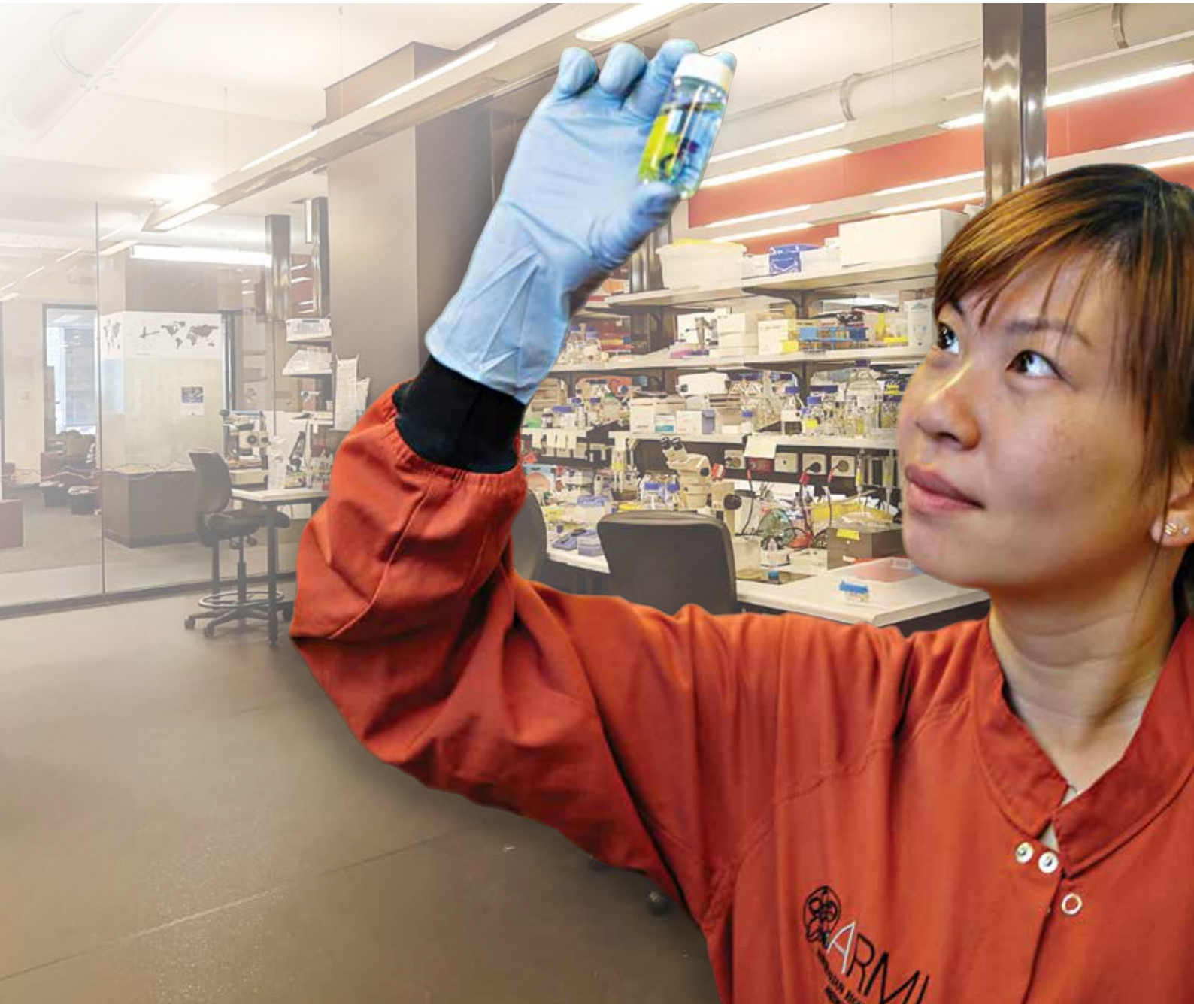
MONASH University | ARMI AUSTRALIAN REGENERATIVE MEDICINE INSTITUTE

Discovery, possibility: for a world free of disease and injury

About the Australian Regenerative Medicine Institute



Regenerative medicine has been hailed as the next evolution of medical treatments.*

The study and use of stem cell based therapies have the potential to revolutionise healthcare and cure a wide-range of currently incurable diseases.

The extraordinary regenerative capacity of other life forms can be harnessed to develop new approaches to curing human diseases; to regrow limbs, restore heart cells and build new body parts.

The Australian Regenerative Medicine Institute (ARMI) is one of the largest institutes of its kind in the world and the only research institute in Australia specialising in regeneration and stem cells.

Focused on promising new approaches in stem cell research, ARMI has a broad and overlapping range of research that investigates how to harness the body's own potential for self-repair of organs and tissues damaged by age, injury, genetic or degenerative conditions:

- Neural regeneration
- Stem cells, cancer and regeneration
- Heart and muscle development and regeneration
- Immunity and regeneration.

**United States Department of Health and Social Services hails regenerative medicine as "the next evolution of medical treatments".*

"Throughout life, our human bodies are vulnerable to disease, injury and, in some cases, congenital conditions that impair or shorten life.

With Australia's ageing population, health issues such as heart disease, stroke and Alzheimer's are on the rise. To tackle these challenges, the Australian Regenerative Medicine Institute is focused on regaining the body's remarkable regenerative capacity of damaged tissues and organs that all people have before birth.

Investigating how the body repairs, replaces, restores or regenerates damaged tissues and organs could hold the key to help unlock the body's own potential to heal and regenerate back to optimal health from an injury or disease."

Professor Peter Currie, Director, Australian Regenerative Medicine Institute.

Every 46 minutes

An Australian is diagnosed with a blood cancer – leukaemia, lymphoma or myeloma

1,000

Australians are diagnosed with MS every year, equating to approximately four people every working day

50,000

Australians suffered a stroke last year – that's 1 stroke every 10 minutes

More than 3,300,000

Australians have arthritis

3,720,000

Australians are affected by heart disease

One in ten

Australians over 65 have dementia

About Regenerative Medicine

What only regenerative medicine can do

Regenerative (regen) medicine holds the promise of teaching our cells, limbs and organs to self-repair and regenerate back to optimal health from injury or disease. Regen medicine has the potential to revolutionise health care for an ageing population that faces an increasing number of degenerative diseases.

For so many diseases, injury and cognitive functions

Imagine a world where the body has the ability to regenerate back to health; a world without:

- **Cancer**
- **Diabetes**
- **Heart diseases**
- **Arthritis**
- **Neurotrauma in the brain, such as stroke or blindness**
- **Parkinson's disease**
- **Alzheimer's disease**
- **Dementia**
- **MS (multiple sclerosis)**
- **Leukaemia**
- **Crohn's disease.**

Without these diseases, how many loved-ones, or friends and colleagues do you know who would still be alive today or be leading a much better life?

The prospect of using embryonic or adult stem cell tools and technologies to produce cell-based therapies and other treatments is no longer a distant dream.

In the medium-term (within the next decade), there are a number of major medical conditions, such as heart failure, insulin-dependent diabetes, complete spinal-cord injury, Parkinson's and possibly Alzheimer's disease, which appear to be addressable via cell-based therapies.

The social and economic burden of incurable diseases and health conditions continues to increase each year.

$55.9 Billion

was spent on hospitals in Australia during 2012–13

In the same time span primary healthcare in Australia cost

$52.9 Billion

$1 B+

MS costs Australia annually

$17.9 B+

Cost per year to Australia for heart disease

$5 B+

Estimated total costs of stroke in Australia per year

2023

The year Australian health expenditure is expected to pass the OECD average

On current trends, health spending per person is predicted to double by the year

2055

ARMI's research in developing effective treatments for a range of currently incurable diseases, as well as neurotrauma and ageing, could help save millions of lives and communities world-wide from being affected or destroyed by disease or injury.

What others say about ARMI and its life saving work

"I want to live a long, happy and pain free life… and I want that even more for those I love. So ARMI's next dimension medical science and development is one of the most effective charities in my opinion."

"The links with the best researchers around the world will lead to medical research breakthroughs that will start to change lives within 5–10 years. That's why it's in my cancer charities list."

"Even if I don't see the benefits of this scientific research, I want ARMI to succeed for my children and grandchildren."

Vision:

A globally-oriented research organisation of excellence committed to revolutionary discoveries and therapeutic strategies that lead to restoring health and normal function, repairing damaged tissues and regenerating the ageing body

Mission:

Promote Australia as a global leader in regenerative medicine and as an integral part of Melbourne's biotechnology research sector

Foster collaboration across Melbourne to link areas of existing research excellence and accelerate clinical results

Enhance research excellence, build linkages with researchers and providers against the backdrop of Monash stem cell science and biomedical research; enhance international research collaboration

Contribute to teaching the next generation of biomedical scientists in regenerative medicine

Regenerative medicine is about harnessing the body's own power to self-repair damaged tissues and organs.

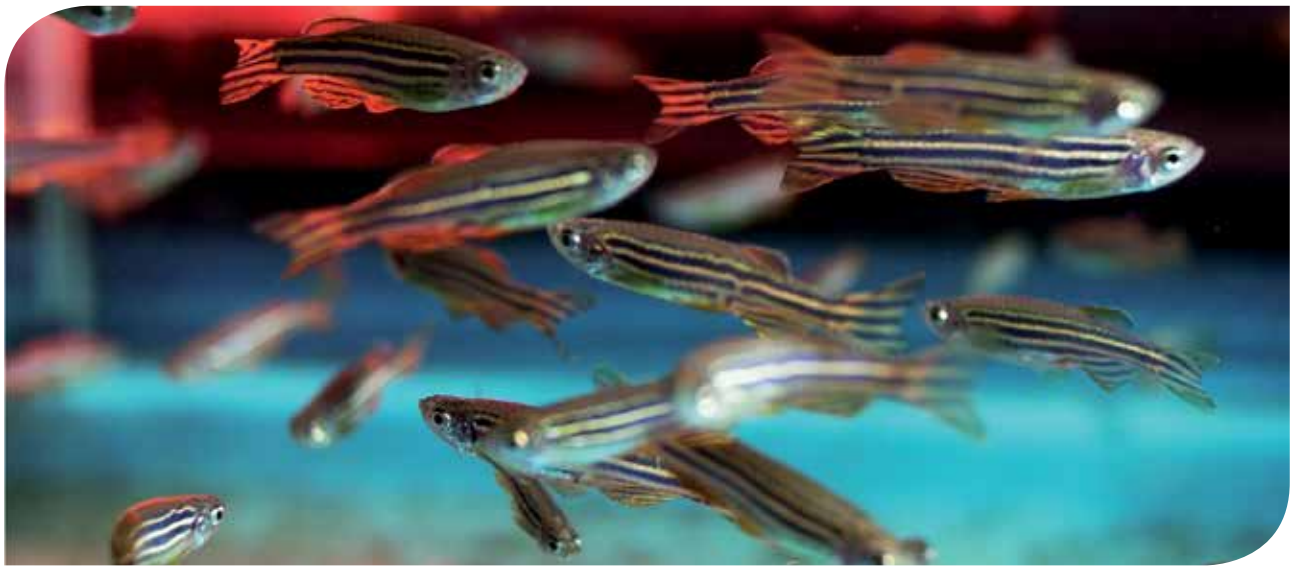
The Australian Regenerative Medicine Institute (ARMI) is a world-leader in this field and Australia's only research organisation focused on this promising new approach to personalised medicine, for a future free of disease and injury.

ARMI is one of the world's largest regenerative medicine and stem cell research hubs.

Established in 2006, ARMI opened a $153 million medical research centre in 2009 based at the Clayton campus of Monash University, in the Monash Science Technology Research and Innovation Precinct.

Facilities at the Institute include AquaCore, the largest zebra fish facility of its kind in the Southern Hemisphere, and the fastest growing system in medical research due to its ability to regenerate most of its organ systems.

ARMI endeavours to continue making major contributions to regen medicine and stem cell research; working towards eliminating currently incurable diseases and injuries, and to regenerate the ageing human body.



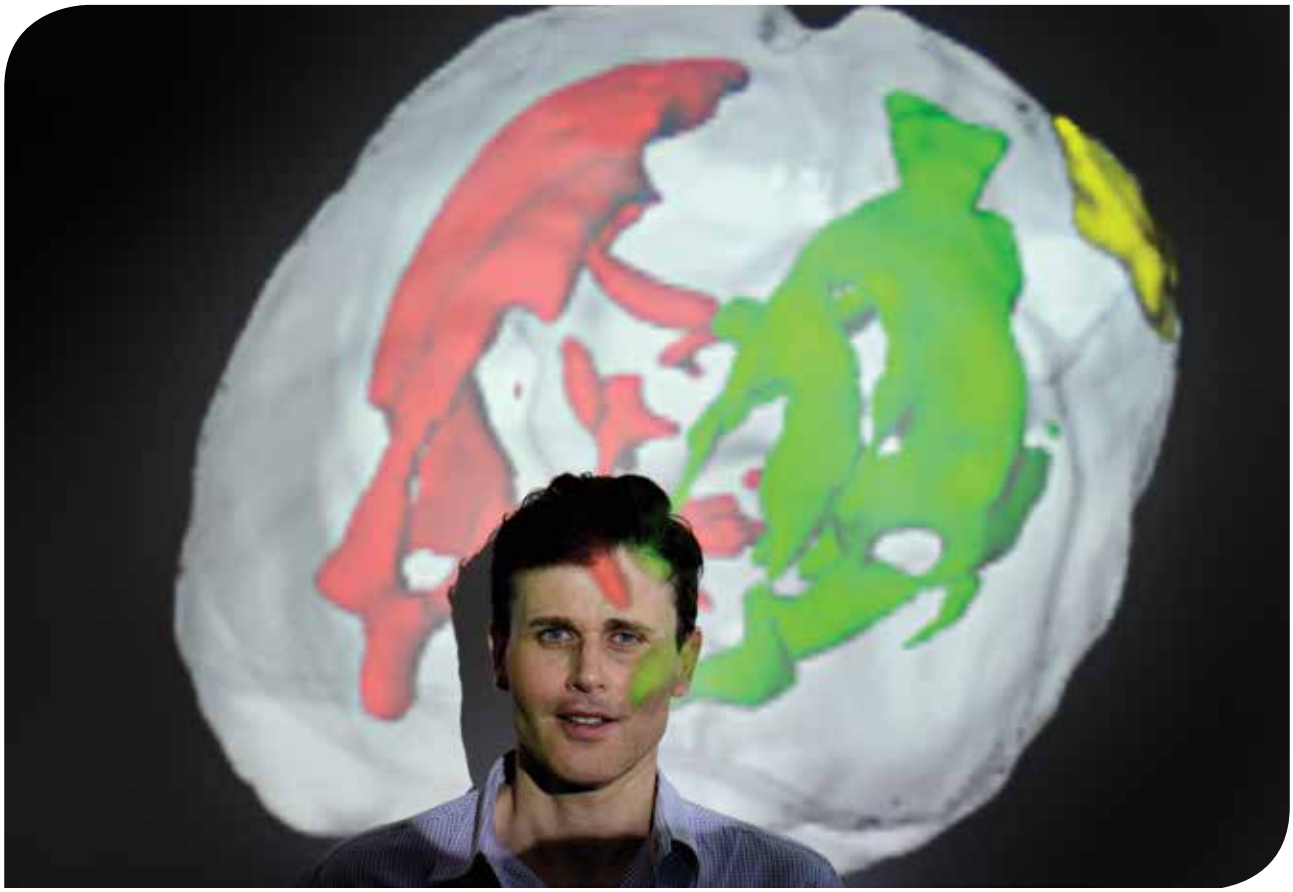


Photo courtesy of Penny Stephens / Fairfax Syndication

"The Institute has a great reputation internationally for its leading research and for bringing forward that next generation of researchers. We are an eclectic mix of researchers from different disciplines.

The way we do science here, as a true team, is the best way to get the questions answered. We can undertake a variety of techniques and greater depths of research coming from different angles.

There's a strong emphasis on succession planning, as they support all stages of a researcher's career from junior to senior staff. Other research organisations tend to focus on the senior scientists.

Young researchers like to try new things and tend to 'push the envelope' in research. This can lead to greater discoveries and innovation.

We are working together to make an impact on people's lives, and so they can have a much better standard of life."

ARMI's Bourne Group Leader, A/Professor James Bourne (pictured above).

Who is ARMI?

ARMI was established in 2006 to deliver on this medical research field's promising work of harnessing the healing power of stem cells to unlock the body's own potential to heal and regenerate damaged organs or tissues caused by disease, injury or genetic conditions.

A research institute of Monash University's Faculty of Medicine, Nursing and Health Sciences, ARMI is located at one of the world's largest regenerative medicine and stem cell research centres at Clayton in Victoria, Australia.

The Institute was established through a joint venture between Monash University and the Victorian Government with additional funding from the Australian Government. ARMI today acts as a focus for public engagement in regenerative medicine and is the source of advice for policy makers.

The Institute builds on Monash University's existing strengths in biomedical research, and the work of the University's pioneers in IVF and stem cells, to attract global regenerative science leaders and a new generation of young and creative researchers; to inspire and lead discoveries and developments in this exciting new therapeutic field.

ARMI's science focuses on delivering the next generation of discoveries in regenerative medicine. The Institute is actively engaged in the emerging area of systems biology, or "systems medicine" – the study of biological components, be it molecules, cells, organisms or entire species – which views the dynamic systems of the human body as an integrated whole, incorporating biomedical, physiological, and environment interactions that sustain life.

This research takes a new approach to clinical problems.

Some species in the animal kingdom have high regenerative potential. ARMI researchers are learning about this ability for self-repair in order to develop new therapies for conditions such as heart disease, muscular dystrophy, diabetes, multiple sclerosis, Alzheimer's Disease, brain injury and autoimmune disorders.

The Institute is one of the largest regenerative medicine and stem cell research organisations in the world and Australia's only research institute specialising in regeneration and stem cells; with a broad program across five overlapping key research streams:

- neural regeneration
- stem cells, cancer and regeneration
- heart and muscle development and regeneration
- immunity and regeneration
- organ engineering and synthetic biology

The Institute trains the next generation of basic and clinical scientists.

Most ARMI researchers are based at Monash University's Clayton campus with some having joint appointments with other Monash academic department or the CSIRO. Some of the Institute's research is undertaken through participation in national initiatives including Stem Cells Australia and the EMBL Australia Partner Laboratory.

"Young researchers like to try new things and tend to 'push the envelope' in research. This can lead to greater discoveries and innovation."

A/Prof James Bourne, Head of the Bourne Research Group, ARMI.

ARMI's integrated approach to improving outcomes encompasses

Research

18 Research Group leaders
addressing
5 key research themes

Training

Comprehensive student programs for PhD, Honours, undergraduate and visiting students to the Institute.

ARMI PhD student (pictured), Celia Vandestadt is earning her stripes on a Westpac scholarship, studying the zebrafish. *"I'm particularly interested in spinal cord regeneration,"* she said. *"Humans are most likely paralysed after a spinal cord injury — but the zebrafish can regenerate fully within six weeks. Hopefully we'll be able to shed some light on regenerative problems. I'm really excited to see where it will go — the sky's the limit, really."*

Outreach

Wide-range of national and international visitor programs.

ARMI's BioEYES program for primary and secondary students provides real science in the class room through interactive, fully immersive and engaging experiences with a science-activity based on the development of the zebrafish; bridging the gap between innovative research and classrooms to open more young minds to the possibilities of fulfilling futures in this field of science.

Facilities

The Micromon genomics, biotechnology and diagnostics facility specialises in high quality, fast-turnaround DNA and RNA technologies; and provides a seamless DNA sequencing service.

FlowCore facility provides cell counting, sorting and analysis services to researchers from Monash University, ARMI, CSIRO and the wider scientific community.

FishCore aquarium, the largest in the Southern Hemisphere, with 1000 quarantine and 5200 non-quarantine tanks. Supplies and houses zebrafish used by researchers to model a variety of human diseases and conditions.

AquaCore, a facility housing axolotls and sharks; animals which are valuable to researchers in development and regenerative biology.

ARMI Embryonic Stem Cell Facility produces mouse and rat embryonic stem cells with specific gene modifications.

Monash Micro Imaging provides the best in optical and fluorescence microscopy, confocal microscopy and live-cell imaging, giving unprecedented insights into the structure and function of proteins; to support research in the life and biomedical sciences across Monash University.

Access to most of the facilities is available through the Victorian Platform Technologies Network.

Significant discoveries and initiatives

ARMI's scientists have already made significant discoveries that have led to research partnerships with biotech companies such as Mesoblast and Sigma. Highlights include:

- discoveries into how areas of the brain that are responsible for vision could potentially adapt to injury or trauma and **ultimately prevent blindness**
- discoveries into the formation of debilitating scar tissue that follows a **spinal cord injury** and how to prevent scarring and improve **an affected patient's mobility and bodily functions**
- Currently leading the Australian arm of an international MS research consortium; the Institute's Professor Claude Bernard is **working to determine whether mesenchymal stem cells,** which can differentiate into a variety of cell types, **can safely and effectively treat multiple sclerosis**
- unlocking a mechanism that triggers stem cell production in the blood, making the production of blood cells in the laboratory an achievable end goal **to reduce the pressure on blood banks and bring humanity a step closer to developing a cure for a range of blood disorders and immune diseases**
- transforming the understanding of stem cell production in zebra fish which carry very similar genes to humans that, unlike humans, are able to regenerate parts of their central nervous system. This provides valuable insights into mechanisms that govern neural regeneration. **This work could help find future drug therapies and cures for Alzheimer's, stroke and traumatic brain injuries**
- developed the first research model for stroke that most closely resembles what happens in the human brain; the team are patenting a target [a receptor – which is a group of specialised cells] to **develop a drug that activates the receptor and prevents scarring in the adult brain after stroke**
- **published a science 'recipe book' for turning skin cells into almost any other cell in the human body;** this may allow doctors to treat conditions involving cell damage by replacing that with tissue grown from patients' own skin cells
- one of the ARMI research teams, led by Institute Director Professor Peter Currie with support from PhD student Phong Nguyen, won a coveted science award – the Eureka Prize – for their **pivotal research into stem cell generation**
- **recruited 18 new research groups to the Institute, the majority of which have been competitively recruited from overseas**
- established a **comprehensive suite of research student programs** that accommodate talented PhD, Honours, undergraduate and visiting students to the Institute
- delivering **innovative science projects into school classrooms**, with the BioEYES Education program to open more young minds to the possibilities of fulfilling futures in the life sciences
- formed **significant international linkages** with Europe's flagship organisation for life sciences – the European Molecular Biology Laboratory (EMBL) – and the Systems Biology Institute (SBI) in Japan
- established a leadership position to progress professional activities, such as the successful bid for the **International Conference on Systems Biology (ICSB2014) that was held in Melbourne** in September 2014
- **joined forces with prestigious US research centre** The Jackson Laboratory for an international exchange program between faculty and students that will also promote joint research initiatives
- has maintained **strong relationships with the European Molecular Biology Laboratory (EMBL) and Japan's RIKEN**, two international powerhouses of research.
- entered into an agreement with the Centre for Commercialization of Regenerative Medicine (CCRM) to introduce that Centre's **commercialisation expertise to ARMI and Australia**.
- announced the **first spinout company, Cell Mogrify**, arising from groundbreaking stem cell research done by Group Leader A/Prof Jose Polo

Research at ARMI is structured along five integrated Discovery Pipelines that allow research groups to explore specific aspects of the regenerative process.

Heart and muscle development and regeneration

Cardiovascular disease kills one Australian every 12 minutes and the crippling effects of traumatic injury are often permanent. ARMI researchers are studying animals with highly regenerative qualities, to develop cures for muscular dystrophy, traumatic injury and heart disease that can be translated to the patient bed-side.

Immunity and regeneration

Soon after birth, our own immune systems mature and we lose our capacity to respond to damage with scar free healing. ARMI scientists are exploring the relationships between immunity and regeneration in the animal kingdom to enhance tissue repair in patients with wounds or degenerative diseases.

Stem cells and regeneration

Stem cells comprise our embryonic origin and persist in adults as essential building blocks for our bodies. ARMI studies embryonic stem cells as a window on the mechanisms of human development, and as an essential part of the tool kit of regenerative medicine.

ARMI is devising methods for growing stem cells that can be used to: repair damaged tissue, investigate particular diseases, test drug candidates for therapeutic safety and effectiveness, and develop ways to enhance the intrinsic mechanisms of stem-mediated repair.

Neural regeneration

Unlocking the regenerative potential in the central nervous system so it can be harnessed to treat neurodegenerative disorders.

ARMI scientists are tackling the fundamental obstacles in neural repair for diseases such as multiple sclerosis and Alzheimer's, by uncovering neural regenerative potential across the animal kingdom.

Organ Engineering and Synthetic Biology

ARMI is exploring a number of innovative techniques to enhance function and form that is lost as a consequence of ageing and degenerative diseases.

These techniques explore various aspects of tissue engineering including organoid and organ on a chip technology, bioactive biomaterials and biointerfaces that simulate the cellular microenvironment at the micro and nanoscale, functional biomaterials and synthetic and biological matrices for tissue engineering and transplant development.

Driving discoveries from the lab bench to the patient bed-side

ARMI Strategic Plan: guiding the Institute from establishment into an accelerated growth phase from 2014–2019

The Institute has been developed on solid foundations; a critical success factor. The second major development period in ARMI's evolution will see further refinement and an expanding research program demonstrating excellence, innovation and impact.

The strategic direction for the Institute over the next five years is to:

- capitalise on the solid foundation that has been created
- advance the many international scientific collaborations and networks that the Institute has created
- expand ARMI's scientific resources and ensure the greatest impact from our research effort
- continue to invest in the extraordinary pool of talented young scientists that our organisation is becoming renowned for developing.

The Strategic Plan was developed with input from key stakeholders including Monash University and the Victorian State Government, and is overseen by the ARMI Leadership Advisory Board.

The next phase of the Institute's development will occur with the preparation of the 2020–2024 Plan, currently being developed. Led by the Institute's Leadership Advisory Board and incorporating input from all key stakeholders, the new plan will provide the roadmap for the continued growth of the Institute.

ARMI Timeline

07

ARMI established after Founding Director, Nadia Rosenthal, a PhD, moved from Europe's leading life sciences lab – the European Molecular Biology Laboratory (EMBL) – to pursue her discoveries towards reversing damage in heart attacks and muscle diseases.

Professor Nadia Rosenthal appointed head of Regenerative Medicine Institute. Prof Rosenthal is internationally renowned for her work on the use of stem cells in muscle regeneration and heart repair.

08

World leading medical scientist from Victor Chang Institute, **Professor Peter Currie appointed** as ARMI's Deputy Director and Head of the Regenerative Biology Unit.

09

ARMI officially opened, with its $153 million medical research centre based at the Monash University Clayton Campus in Victoria.

Professor Christophe Marcelle appointed as a Group Leader at the Institute with a focus on muscle stem cells.

10

Two new research groups commenced. First two EMBL Australia Group Leaders recruited. ARMI hosted EMBL Australia launch. ARMI was part of a national consortium awarded a $21M Australian Research Council Special Research Initiative in Stem Cell Science. Funding awarded for the ARMIRat and AquaCore infrastructure initiatives. Leadership Advisory Board formed. Outreach science program for primary and secondary schools, BioEYES pilot launched.

11

Both ARMI groups from partner network, the European Molecular Biology Laboratory, commenced and recruited their research teams. **Three new group leaders** McGlinn, Kaslin and Plachta commenced bringing the overall total number of research groups to 10. ARMI now has 100 people; made up of researchers, students, affiliates, core facility support and administrative personnel.

12

ARMI's grant application success rate of 38% for the year was higher than the national average of just over 20%. Total income from grants was more than $4.8 million, an increase of 18% over the previous year. ARMI researchers published 53 papers (up from 26 in 2011) as well as four book chapters and one book. Highlights include papers in the high impact journals Cell and Science.

ARMI's international linkages were further strengthened by the Systems Biology Institute's (SBI) decision to open its first international node at Monash University. SBI Australia is hosted at ARMI. EMBL Australia launched a student travel grants program. The Australian Bioinformatics network was launched, in partnership with CSIRO and BioPlatforms Australia.

13

ARMI's grant application success rate of 30% for the year was higher than the national average of around 20%. ARMI researchers published 52 papers and 1 book chapter. Highlights include papers in the high-impact journals Science, Nature Cell Biology, Nature Materials, Nature Communications, and The Journal of Experimental Medicine.

Five more research Group Leaders and their teams move to ARMI. Three new group leaders were welcomed as affiliates, Prof David Haylock, Assoc Prof Andrew Laslett and Assoc Prof Susie Nilsson, who all have joint appointments at CSIRO and Monash University. At the end of 2013, the Institute consisted of 194 people comprising academics and technical staff, students, administrative support and affiliate appointments.

Connections to local, national and international research grew. ARMI researchers were also involved in several large collaborative projects.

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ARMI's second five year strategic plan was delivered, guiding the Institute from establishment into an accelerated growth phase from 2014–2019.

ARMI now has 16 exceptional research groups, including joint appointments with CSIRO and the Department of Anatomy and Development Biology, each one led by a scientist renowned in their field, directing a team to explore a specific research challenge.

ARMI researchers published 54 papers and one book chapter. Highlights include papers in the high-impact journals Nature, Nature Medicine, Circ Res, Cell Stem Cell, Journal of Experimental Medicine and Cell. At the end of 2014 the Institute counted 216 people comprising academics, technical staff, students, administrative support staff and affiliate appointments. A total of 39 students are associated with ARMI making up almost 20% of the total staff at the Institute.

15

Finalised an agreement and launched a new scientific journal in regenerative medicine. npj Regenerative Medicine is an open access, online-only journal published by ARMI in partnership with the Nature Publishing Group and demonstrated the Institute's growing international leadership in the fast developing regenerative medicine research sector.

Founding Director, Prof Nadia Rosenthal was appointed as Scientific Director at the prestigious Jackson Laboratory in Maine, USA. A new EMBL Australia Group Leader was recruited maintaining the total number of of research group leaders at 16.

16

Professor Peter Currie is appointed as new Director of ARMI, and replaces Founding Director, Professor Nadia Rosenthal, who has moved to The Jackson Laboratory in Maine, USA as Scientific Director.

Entered into an agreement with the Centre for Commercialization of Regenerative Medicine (CCRM) to introduce that Centre's **commercialisation expertise to ARMI and Australia**.

The **first spinout company, Cell Mogrify**, arising from groundbreaking stem cell research done by Group Leader A/Prof Jose Polo.

Initiated the Regenerative Medicine Industry Interface to better understand the Australian Regenerative Medicine industry sector to further inform the Institute's research program.

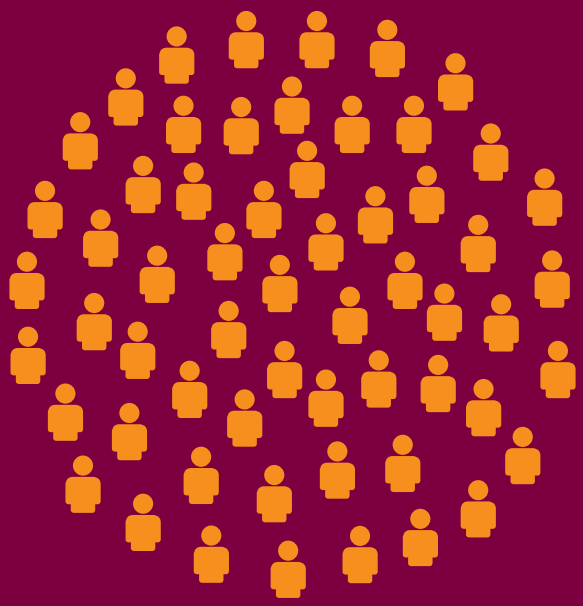
ARMI's people

6

Office of the Director

59

Academic



3

Executive

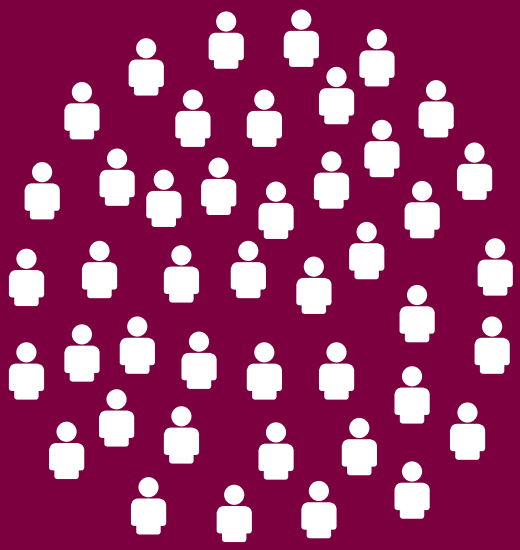
28

Affiliate researchers

ARMI began in 2007 with founding director Professor Nadia Rosenthal and a small team of dedicated staff. ARMI opened its research centre in 2009 and has since grown to become a world leader in this field, with one the largest biomedical facilities for regenerative medicine globally; with specialised and diverse teams of talented researchers.

44

Technical



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Governance (ARMILAB)*

4

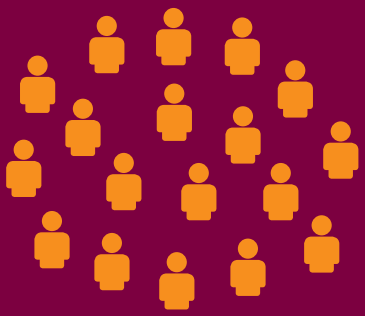
Scientific Advisory**

38

Research students

18

Research groups



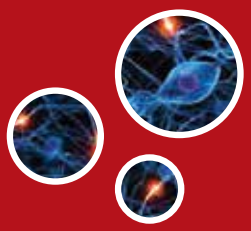
* **ARMI's Leadership Advisory Board (ARMILAB)** and the Scientific Advisory Board play a vital part in ARMI. ARMILAB Members include: Dr Janine Kirk, AM, Chair; The Hon Dr Kay Patterson, Deputy Chair; The Hon John Brumby; Mr Andrew Dyer; Dr Zita Unger; Professor Peter Currie, Dr Tangerine Holt, Dr David Rhodes, Ms Sonya Walker, Mr Andrew Brough and Dr Frances Guyatt.

****The Scientific Advisory Committee** provides advice to the Director, in particular with regard to scientific proposals and on the preparation and realisation of the scientific programme of the Institute. It performs its task in due cooperation and in consultation with the Director, seeking the advice of experts where appropriate. Members include: Prof Dame Kay Davies, DBE, FMedSci, FRS, University of Oxford, UK; Prof Sir Magdi Yacoub, FRCS, FRS, Imperial College London and Harefield Heart Science Centre, UK; Prof Peter Rigby, FRS, FMedSci, The Institute of Cancer Research, UK; Prof Eric Olson, University of Texas Southwestern Medical Center, Dallas, USA.

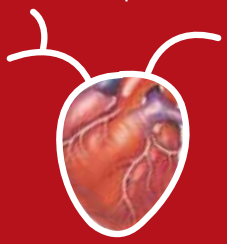
ARMI's areas of research

neural regeneration

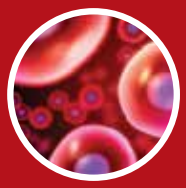
stem cells and regeneration



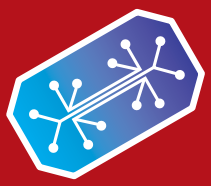
heart and muscle development and regeneration



immunity and regeneration



organ engineering and synthetic biology



Research groups

The Bernard Group – work on promising new approaches to understanding multiple sclerosis (MS) and ways to treat and protect patient's from the damage it causes. Group Head, Professor Claude Bernard is currently leading the Australian arm of an international MS research consortium for a clinical trial to help progress treatment of MS. The group's research concentrates primarily on unravelling the inflammatory processes that lead to degeneration in the human central nervous system. The group is interested in understanding the pathophysiology of MS and developing new cell-based and gene therapy treatments that may offer alternatives to current MS therapeutics.

The Bourne Group – is working to develop a treatment for the most common form of stroke that can be administered up to three weeks after a stroke.

The group have garnered an international reputation for being at the forefront of visual neuroscience with a particular emphasis on development, plasticity and repair following injury. They are the first in the world to develop a model akin to stroke in humans. Further understanding of visual system neurobiology will result in not only understanding how visual function works in a normal brain, but also in the repair and functional recovery of adult brains following an injury like stroke. The group is currently working on developing a treatment for the most common form of stroke that can be administered up to three weeks after a stroke. Clinical trials will start within the next 5 years.

The Currie Group – study zebra fish muscle development and evolution to identify drug candidates, leading to new treatments for muscular dystrophy. The group is studying mutations in zebra fish that mirror the onset of human muscular dystrophy, and have developed zebra fish models of common muscular dystrophies; with the aim of understanding the cell biological and developmental mechanisms that underlie the pathogenesis [the production and development of disease] of this group of diseases.

The Hobbs Group – aims to uncover the self-renewal capabilities of adult stem cells, which will have importance to the fields of fertility, tissue regeneration and cancer. Their primary research aim is to identify and define the critical molecular mechanism underlying adult stem cell function. The main role of adult stem cells is to maintain and repair the tissue in which they are located by a process of cell division to replenish dying cells. When stem cell renewal and differentiation becomes unbalanced or disrupted, it contributes to degeneration or cancer. Discovering the mechanisms behind this will provide invaluable information to medical science.

The Kaslin Group – focus on understanding the molecular and cellular mechanisms that control cellular plasticity in the intact and injured vertebrate brain. Zebra fish exhibit widespread adult neurogenesis (formation of nervous tissue) and are able to regenerate parts of their central nervous system. The zebra fish is used as a model to study adult neurogenesis and for insights into mechanisms that govern neural [brain] regeneration. This could have clinical implications in future for Alzheimer's, stroke and traumatic brain injuries.

The Laslett Group – is focused on assessing a cell based therapy for multiple sclerosis. A pluripotent cell type has the capacity to continually reproduce itself and to turn into any cell in the human body. This creates huge potential for the treatment of diseases and injuries. The group aims to better understand the processes that occur when pluripotent cells become specialised cells, such as neural cells. This information is then used to develop tools and assays to help produce desirable cell types and to identify and remove unwanted cell types.

The Lieschke Group – seek to exploit the unique strengths of the zebrafish model in genetics, embryology, and for visualizing cell behaviour in vivo to understand blood cell development and diseases. They study the haemopoietic system (blood production) and leukocytes (white blood cells). The haemopoietic system is a collection of organs and tissues (bone marrow, spleen, lymph nodes etc.) responsible for the production of blood in the body. Leukocytes are the keys cells involved for counteracting foreign substances and disease. They also play a major role in determining whether tissue repairs and regenerates rather than scars after injury.

Research themes include discovery of genes critical for white blood cell development, investigating how the inflammatory response is regulated; looking at how modulating the inflammatory white blood cells might tip the outcome to favour regeneration rather than scarring, and investigating how white blood cells keep.

Research groups (cont.)

The Cooper-White group is focused on the development of novel microfabricated devices, artificial cell culture substrates, directive bionanomaterials, and injectable tissue-integrating hydrogels for applications in stem cell culture, gene therapy, regenerative medicine and tissue engineering.

The Janovjak group's research lies at the interface of synthetic biology and physiology with a focus on understanding and manipulating cellular signalling and cell-cell communication in health and disease. The group has developed innovative methods to remotely control cellular signals with high spatio-temporal precision (e.g. using light or ultrasound). And will use these methods to address major problems in signalling and tissue regeneration using synthetic approaches. Because the research program encompasses the development of new molecular methods and their application to physiology the Group has termed this 'synthetic physiology'.

The Marcelle Group – focus on understanding how functional skeletal muscle arises from a group of unspecialised mesodermal cells – of which the essential building blocks are derived for connective tissue, bone, cartilage, muscle, blood and blood vessels, lymphatics, lymphoid organs, notochord, pleura, pericardium, peritoneum, kidneys, and gonads. This period is crucial to development because the fate of individual cells are decided, extensive cell migration occurs and tightly regulated cell division takes place. The group's three main aims are to observe the cellular events that take place during muscle formation, understand the molecular mechanisms underlying muscle fusion, and identify gene networks implicated in the maintenance and differentiation of muscle stem cells.

The Martino Group – is focused on combining knowledge of immunology, stem cells, and bioengineering, to understand how the immune system modulates tissue repair and regeneration. By leveraging discoveries from the lab, the group aims to engineer effective strategies for repairing and ideally regenerating damaged tissues.

The Merson Group studies the cellular and molecular interactions between neurons and myelin-forming oligodendrocytes with the central nervous system. The major goal their research is to develop strategies to promote myelin repair in diseases such as multiple sclerosis. The Group also has an emerging interest in the role of oligodendrocyte turnover and myelin remodelling in cognitive processes such as learning and memory and the contribution of myelin dynamics to neurological disorders.

The McGlinn Group – is interested in how genes influence the pattern mechanisms of the vertebrate skeleton. Pattern formation refers to how particular cells develop into final cell types. Their work will ultimately provide insight into how genetic hierarchies govern how the vertebrate skeleton is formed.

The Nagy Group – is focused on combining knowledge of developmental biology, stem cells and genetic engineering to create successful therapeutics for regenerative medicine applications. Through an internationally initiated consortium, the group are continually expanding knowledge of stem cells, reprogramming and cellular states and further refining hypotheses and experimental approaches; and is establishing underlying technologies to engineer "designer cells" with important novel functions.

The multidisciplinary team of computational and molecular biologists specialise in genomics. They conduct research using new genomic technology and the zebrafish as a model organism.

The Roselló-Díez group – studies the signals that operate within the bones and between them and other tissues/organs during development and regeneration. At the local level, they study phenomena such as compensatory proliferation in response to biochemical and mechanical changes in the cell vicinity. At the systemic level, they are exploring the role of the vascular and nervous systems in the bidirectional communication between the bones and the rest of the body.

The Nilsson Group – is currently involved in a number of research projects that focus on understanding haemopoietic stem cells, which are responsible for the production of blood and immune cells. They focus on the microenvironment in which blood stem cells reside. They also look at blood stem cells at a cellular and molecular level, as well as analysing how they create new blood cells. Learning more about normal and diseased stem cells will lead to better prevention, clinical diagnosis and treatment, which will ultimately improve human health. An example of this is better bone marrow transplantation outcomes in cancer patients, because they will be able to replace normal cells that are destroyed during anticancer therapy. Essentially, it will allow higher doses of chemotherapy or radiation to be given, which will be a more effective form of treatment.

The Polo Group – is interested in mechanisms that govern cell identity and cell fate, making cells ready for therapy. The work in this area is of great interest in pharmaceutical and clinical settings, since the technology can be used to generate animal and cellular models for the study of various diseases as well as provide (in the future) specific patient tailor-made cells for their use in cellular replacement therapies.

The Ramialison Group – working on heart disease and applying systems biology (the study of biological components, be it molecules, cells, organisms or entire species) to reconstruct the cardiac gene regulatory networks and to work out not only what leads to proper heart formation, but what are the causes of congenital heart disease.

ARMI has a total staff of 216, with 17 research group leaders

Bernard Group Leader
Prof Claude Bernard

Bourne Group Leader
A/Prof James Bourne

Cooper-White Group Leader
Prof Justin Cooper-White

Currie Group Leader
ARMI Director
Prof Peter Currie

Hobbs Group Leader
Dr Robin Hobbs

Janovjak Group Leader
Prof Harald Janovjak

Kaslin Group Leader
Dr Jan Kaslin

Laslett Group Leader
A/Prof Andrew Laslett

Lieschke Group Leader
Prof Graham Lieschke

Marcelle Group Leader
Prof Christophe Marcelle

Martino Group Leader
A/Prof Mikaël Martino

Merson Group Leader
Dr Toby Merson

McGlinn Group Leader
EMBL Australia Partner Laboratory
A/Prof Edwina McGlinn

Nagy Group Leader
Prof Andras Nagy

Nilsson Group Leader
Prof Susie Nilsson

Polo Group Leader
A/Prof Jose Polo

Ramialison Group Leader
Dr Mirana Ramialison

Rosello-Diez Group Leader
Dr Alberto Rosello-Diez

ARMI's recent major awards

ARMI is recognised as a world leader in regenerative medicine research, as indicated by some of the major awards our staff have recently received

Eureka Prize for Scientific Research 2015

The Australian Museum Eureka Prizes are the most comprehensive national science awards, honouring excellence in Research and Innovation, Leadership, Science Communication and Journalism, and School Science. The prestigious award is billed as "the Oscars of Australian Science".

ARMI Deputy Director Professor Peter Currie and ARMI PhD student Phong Nguyen, from the Faculty of Medicine, Nursing and Health Sciences, together with Dr Georgina Hollway from the Garvan Institute of Medical Research won the 2015 Eureka Prize for scientific research. The team identified a new family of cells – endotomal cells – that wrap themselves around nascent stem cells, signalling them via released proteins that it's time to 'switch on'.

Their award winning work has transformed the global scientific community's understanding of stem cell development and opens up a host of new research routes, with exciting potential to generate blood cells on demand for medical treatment.

Metcalf Prize for Stem Cell Research; and the Dean's Award for Excellence in Research

ARMI's Polo research group leader, Dr Jose Polo was awarded the inaugural Metcalf Prize for Stem Cell Research in 2014, the Dean's Award for Excellence in Research and a Sylvia and Charles Viertel Senior Medical Research Fellow.

National Health & Medical Research Council, UK

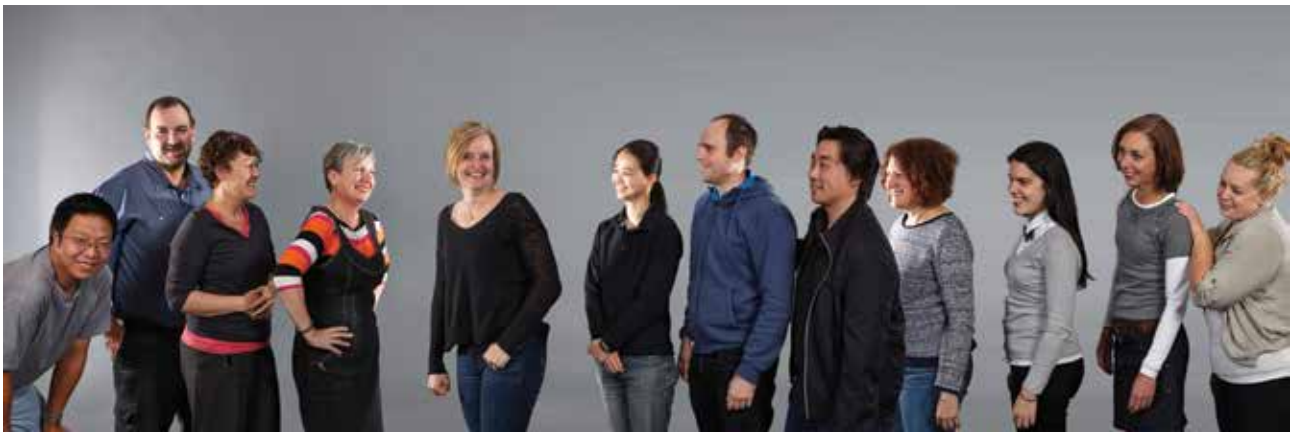
ARMI Founding Director Professor Nadia Rosenthal was elected to the Academy of Medical Sciences (UK) in 2014, The Australian Academy of Health and Medical Sciences and announced as one of the National Health & Medical Research Council High Achievers.

ARMI Director Professor Peter Currie is a recipient of a European Molecular Biology Organization Young Investigators Award and a Wellcome Trust International Research Fellowship.

A new open access, online-only journal – the npj Regenerative Medicine – has been established and is published in partnership with the Australian Regenerative Medicine Institute at Monash University and Nature Publishing Group.

ARMI's most recent success highlights

New way to harvest stem cells from bone marrow donors reduces procedure time and side effects



The Nilsson Group (pictured above), headed by Professor Susie Nilsson, discovered a new way to harvest stem cells better for donors.

For bone marrow transplantation, stem cells are routinely harvested from healthy donors and used to treat patients with cancers including leukaemia. Current harvesting methods take a long time and require injections of a growth factor to boost stem cell numbers. This often leads to side effects.

The discovery, published March 2016 in Nature Communications, reduces the time required to obtain adequate numbers of stem cells, without the need for a growth factor. The method combines a newly discovered molecule (known as BOP), with an existing type of molecule (AMD3100) to mobilise the stem cells found in bone marrow out into the blood stream.

Professor Susie Nilsson said her team was able to demonstrate that combining the two molecules directly impacts stem cells so they can be seen in the blood stream within an hour of a single dosage. *"Current treatment requires the donor to have growth factor injections for several days leading up to the procedure," Dr Nilsson said.*

"Using the new method eliminates the need for this, meaning a procedure that once took days can be reduced to around an hour."

Until now AMD3100 has only been effective in increasing stem cell numbers when combined with the growth factor. "But the growth factor can cause unpleasant side effects like bone pain and spleen enlargement for some donors," Dr Nilsson said. "Other donors simply don't respond well, and their stem cell count never gets high enough for a successful transplant."

The scientists found that combining the two small molecules not only eliminates the need for the growth factor, but when the harvested cells are transplanted they can replenish the entire bone marrow system, and there are no known side effects.

Recipe for tissue repair a skin cell breakthrough

Researchers have created the "recipe book" for turning skin cells into almost any other cell in the human body. The landmark finding from the international research project **paves the way for growing whole organs from human cells, as well as fast-tracking cell regeneration treatments for conditions such as diabetes, heart attacks, Alzheimer's, burns and spinal cord injury. The important finding will advance the stem cell field in the area of repair and regeneration.**

The field of cell reprogramming has until now been moving slowly, stalled by the trial-and-error method of finding the right combination of proteins to create the desired cells. But an algorithm created by University of Bristol scientists in the UK, and tested by Monash University stem cell biologists, has found a predictive model that calculates the right ingredients — the proteins needed to activate the right genes — to reprogram cells in as little as four months, instead of the usual three to four years.

The findings were published January 2016 in the prestigious journal Nature Genetics. Monash PhD student Jaber Firas said their work, with supervisor Associate Professor Jose Polo (pictured above), could **allow doctors to treat conditions involving cell damage by replacing that with tissue grown from the patient's own skin cells.** *"Hopefully the recipe will pave the way to that, and it will fasten the work,"* he said. The Mogrify algorithm was placed online allowing researchers to enter their starting and desired cell type to give them the right recipe.

New stroke treatment gives brain repair hope

Melbourne researchers are developing a treatment for the most common type of stroke, which can be administered up to three weeks later. **It is hoped the treatment will enable the injured brain to repair itself like a baby's brain can.**

More than 50,000 Australians had an ischaemic stroke in 2014, caused by a blood clot or artery blockage. But just 5 per cent of patients got the best-available treatment.

And clot-busting drug tPA can only be given within four hours of the stroke happening, or else there is a high risk of bleeding in the brain. About 35 per cent of patients either have the stroke in their sleep or don't know the time of onset, so they cannot be given the drug.

Associate Professor James Bourne, a group leader at the ARMI (pictured below), is aiming to salvage cells in the penumbra, the wider rim of brain tissue around the dead tissue at the site of the stroke. His group is **the first to develop a research model that closely resembles what happens in a human brain.**

"Most people know someone with a brain injury, whether it's stroke, or Alzheimer's or from an accident. It's a plague on society," says A/Prof Bourne. "We are patenting a target to develop a drug that activates the receptor and prevents scarring in the adult brain after stroke. This would benefit so many people, their families and society."

Sharks could reveal how neck disease forms in humans

PhD student, Celia Vandestadt.

New insights into how the neck vertebrae of elephant sharks naturally become fused could help researchers to understand how neck development can go wrong in people affected by disease.

Researchers from ARMI, Curtin University, the Natural History Museum, London and the Australian Synchrotron, investigated how the fused neck developed in elephant sharks. In people with the disease known as Klippel-Feil syndrome, the vertebrae of the neck becomes fused, but in living sharks and rays, and in some fossil armoured fish called placoderms, having a neck encased in bone is normal.

Lead researcher, Dr Catherine Boisvert, ARMI, said knowing how this fused neck formed under normal conditions could be the first step in understanding how neck development can go wrong in people when affected by the disease.

"In some animal species, part of the animal's body mimics what we see in a human disease. These species are known as 'evolutionary mutants', and analysing them provides unprecedented access to information in a healthy individual."

"We are gaining a better understanding on how these morphologies develop and what developmental pathways (genes and their networks) are involved in producing them. This knowledge may help us better understand the disease in humans.

"All in all, we are coming closer to understanding how a fused neck develops normally or under stressful conditions *(as is the case for farmed salmon) in a range of vertebrates at the base of our ancestry."*

Discovery of brain pathway could lead to ways to prevent blindness

Associate Professor James Bourne.

Associate Professor James Bourne from ARMI has discovered that there are several pathways to the visual brain. The research was featured in The Age, 17 February 2015 and published in the prestigious journal *Current Biology.*

The research overturned the long-held view that there is only one route for information to travel from the eye to the brain, **with the discovery of a second "pathway" boosting hopes for future treatments to prevent blindness.**

"It is a very novel idea," said Associate Professor James Bourne. "It's a great leap forward in understanding how the brain is wired."

The findings, outlined in the journal Current Biology February 2015, in effect redraw the map of the human brain as we know it and provide a greater insight into the brain's capacity to rewire itself after injury.

It was thought that one route from the eye to the brain was responsible for conscious vision and if this were damaged, sight was lost.

However, the research, led by ARMI researchers, shows that if the primary pathway is injured in the first year of life, the brain can modify its structure and continue to function normally.

Professor Bourne said that given its complexity, the pulvinar was an area of the brain that had been ignored for years, though there were likely other pathways yet to be discovered.

Vision is the most complex sense. More than 50 per cent of the large outer layer of the brain, known as the cortex, is devoted to it.

People with conditions such as autism or schizophrenia, which feature sensitivity to light or hallucinations, may also benefit from the new brain findings.

"This gives a bit of a clue and an insight into how those things might be happening if the primary pathway looks normal," A/Professor Bourne said. "Understanding this route of information is really important, and this is really the first study looking at it."

ARMI International

ARMI researchers have been recruited from

21

different countries around the world and are from

34

different nationalities

The European Molecular Biology Laboratory (EMBL) Australia headquarters is hosted at ARMI. Australia's Associate Membership of the EMBL and associated activities are coordinated through the establishment of EMBL Australia.

Systems Biology Institute (SBI) Australia is also headquartered at ARMI, the first international node of the SBI in Japan. The node connects Japanese and Australian research and industry partners, and facilitates the sharing of scientific technology, resources and expertise.

ARMI has a cooperative agreement with internationally recognised US research centre, the Jackson Laboratory, an independent non-profit biomedical research institution. The agreement creates opportunities for exchange of faculty, postgraduate students and research staff; establish programs in areas of teaching, research or university administration and identify other areas of possible interest and collaboration.

Canada's Centre for Commercialization of Regenerative Medicine (CCRM) has become globally recognised as a translation centre and is now a leading global commercial hub for regenerative medicine and related therapies. In partnership with CCRM, the ARMI is leading the development of CCRM Australia, modelled on the successful operational model of CCRM, which is a national initiative to support the Australian regenerative medicine sector.

The Mount Desert Island Biological Laboratories (MDIBL) and ARMI have also finalised an MOU that outlines the intent of the MDI Biological Laboratory and ARMI to collaborate in scientific, education and public and political relations activities that are mutually beneficial and serve to advance both organizations.

International Scientific Advisory Committee UK

Prof Dame Kay Davies, DBE, FMedSci, FRS, University of Oxford, UK

Prof Sir Magdi Yacoub, FRCS, FRS, Imperial College London and Harefield Heart Science Centre, UK

Prof Peter Rigby, FRS, FMedSci, The Institute of Cancer Research, UK

International adjunct appointments (Italy)

Prof Cornelius Gross
European Molecular Biology Laboratory (EMBL)

International adjunct appointments, USA

Prof Kevin Strange

Mount Desert Biological Laboratory (MDIBL)

Prof Nadia Rosenthal

The Jackson Laboratories, Maine, USA

International adjunct appointments, Japan

Prof Hiroaki Kitano

Systems Biology Institute, Tokyo

International Scientific Advisory Committee USA

Prof Eric Olson, University of Texas Southwestern Medical Center, Dallas, USA

International adjunct appointments, South America

Prof Miguel Allende

FONDAP Centre for Genome Regulation, University of Chile

Prof Jose Xavier-Neto

Brazilian Biosciences, National Laboratory (LnBio)

Governance and risk

The Australian Regenerative Medicine Institute (ARMI) is a not-for-profit organisation limited by guarantee. It is a charitable entity with Deductable Gift Recipient Status (DGR) via Monash University and is an approved research institute. All national or international donations over $2AUD to the Institute are tax-deductible.

ARMI is led by a Board of Directors, the Leadership Advisory Board, chaired by Dr Janine Kirk AM. The Board plays an important role in helping the Institute achieve its objectives and strategic goals. The Board's operations are informed by an Audit and Risk Committee and Scientific Advisory Committee. Professor Peter Currie leads the Executive, which is responsible for delivering ARMI's Strategic Plan and managing all aspects of the Institute's daily operations.

Research Group Leaders

Prof Peter Currie (Director)
Prof Claude Bernard (Deputy Director)
A/Prof James Bourne
Prof Justin Cooper-White
Dr Robin Hobbs Assoc
Dr Harald Janovjak
Dr Jan Kaslin
A/Prof Andrew Laslett (CSIRO)
Prof Graham Lieschke
Prof Christophe Marcelle
A/Prof Mikaël Martino
Dr Toby Merson
A/Prof Edwina McGlinn
Prof Andras Nagy
Prof Susie Nilsson (CSIRO)
A/Prof Jose Polo
Dr Mirana Ramialison
Dr Alberto Rosello-Diez

Leadership Advisory Board

Board members include:

Chair, Dr Janine Kirk is the Chief Executive of The Prince's Charities Australia (PCA).

Deputy Chair, The Hon Dr Kay Patterson, a former Senator for Victoria for 21 years.

Directors:

Mr Andrew Brough has worked in technology venture capital and management in Europe developing several ventures from University R&D and consulting on innovation to leading organisations such as the BBC, NHS, UCL, Siemens and Philips.

The Hon John Brumby, was Premier of Victoria from 2007–2010.

Prof Peter Currie, is the Institute Director and one of the world's leading researchers in the development and regeneration of muscle.

Mr Andrew Dyer, is Chairman of the Telecommunications Industry Ombudsman Council and ITSS.

Dr Frances Guyatt is Executive Director, Innovation and Commercial Strategy, Australian Red Cross Blood Service.

Dr Tangerine Holt is Director, Higher Education Markets & Growth for KPMG.

Mr Tim Murphy has held senior roles across a range of industries in the public and private sectors from the Federal Government to pharmaceutical, medical research and biotechnology to higher education, arts and tourism.

Dr David Rhodes has more than 16 years' experience in healthcare and biotechnology, where he has held several senior management and executive level roles.

Dr Zita Unger, has a distinguished career spanning 15 years as an evaluator, educator and entrepreneur.

Ms Sonya Walker is Vice President – Pacific Region and Managing Director Australia and New Zealand for Infor, a leading international enterprise software provider.

Contact Details

Australian Regenerative Medicine Institute
15 Innovation Walk, Monash University
Wellington Road, CLAYTON VIC 3800

Laura Crilley
Executive Officer
+61 3 9902 9604
laura.crilley@monash.edu

Peter Dalton
Development Advisor
+61 407 181 944
peter.dalton@monash.edu

www.armi.org.au

@Armi_Labs

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The Australian Regenerative Medicine Institute would like to acknowledge the ongoing support of our stakeholders – Monash University, the state government of Victoria, the Australian Research Council and the National Health and Medical Research Council. Their assistance is greatly appreciated and allows ARMI to continue its research into regenerative medicine.

The scientists and students of the Institute also acknowledge the following corporate partners for their support.

Accor Group

Inkube8 Design

The Social Science

The Institute was established through a joint venture between Monash University and the Victorian Government to deliver the next generation of discoveries in regenerative medicine.

ARMI is part of the largest commitment to research that Monash University has ever made, with $103 million that funded the construction of ARMI's $153 million laboratory facilities that opened in 2009.

ARMI is supported by grants from the State Government of Victoria and the Australian Government. The Victorian Government dedicated $35 million towards major research equipment and the specialist fit-out of laboratories. In 2007, the Australian Government contributed $15 million.

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