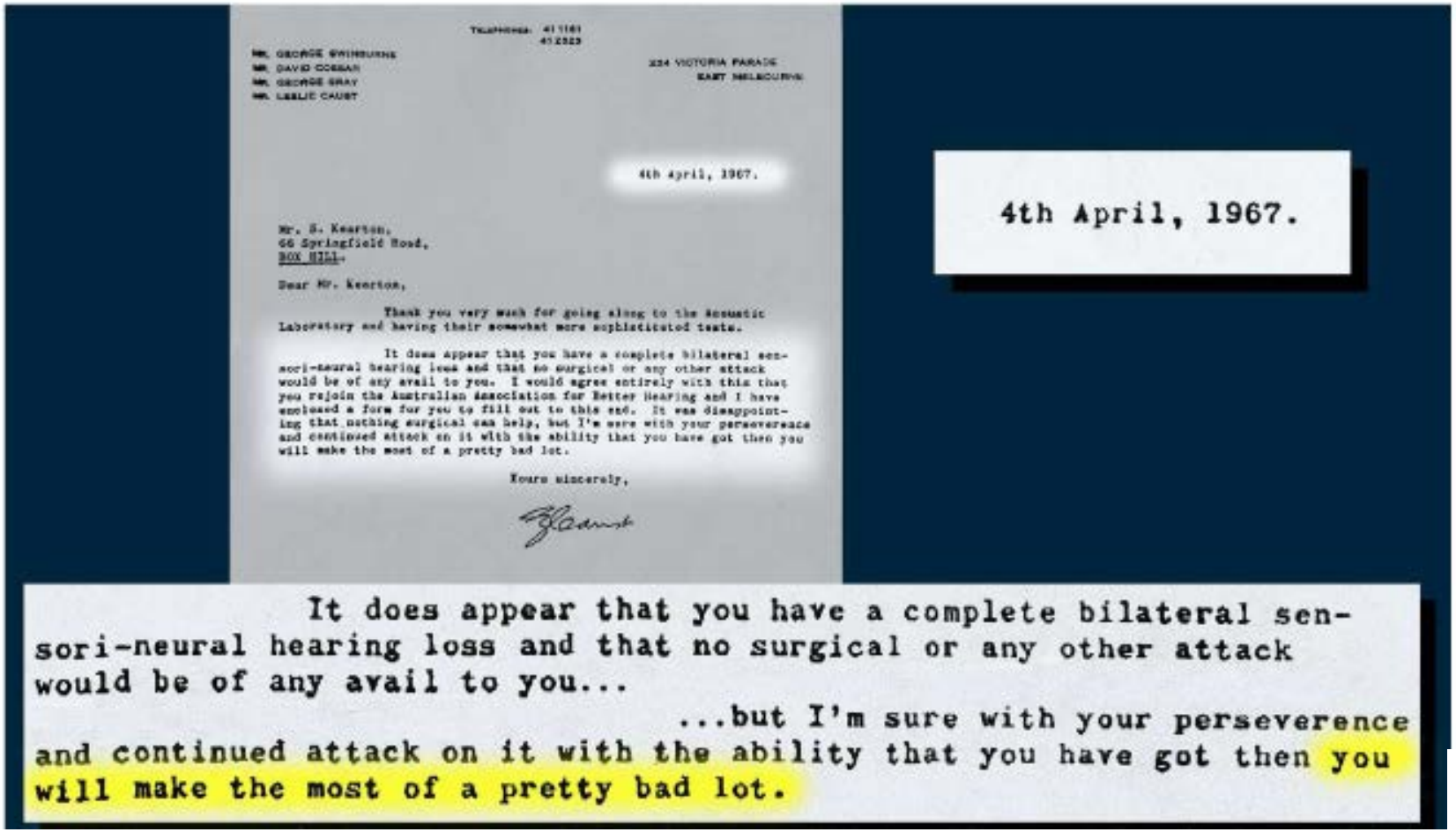
From Kringelbach, et al., Nature Reviews Neuroscience 8, 623-635, 2007.

THE UNIVERSITY OF MELBOURNE

Bionics institute

Cochlear implants for severe-profound deafness

Profound Deafness – Surgeon's Opinion 1967



MR. GEORGE SWINBURNE
MR. DAVID COSSAR
MR. GEORGE GRAY
MR. LESLIE CAUST

334 VICTORIA PARADE
EAST MELBOURNE

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,

4th April, 1967.

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 perseverence 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

Expertise required to develop implantable devices:

Graeme Clark assembled a small multidisciplinary team
in the Department of Otolaryngology, University of Melbourne

circa 1976

THE UNIVERSITY OF MELBOURNE

Bionics institute

Climate of Research Opinion – 1960s

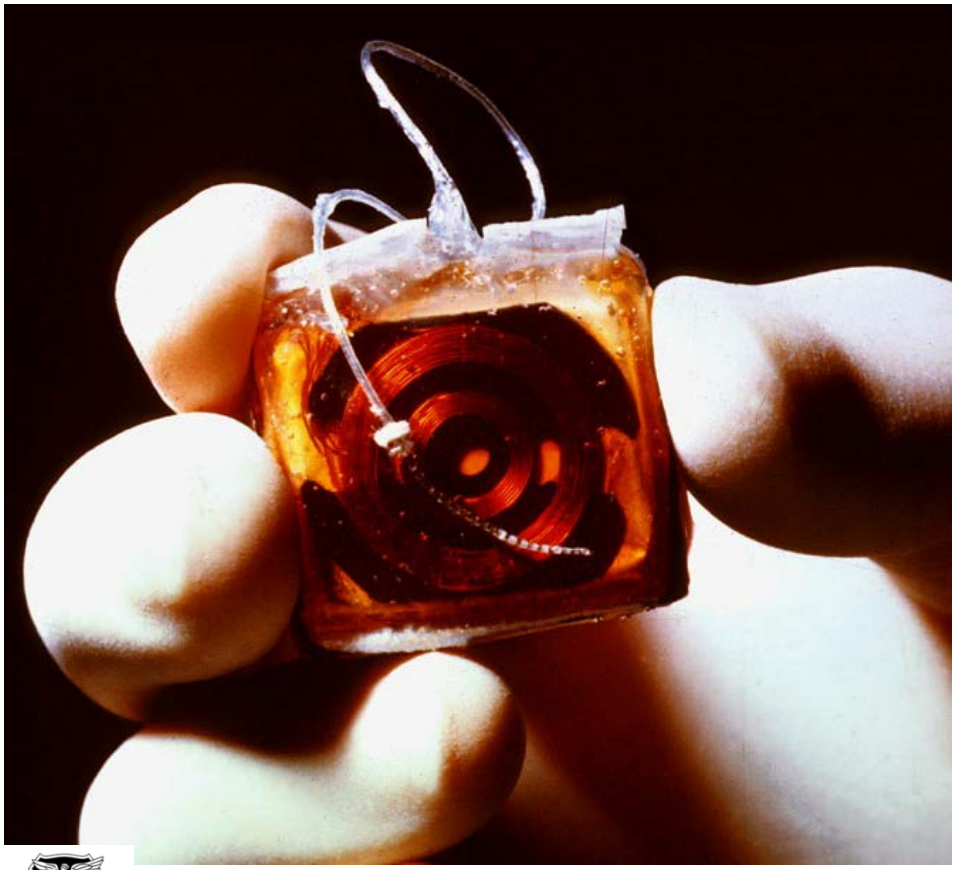
"Direct stimulation of the auditory nerve fibres with resultant perception of speech is not feasible"

Lawrence (1964)

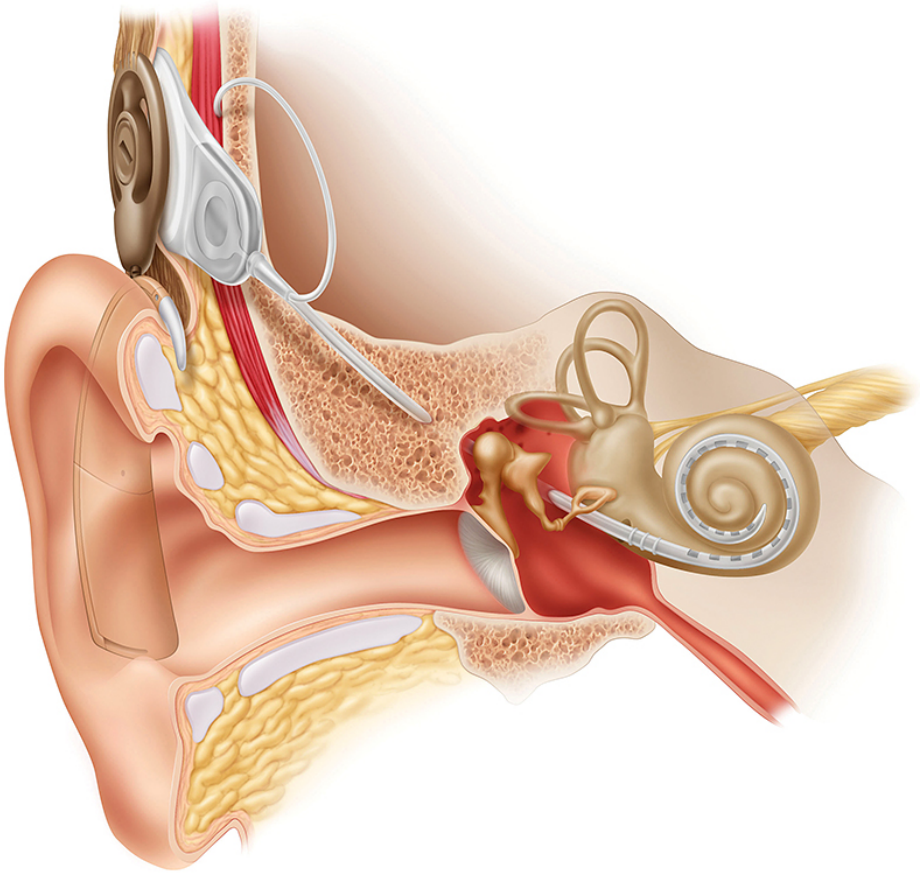
"Direct stimulation of the cochlear nerve will from time to time be discovered. There is no indication that it will ever succeed in enabling a patient to readily hear speech"

Fowler (1968)

The University of Melbourne
Multi-channel Cochlear Implant 1978



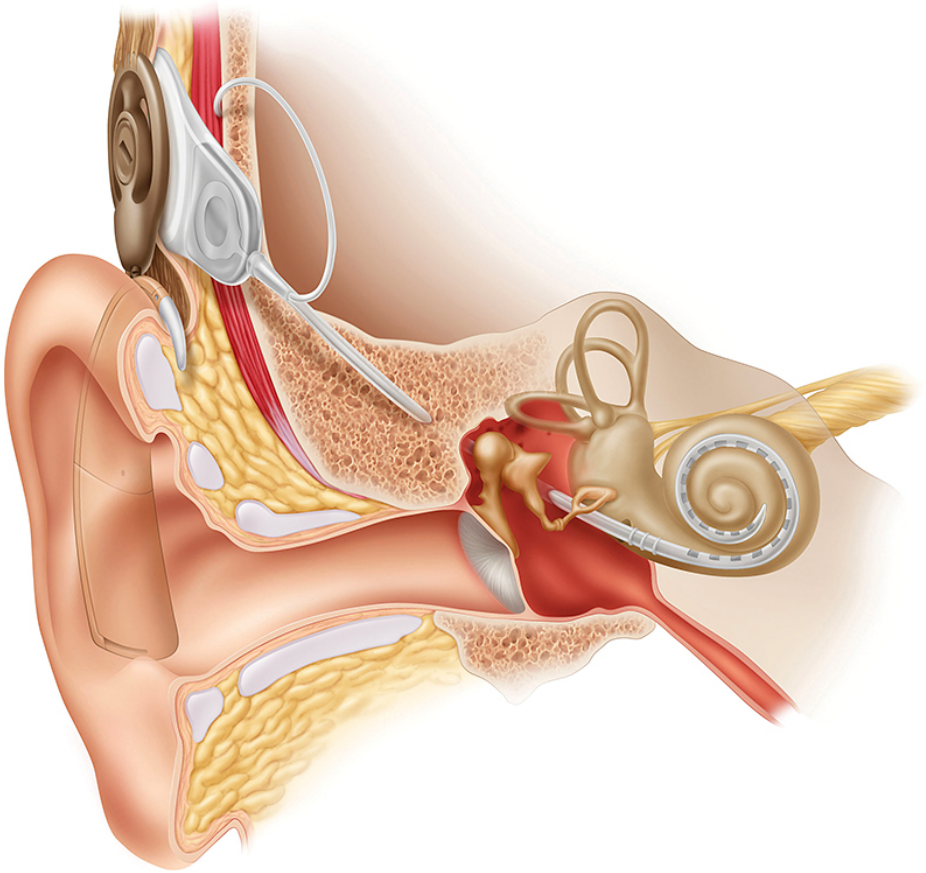
Cochlear Implant

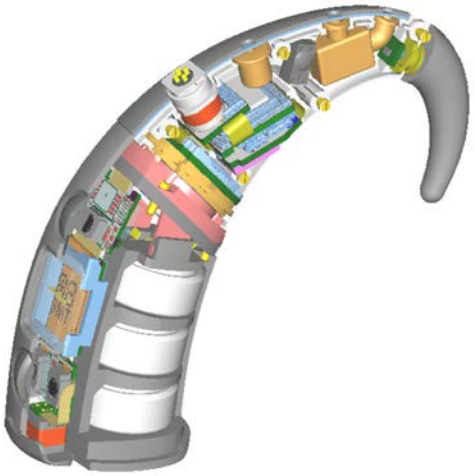


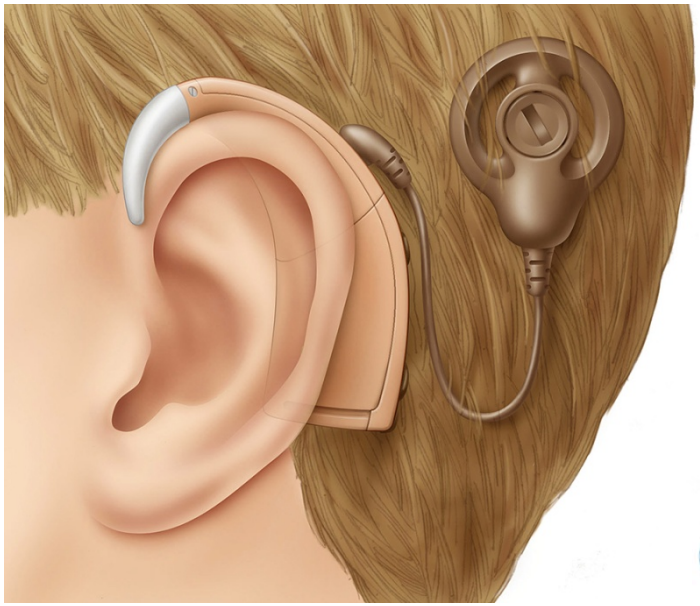
Cochlear

Bionics institute

Cochlear Implant







Cochlear

Bionics institute

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 theraputic competition
- Ignored the many doubters
- Luck and hard work
- High level political support

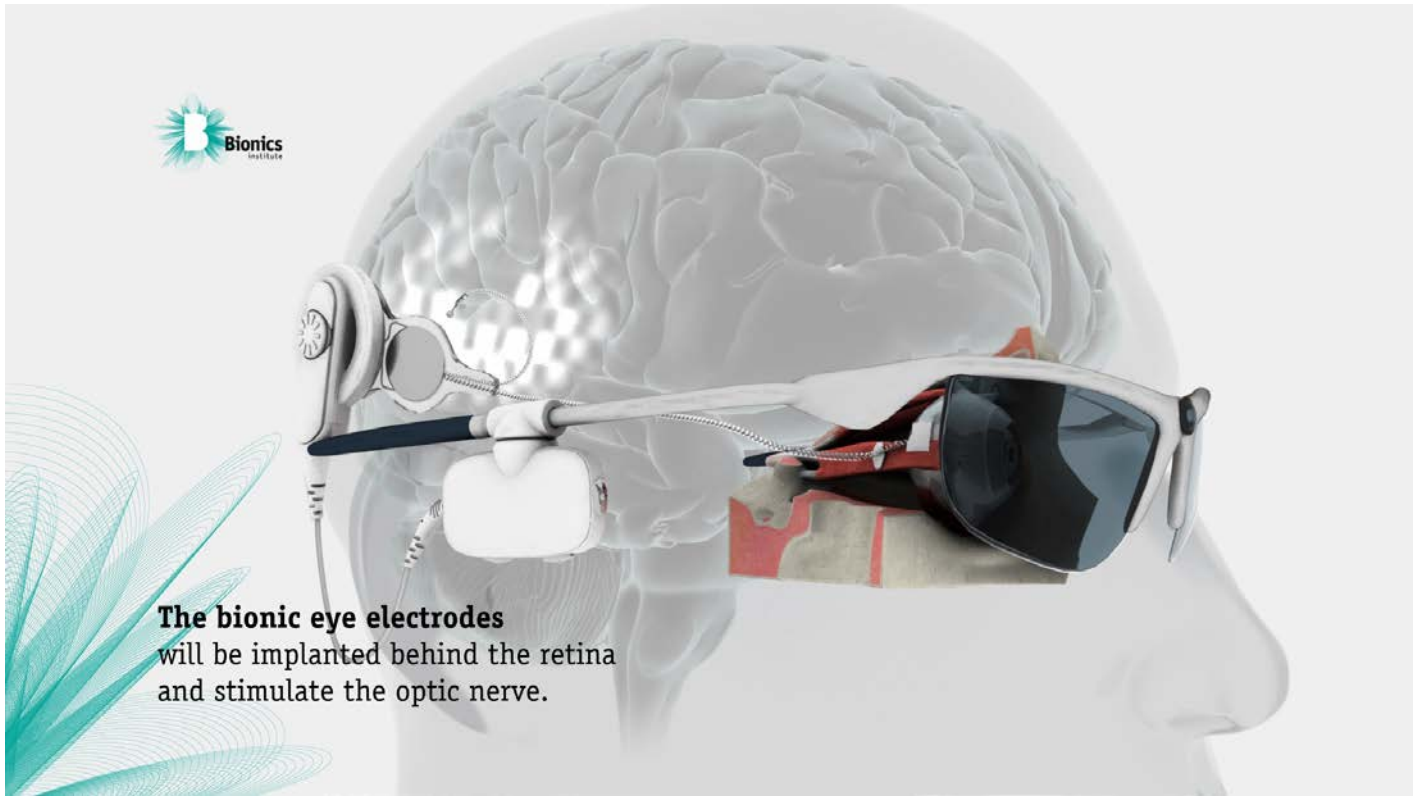
Cochlear Ltd:

- 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

Cochlear

Bionic vision

BIONICVISION AUSTRALIA



An initiative of

Australian Government
Australian Research Council

Our members

Centre for Eye Research Australia
UNSW THE UNIVERSITY OF NEW SOUTH WALES
NICTA
THE UNIVERSITY OF MELBOURNE
Bionics institute

Our partners

NATIONAL VISION RESEARCH INSTITUTE OF AUSTRALIA
University of Western Sydney Bringing knowledge to life
The Royal Victorian Eye & Ear Hospital caring in every sense

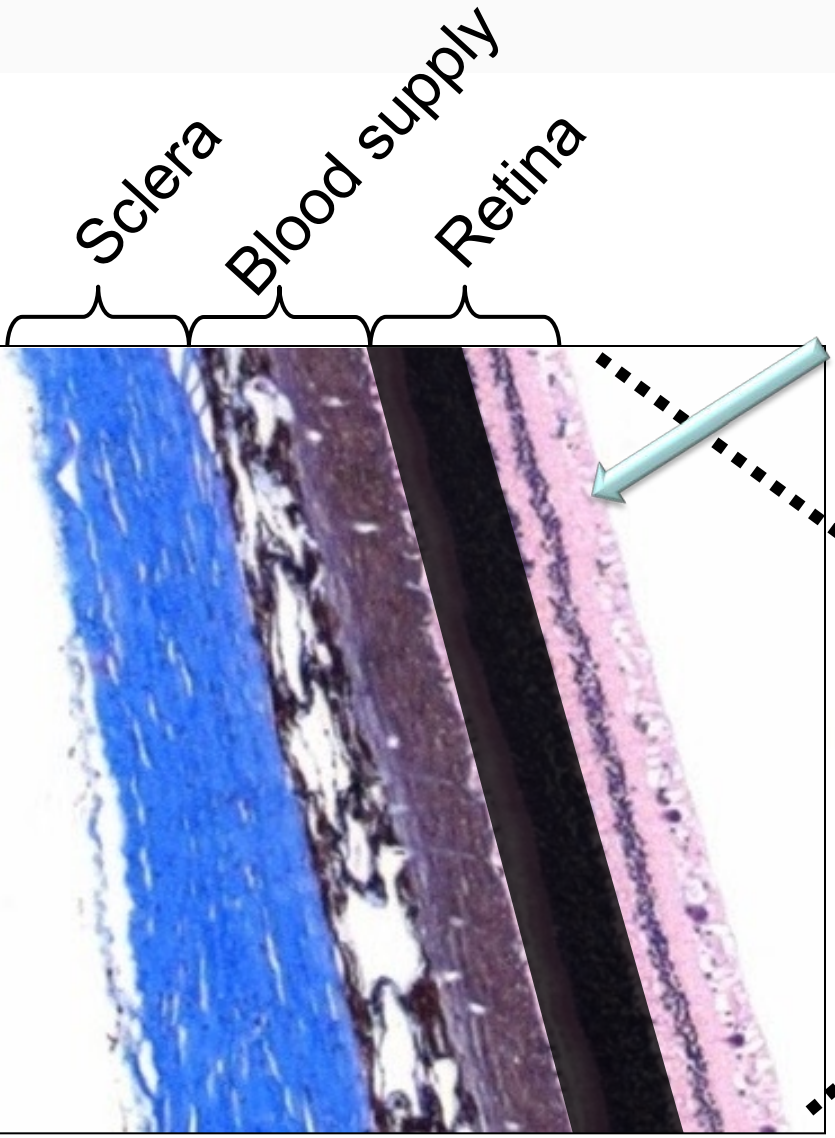
Imagine your eyesight is failing

… in 5 years you will be legally blind

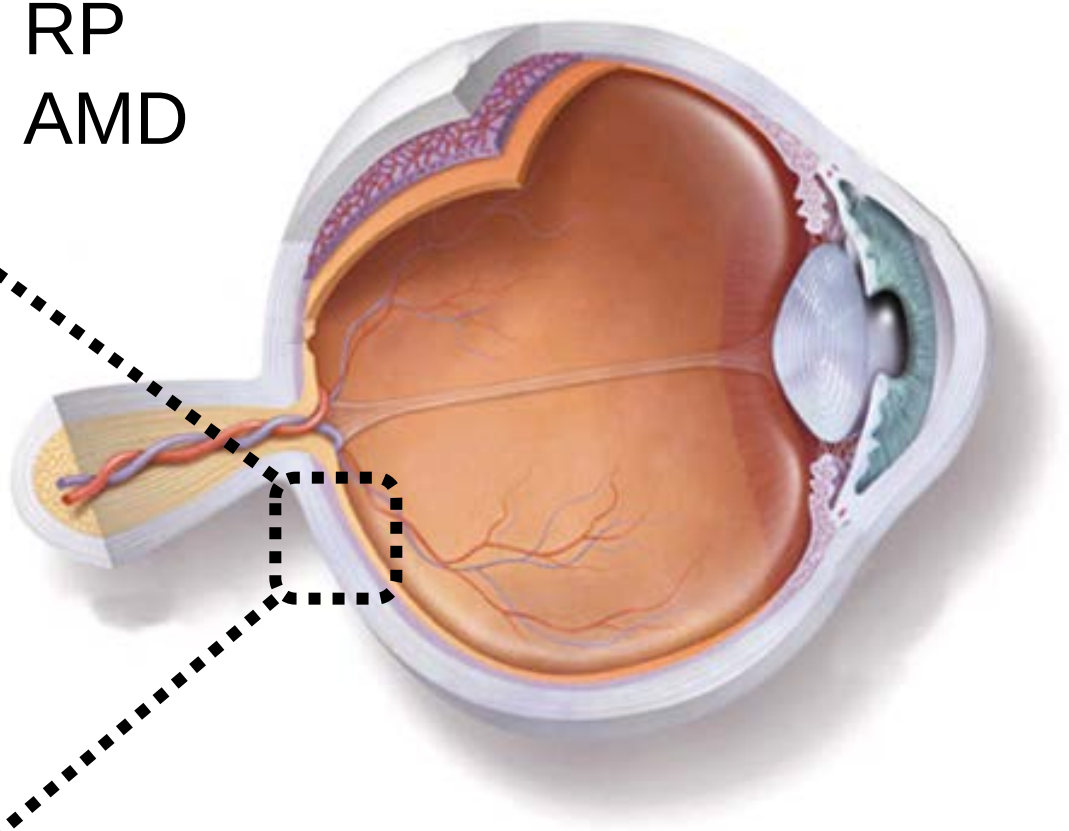
… in 10 years you will have no useful vision

… in 20 years your children’s eyesight will begin to fail!

BIONICVISION
AUSTRALIA



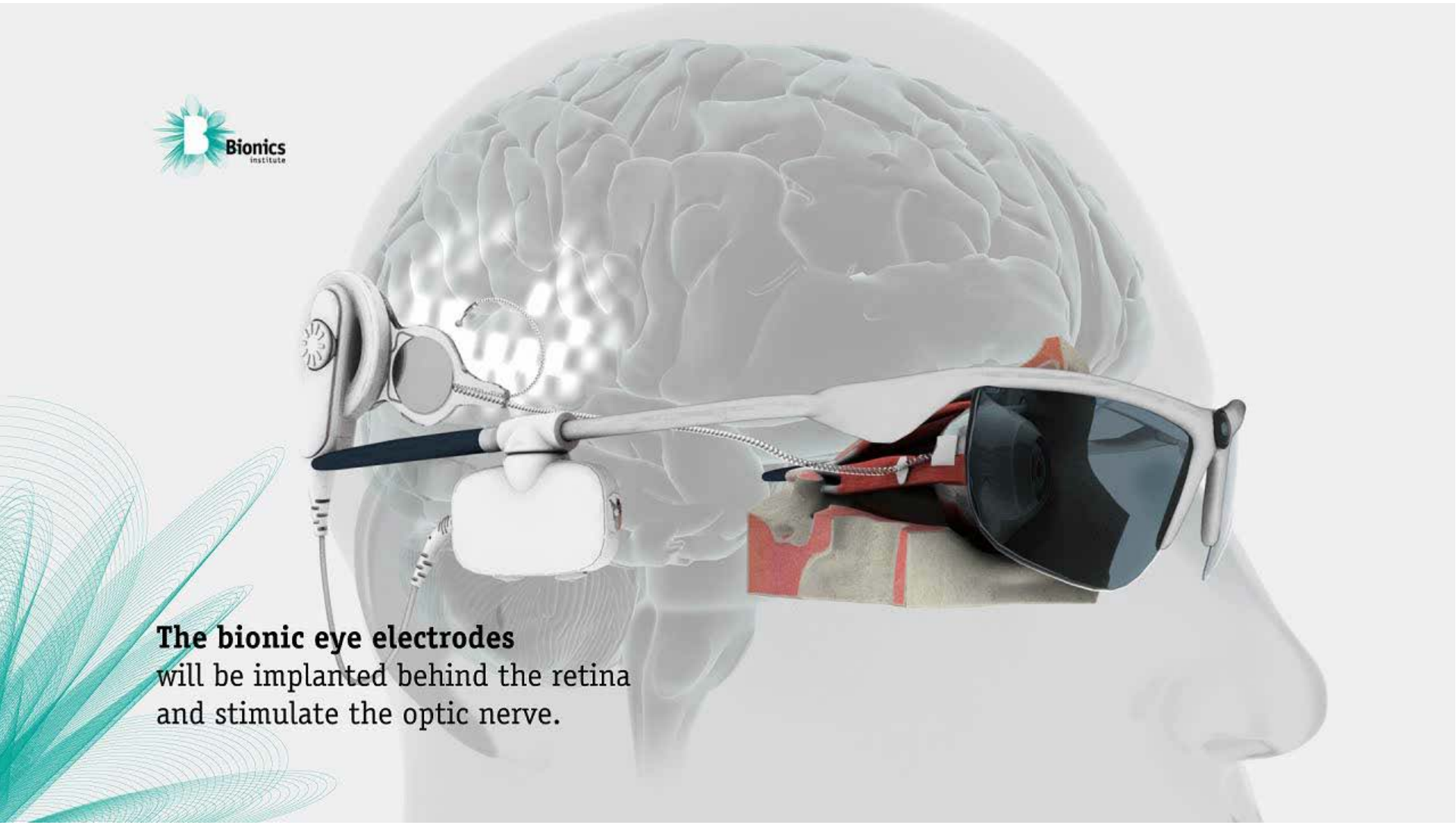
Diseases:
RP
AMD



Bionics institute

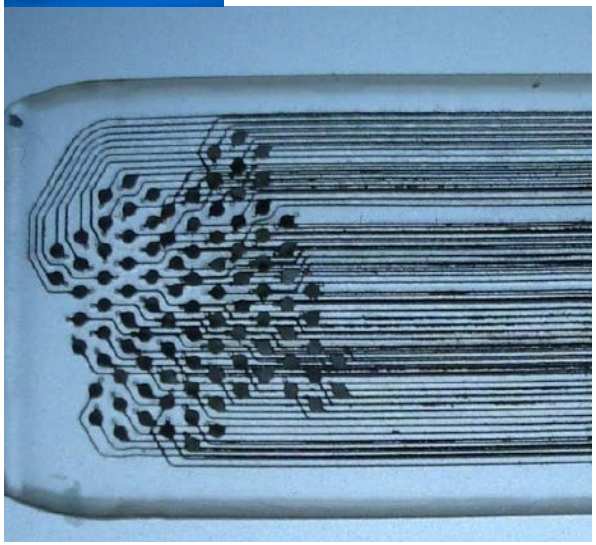
BIONICVISION
AUSTRALIA

Bionics
institute



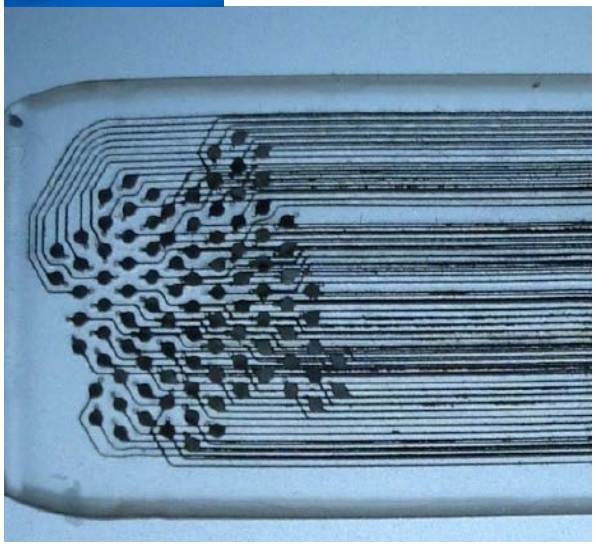
The bionic eye electrodes
will be implanted behind the retina
and stimulate the optic nerve.

Phase 1 - 100 electrodes!

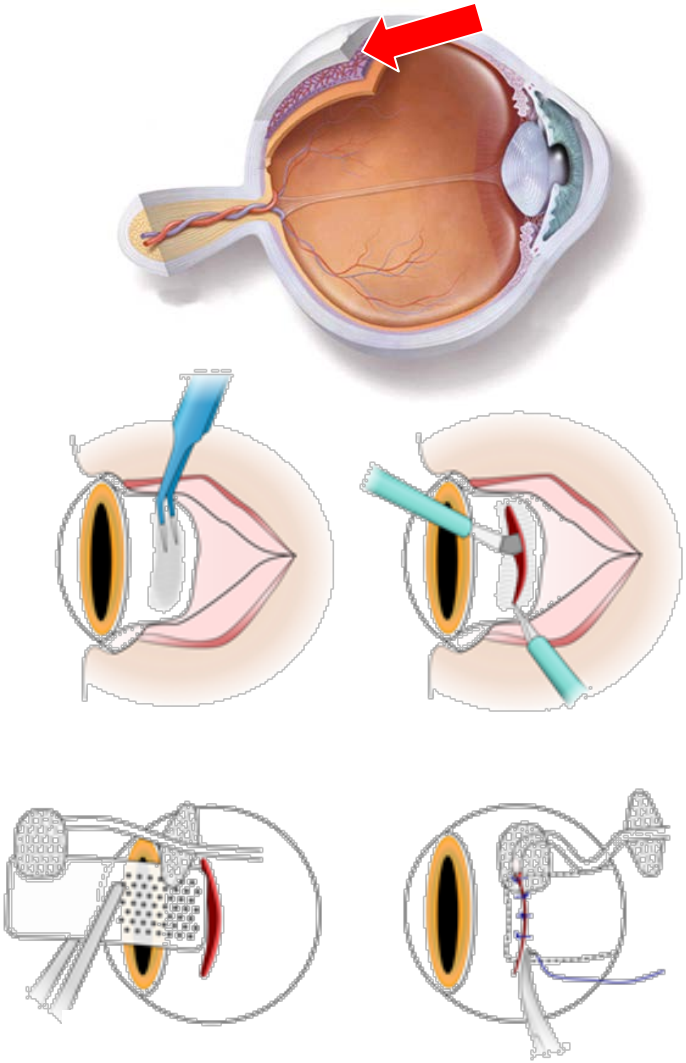


High-density Pt electrodes on a medical grade silicone carrier

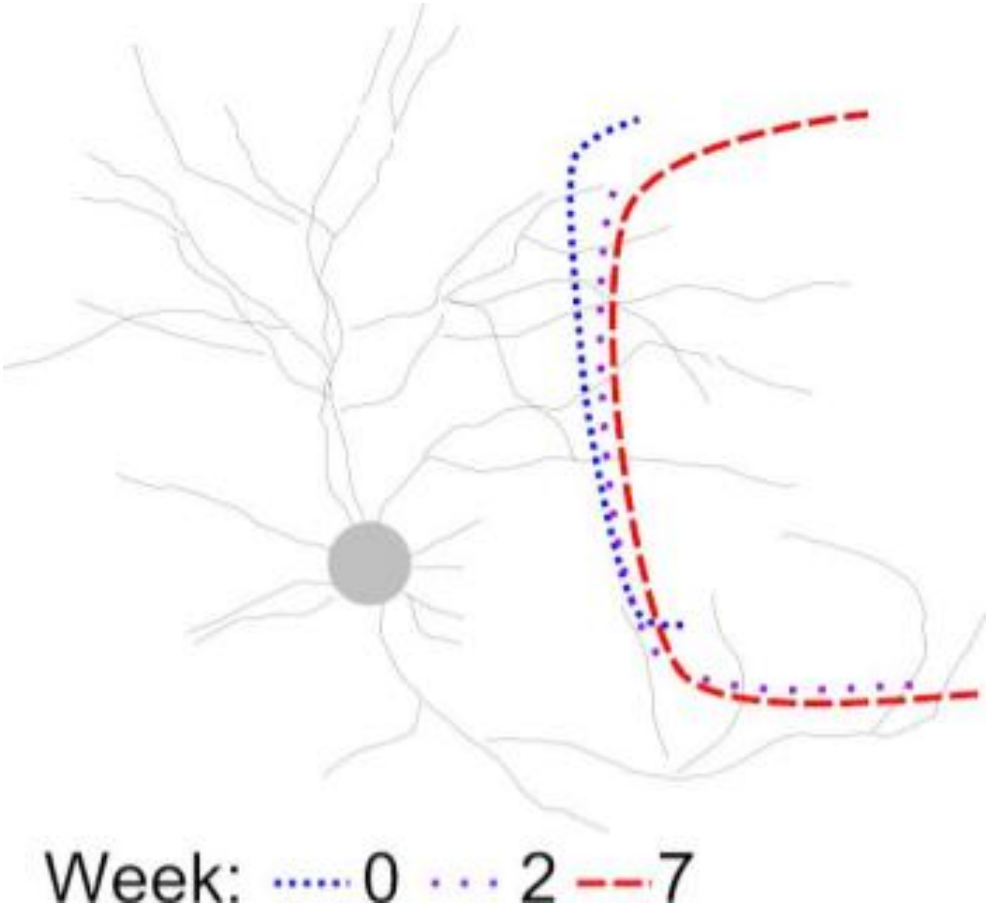
Phase 1 - 100 electrodes!



High-density Pt electrodes on a medical grade silicone carrier

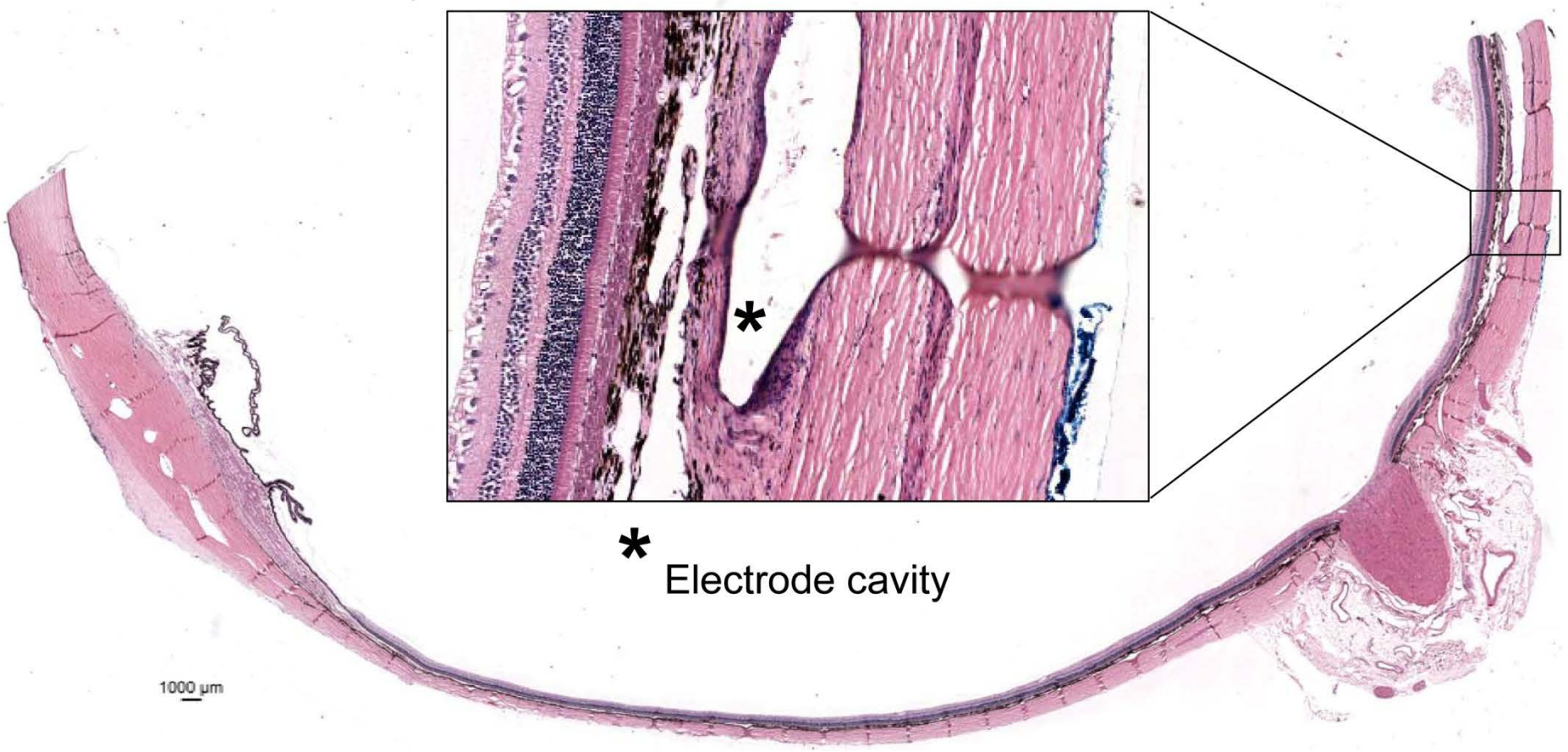


Mechanical stability!



Villalobos et al., 2012

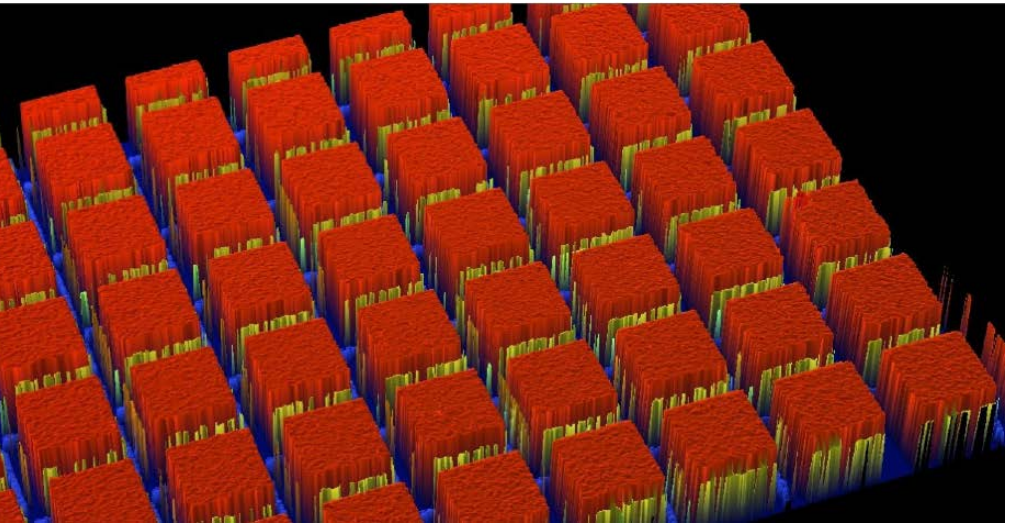
Biocompatible!



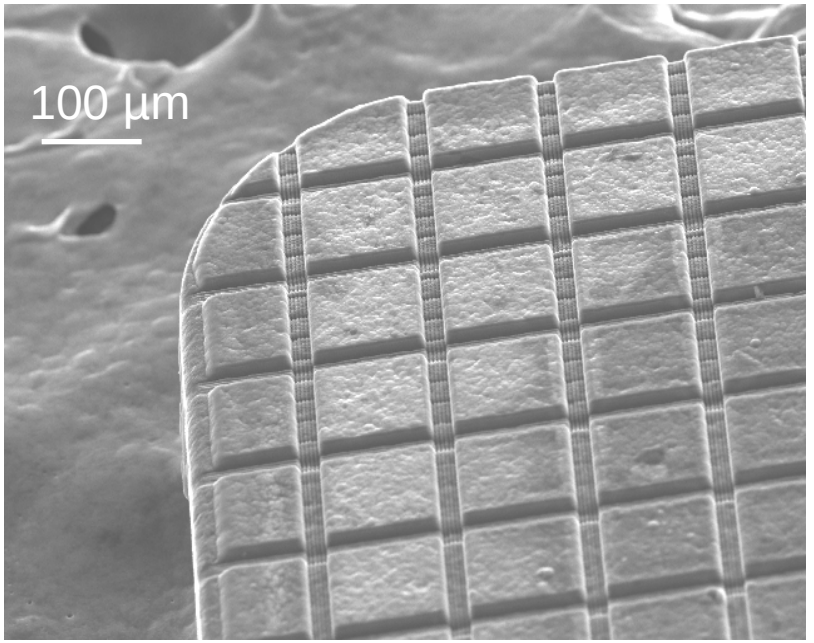
Nayagam et al., 2012

3 months implantation

Phase 2 - 1000 electrodes!

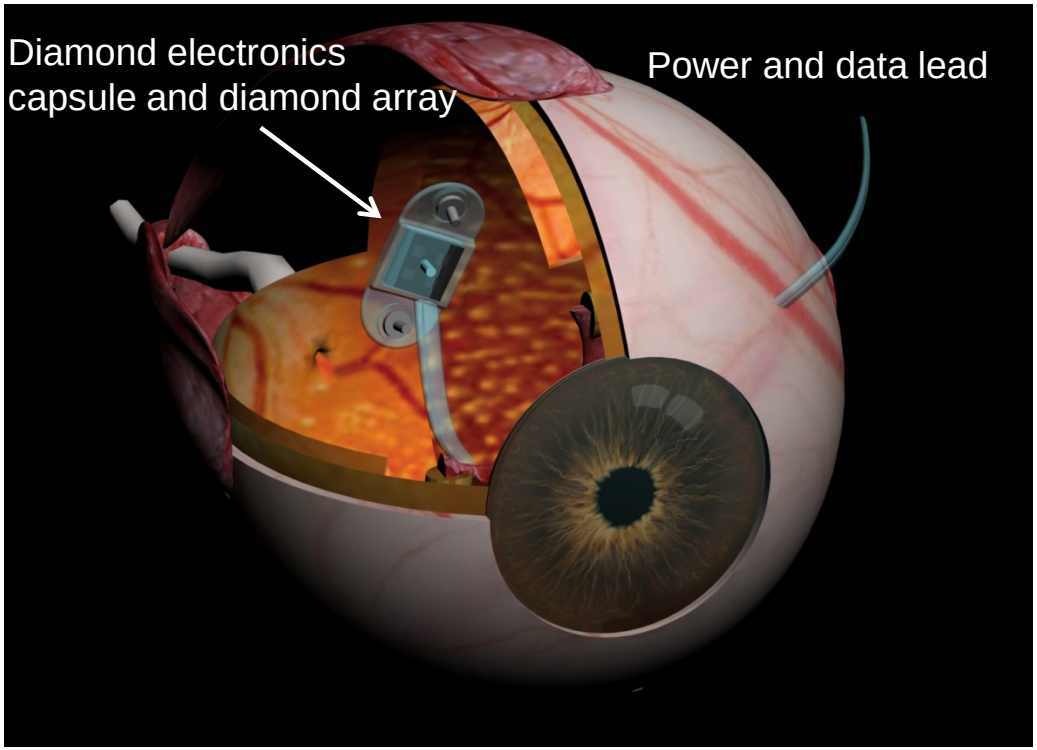


Dr Kumaravelu Ganesan & Prof Steven Prawer



THE UNIVERSITY OF MELBOURNE

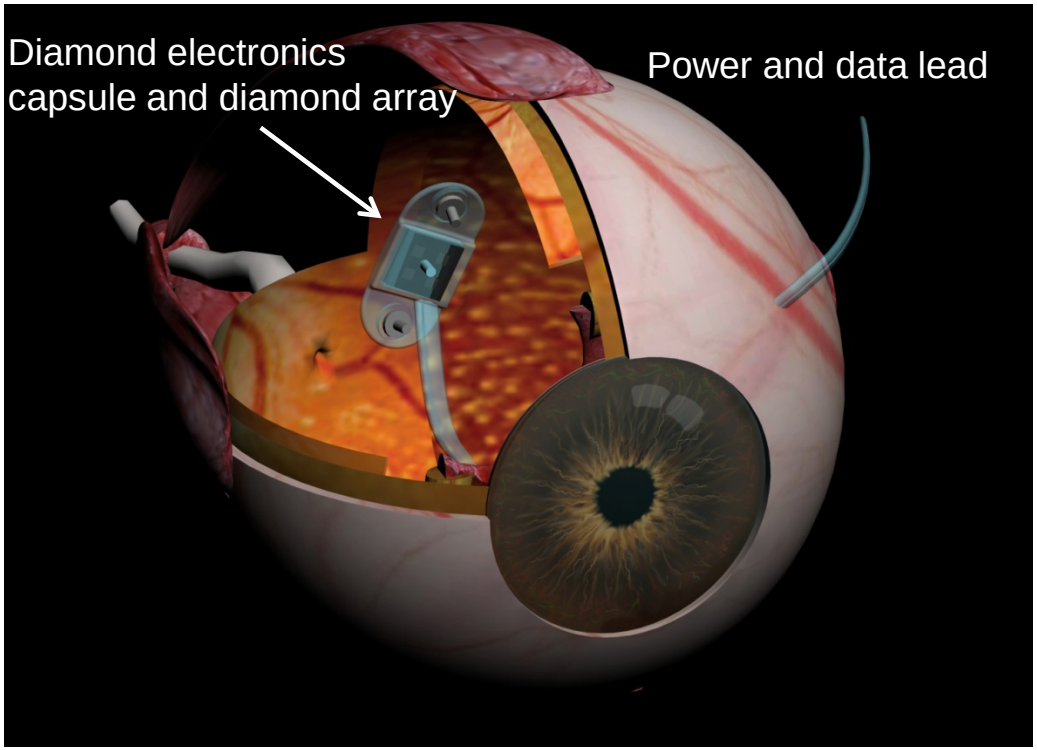
Phase 2 - 1000 electrodes!



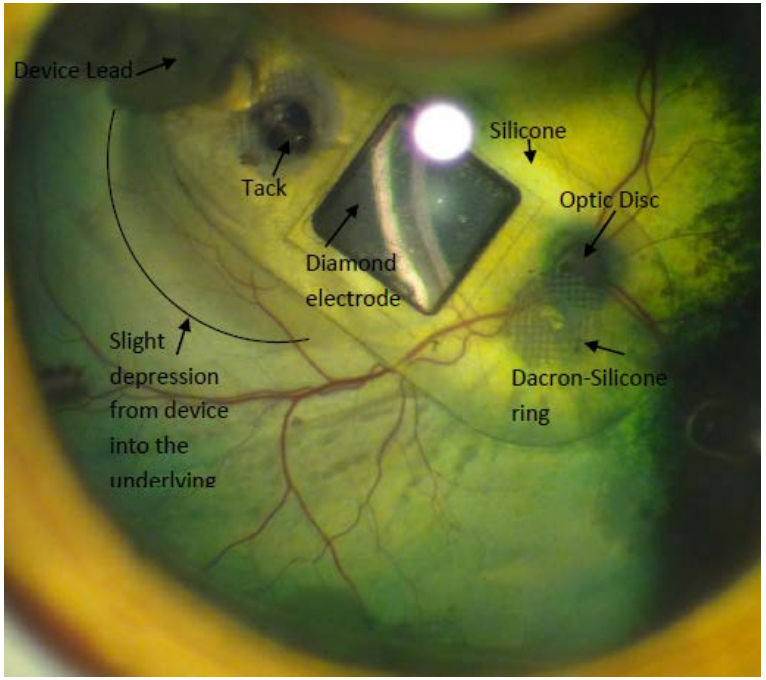
Dr David Garrett

THE UNIVERSITY OF MELBOURNE

Phase 2 - 1000 electrodes!



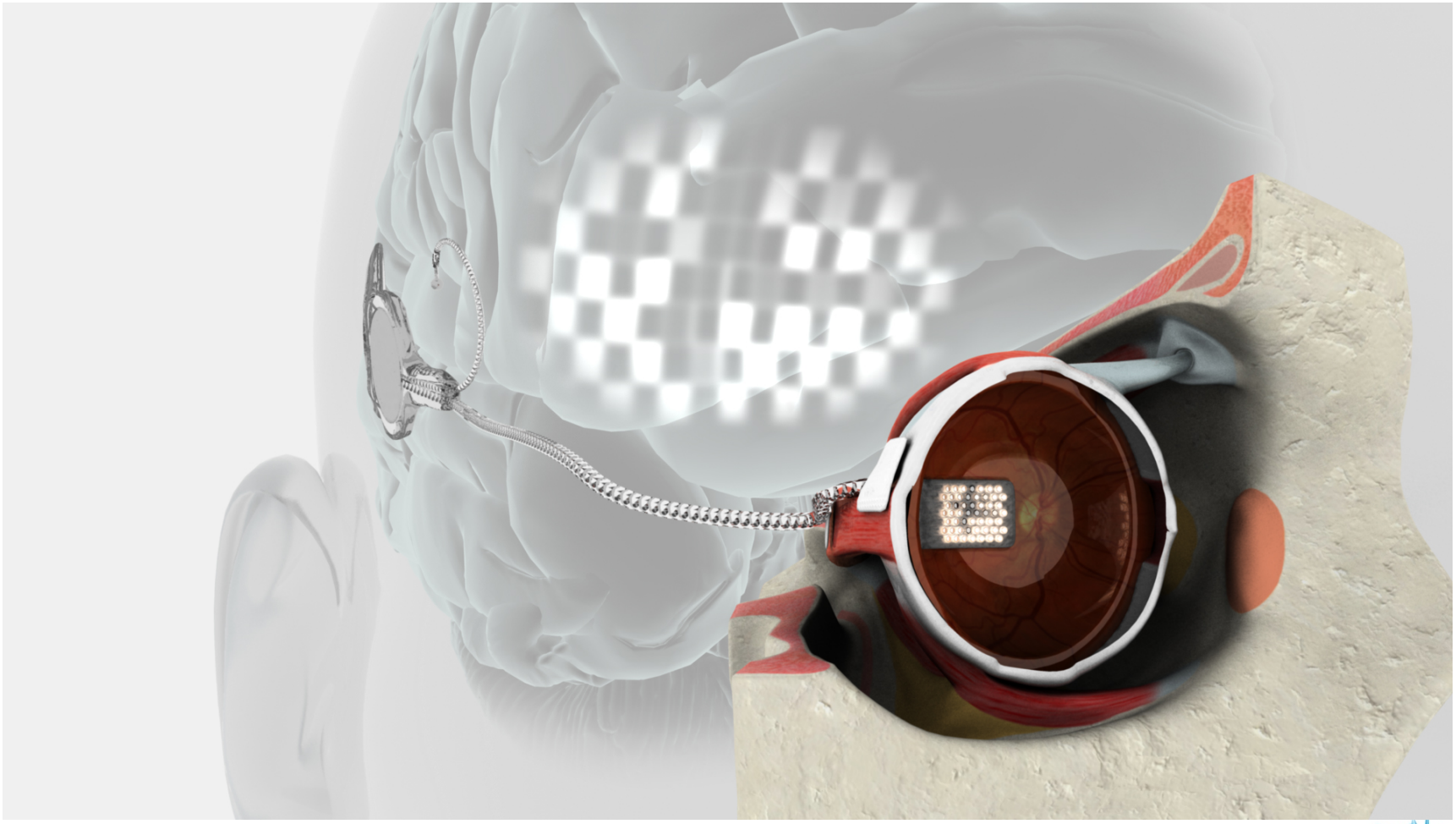
Dr David Garrett



Dr Kate Fox & Dr Penny Allen

THE UNIVERSITY OF MELBOURNE

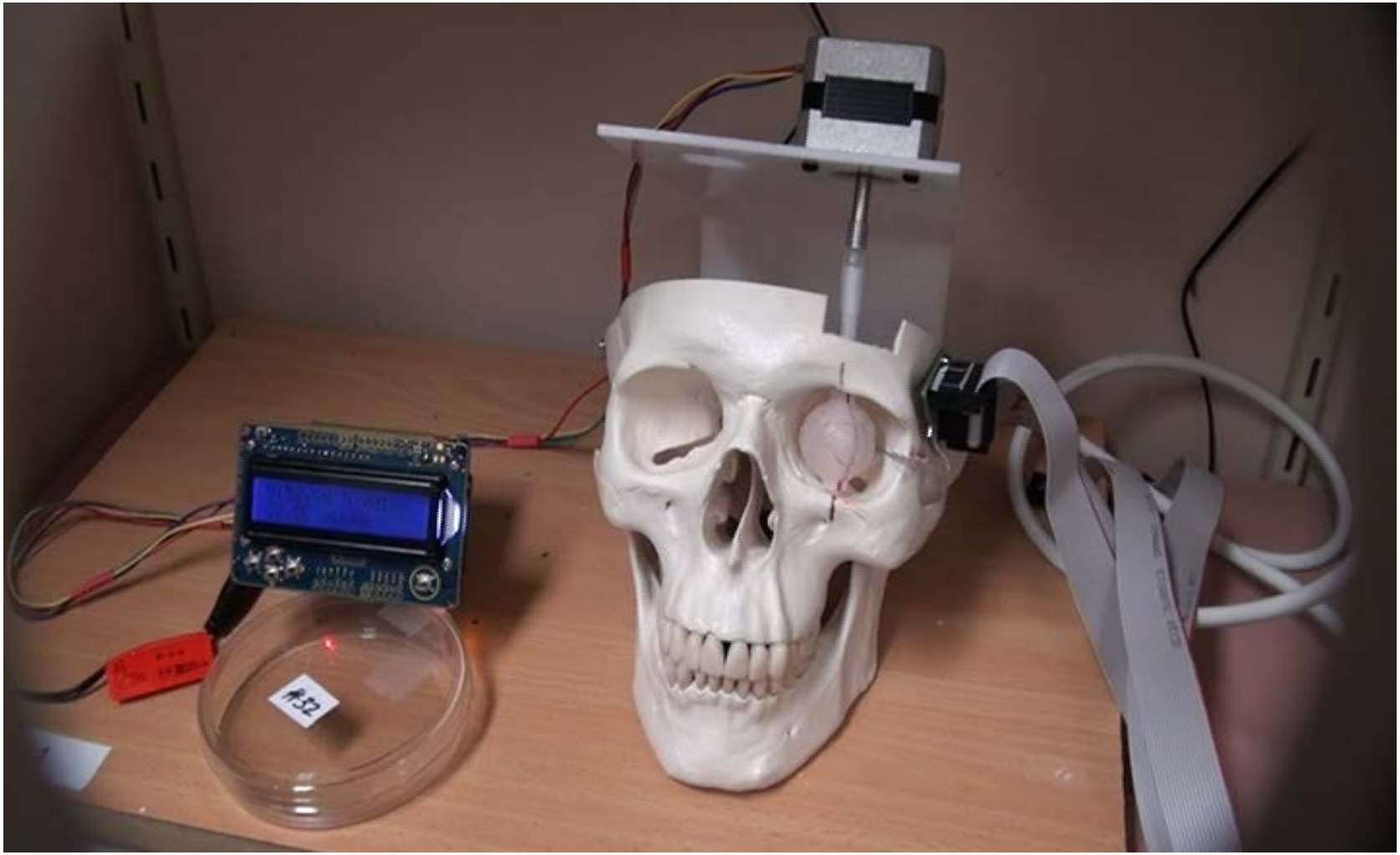
Don’t forget the cables!



Bionics institute

Don’t forget the cables!

BIONICVISION AUSTRALIA



Bionics Institute

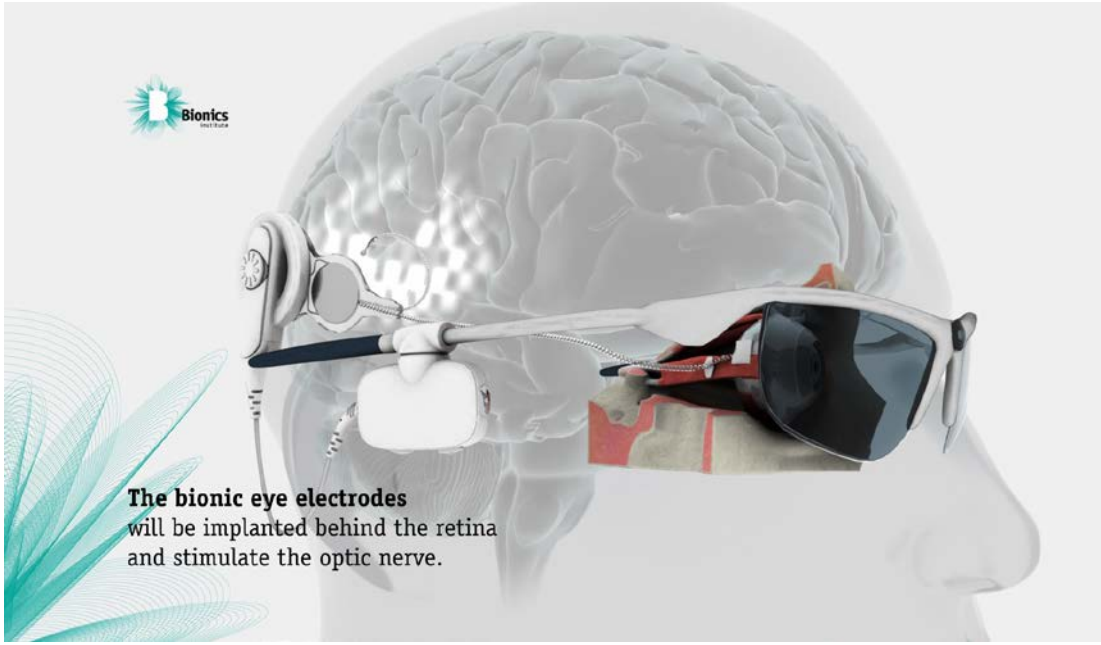

Bionics
institute

BIONICVISION
AUSTRALIA

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

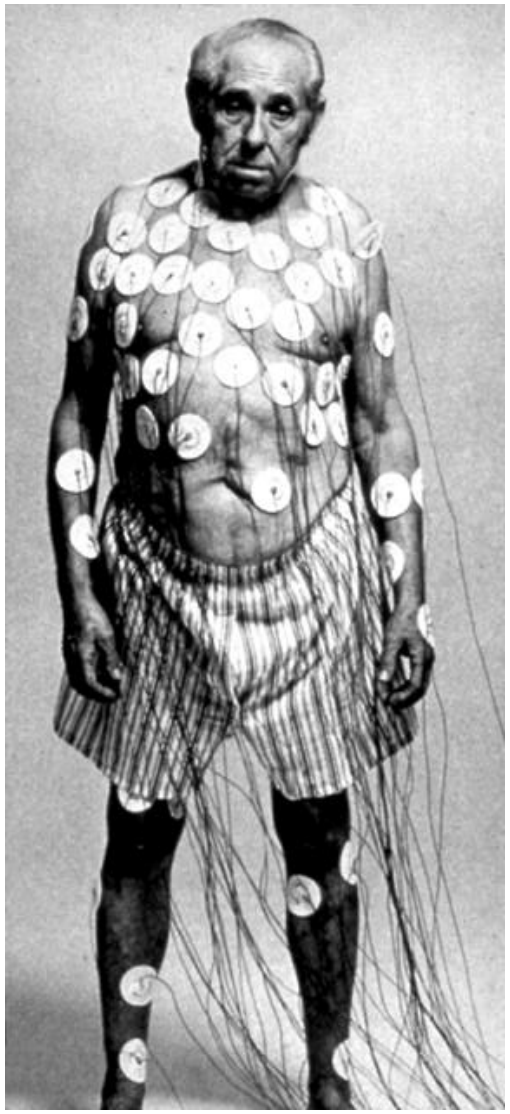
Social Sciences:

Ethicists

THE UNIVERSITY OF MELBOURNE

Bionics institute

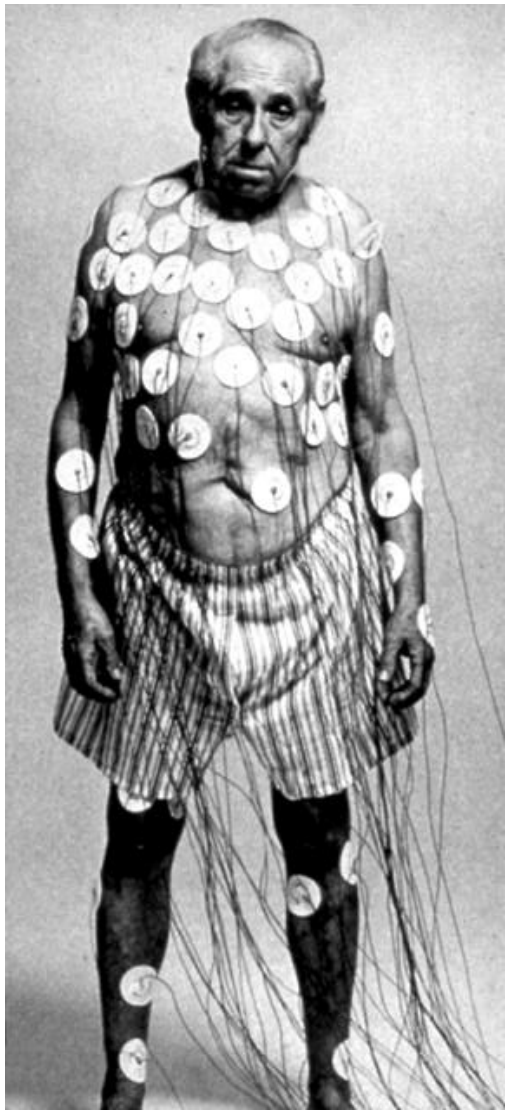
Smarter devices for patients



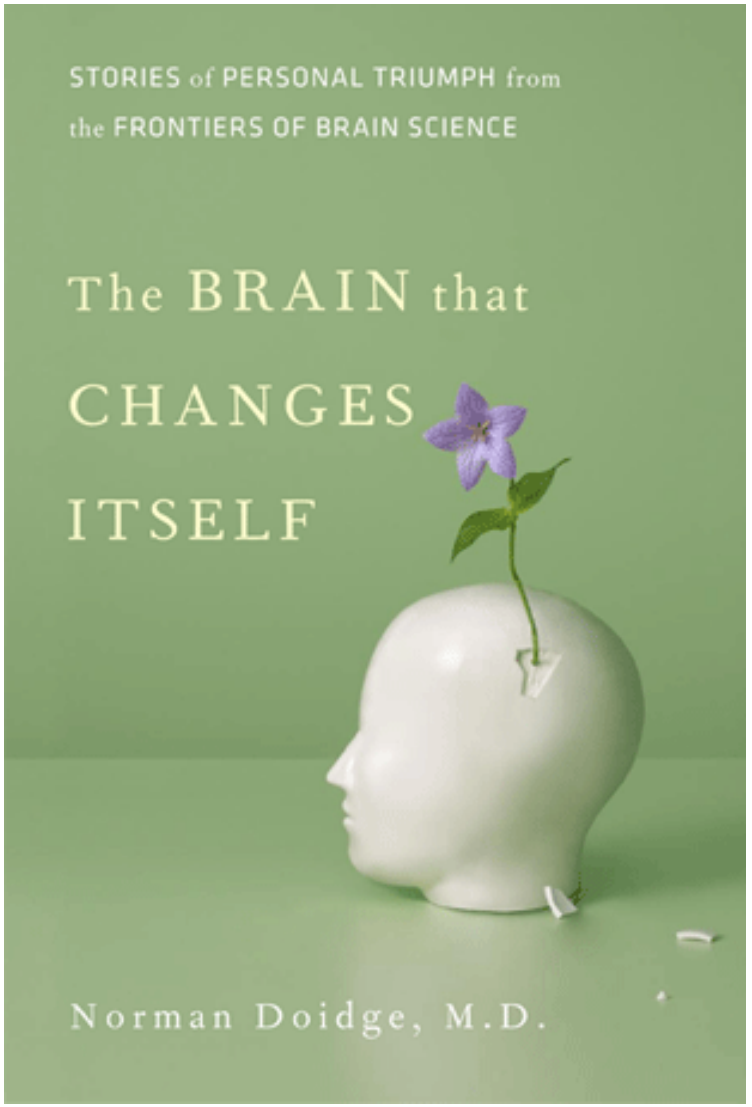
THE UNIVERSITY OF MELBOURNE

Bionics institute

Smarter devices for patients



Brain plasticity



Bionics Institute & Medical Bionics Department Team

www.bionicsinstitute.org

Bionics institute

THE UNIVERSITY OF MELBOURNE

Our Collaborators

Research

THE UNIVERSITY OF MELBOURNE

NICTA

Centre for Eye Research Australia

ARC Centre of Excellence for Electromaterials Science

UNSW

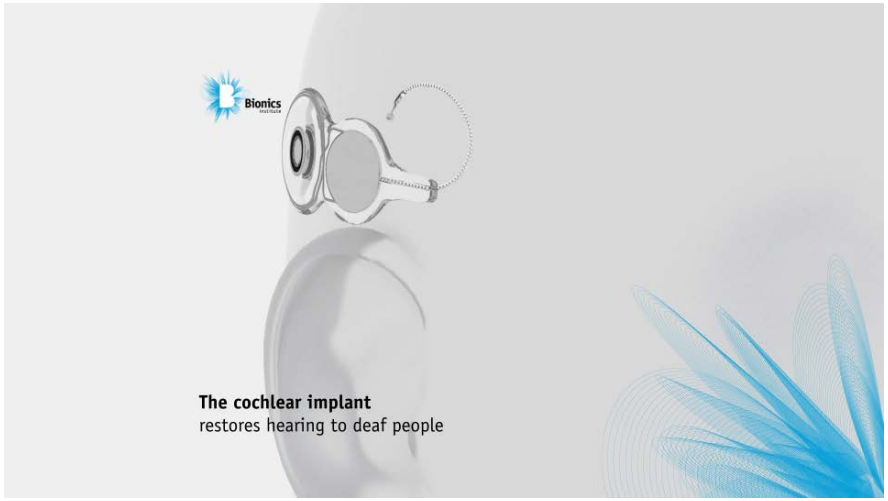
CSIRO

SWINBURNE UNIVERSITY OF TECHNOLOGY

Clinical

St Vincent's Health

Eye & Ear Hospital
caring in every sense



Commercial

Bionic enterprises
New solutions for chronic health conditions

Cochlear

HEAR
CRC for Cochlear Implant and Hearing Aid Innovation

LCT

Funding

Australian Government
Australian Research Council

Australian Government
National Health and Medical Research Council

NIDCD
National Institute on Deafness and Other Communication Disorders
Research to improve the lives of people with communication disorders

Garnett Passe and Rodney Williams Memorial Foundation