MONASH University | ARMI AUSTRALIAN REGENERATIVE MEDICINE INSTITUTE

About the Australian Regenerative Medicine Institute

Your partner in collaborative research and development

ARMI is actively seeking collaborative opportunities with leading research organisations and industry to further advance our discovery program. Please contact Institute Director, Prof Peter Currie peter.currie@monash.edu.

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 diseases are the number one cause of death globally: more people die annually from CVDs than from any other cause. An estimated 17.9 million people died from CVDs in 2016, representing 31% of all global deaths. Of these deaths, 85% are due to heart attack and stroke.

ARMI researchers are studying animal models with highly sophisticated and specific tissue regenerative qualities, to develop cures for heart disease and other muscular disorders "including dystrophies" that can be translated to the patient bed-side.

Immunity and regeneration

Soon after birth, our 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 across the animal kingdom to enhance tissue repair in patients with wounds or degenerative diseases.

Stem cells and regeneration

Stem cells are integral to the development of tissues in the embryo 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 has devised 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 cell-mediated repair. ARMI is able to offer IP on specific stem cells for culturing and scale up and models that allow testing of stem cell potency.

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 the 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 Regenerative Science

ARMI was established in 2006 to deliver on this medical research field's promise of harnessing the healing power of stem cells to unlock the body's 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 State Government with additional funding from the Australian Federal Government. ARMI today acts as a focus for public engagement in regenerative medicine and is the source of advice for policymakers.

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 research 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."

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

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**
- 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 similar genes to humans that, unlike humans, are able to regenerate parts of their central nervous system. **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 in non human primates that most closely resembles what happens in the human brain; the team have a patent for a candidate drug that activates a specific 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 20 new research groups from leading national and international research organisations with expertise and skills in high demand by the regenerative medicine and pharmaceutical sectors**
- established a **comprehensive suite of research student programs** that accommodate talented PhD, Honours, Masters, undergraduate and visiting students that power the institute's research program
- 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
- **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 by Group Leader Prof Jose Polo. Recently (Feb 2019) announcing additional funding for a total of US$3.7m, Mogrify, through its direct cellular conversion platform can identify the optimal combination of transcription factors (in vitro) or small molecules (in vivo) to convert any mature cell type into any other mature cell type – without needing to transition through a stem cell.
- have discovered a factor that triggers **muscle stem cells to proliferate and heal**. ARMI researchers have identified a group of immune cells, called macrophages, which have a role in triggering the muscle stem cells to regenerate. Macrophages are the cells that flock to any injury or infection site in the body, removing debris and promoting healing.
- led an international team of scientists to **generate a model of a human embryo from skin cells**. The team, led by Professor Jose Polo, has successfully reprogrammed these fibroblasts or skin cells into a 3-dimensional cellular structure that is morphologically and molecularly similar to human blastocysts. Called iBlastoids, these can be used to model the biology of early human embryos in the laboratory.

Our Research Teams

Heart and muscle development and regeneration

Currie Group

The Currie group is curious about the biological mechanisms of the Zebrafish, a fresh water fish that is native to South East Asia. Zebrafish are used in scientific research to understand human genetics and the biological processes of human diseases.

The Currie group use zebrafish embryos to learn about muscle cell types. In particular, they are interested in how specific muscle cell types are determined within the developing embryo, how they grow and how they regenerate after injury, to provide insights into muscle wasting and other diseases including the dystrophies.

McGlinn Group

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.

The group use the limb bud and axial skeleton as points of study because it helps them understand broader developmental processes. A greater level of comprehension into the limb bud and axial skeleton will allow the group to provide insight into how genetic hierarchies govern how the vertebrate skeleton is formed. This work has developed an understanding of how to grow and shape different tissue for therapeutic benefit.

Ramialison Group

The Ramialison group is studying development and disease. They are a multidisciplinary team of computational and molecular biologists who specialise in genomics. They conduct their research using new genomic technology and the zebrafish as a model organism.

The group focuses on 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.

del Monte Nieto Group

The del Monte-Nieto group is interested in the study of the molecular mechanisms and developmental processes orchestrating normal heart development in embryos by integrating all the cellular and non-cellular components involved.

The lab aims to apply multidisciplinary approaches including mathematical modeling and bioengineering to developmental biology studies in order to generate in silico and in vitro models to confirm our biological results and formulate new hypothesis. The group aims to apply multidisciplinary approaches including mathematical modeling and bioengineering to developmental biology studies in order to generate in silico and in vitro models to confirm our biological results and formulate new hypothese to design novel therapies for heart disease.

Immunity and regeneration

Lieschke Group

The Lieschke group studies the haemopoietic system and leukocytes.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 (white blood cells) 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. The group's increased understanding of the role of the leucocytes when the immune system is compromised, eg as in leukemias has helped identify potential target molecules.

Martino Group

Dr Mikaël Martino and his group focusses on the immune regulations of stem cells and regeneration, seeking to design regenerative medicine strategies integrating a control of the immune system.

Compounds that can accelerate regenerative processes in a wide range of tissues and organs are being identified and evaluated.

Stem cells and regeneration

Laslett Group

The Laslett group investigate the biology of human pluripotent stem cell lines, including embryonic stem cells (hESC) and human iPS cells.

Further comprehension of human pluripotent stem cell lines will lead to the development of tools and novel cell lines that will be required for the safe use of these cell types in future cell-based industries.

Andrew Laslett and his group are employed by CSIRO and hold adjunct appointments with ARMI.

Nagy Group

The Nagy Group is focused on combining knowledge of developmental biology, stem cells and genetic engineering to create successful therapeutics for regenerative medicine applications.

The group's research program also aims to tackle several major challenges facing the translation of cell therapies to the clinic, such as generating and improving the effectiveness of therapeutic cells and eliminating risks of tumorigenesis.

Nilsson Group

The Nilsson Group is currently involved in a number of research projects that focus on understanding haemopoietic stem cells (HSC). Haemopoietic stem cells are responsible for the production of blood and immune cells.

The main objective of the group's research is to characterise the microenvironment in which blood stem cells reside. They also look at blood stems cells at a cellular and molecular level, as well as analysing how they create new blood cells.

This can be used to treat a range of blood diseases including leukemia.

Polo Group

The Polo group is interested in the transcriptional and epigenetic mechanisms that govern cell identity and cell fate, in particular pluripotency and the reprogramming of somatic cells into induced pluripotent stem (iPS) cells and other mature cell types.

Being able to reprogram any specific mature cell into a pluripotent state and then back into any other particular cell gives the group a unique tool to study the molecular and cellular events that permit the conversion of one cell type to another.

This knowledge allows for development of therapies for specific tissue and organs from stem cells.

Zenker Group

The Zenker group seeks to understand how a cell's structure and function is regulated by the continuous re-organization of the microtubule network. Live imaging is used to discover the spatio-temporal accuracy of the microtubule dynamics in animal models of developmental and stem cell biology. Understanding the formation of the first stem cells in embryos is leading to insights into how these cells can be harnessed for therapeutic benefit.

Neural regeneration

Bourne Group

The Bourne 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.

The main focus of the group is to study the development and maturation of the cerebral cortex in primates and other mammals. The group explore, at a cellular and system level, how the brain processes the environment, which is rich with visual information.

Kaslin Group

The Kaslin group is interested in cellular plasticity, which is the ability of cells to take on characteristics of other cells in the body. But rather than study the process throughout the entire body, the group are focused in understanding the molecular and cellular mechanisms that control this process in the intact or injured vertebrate brain.

Understanding the process of cellular plasticity is essential to the development of successful therapies to promote neural regeneration.

Merson Group

The Merson group studies the interaction between neurons and glial cells in the central nervous system. A primary focus is understanding the mechanisms that regulate myelination of axons by oligodendrocytes, particularly in response to myelin loss as occurs in multiple sclerosis (MS). The group adopts cutting-edge approaches to identify new therapeutic targets to treat MS. Our core objectives are to optimise myelin regeneration to restore neuronal function rapidly and prevent progressive neurological decline.

Nillegoda Group

The Nillegoda group is probing attractive new proteostasis-based directions for future therapeutic interventions that could potentially slow and/or reverse neurodegeneration and are applicable for a broad range of disorders from Alzheimer's disease to Multiple sclerosis.

Organ engineering and synthetic biology

Janovjak Group

The Janovjak group combines synthetic biology and physiology to understand and manipulate the behavior of cells in health and disease. By applying physical actuators, such as light or sound, the Group aims to target cells in situ with spatial precision (for instance, selected cells in a tissue or organism) and with temporal precision (for instance, at selected stages during development).

The team is focused on the development of molecular tools for the precise activation or inhibition of cellular signaling pathways and on the application of these tools to tune the balance of cell growth and cell death in animal models.

Rossello-Diez Group

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 group has devleoped insights into growth regulation in the developing body enabling the design of therapeutics for situations where tissue growth and organ repair is perturbed.

Unique Capabilities

- Automated drug candidate screening using zebrafish embryos
- Stroke mitigation drug candidate
- Stem cell therapies for muscular dystrophy

Neurodegenerative Disease Focus

- Alzheimer's and Brain Repair Centre
- Advanced Multiple Sclerosis research
- Stroke mitigation
- Neural Plasticity

Clinical Cardiac Focus

- 200 bed Victorian Heart Hospital
- Dedicated Research Facilities
- Access to state and national clinical trials and data management expertise

Aquatics Research Platform

- Largest zebrafish facility
- Killi and Medakafish
- Axolotls
- Unique to Australia

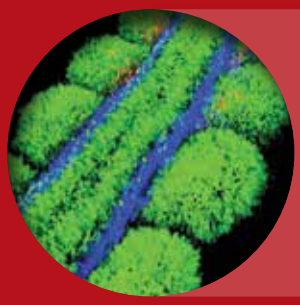
Avian Research Platform

- Transgenic Quail Facility
- One of three in the world
- Unique to Australia

Commercialisation Expertise

- Deep regenerative medicine commercialisation focus
- Founding member of CCRM Global Network
- Direct access to Australia's leading regenerative medicine companies and research organisations

ARMI discovery pipelines

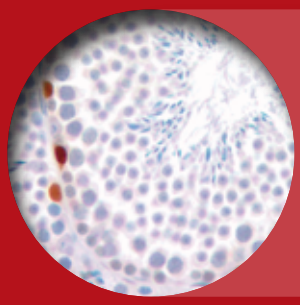


Heart and muscle development and regeneration

Currie	www.armi.org.au/research-leadership/currie-group
McGlinn	www.armi.org.au/research-leadership/mcglinn-group
Ramialison	www.armi.org.au/research-leadership/ramialison-group
del Monte Nieto	www.armi.org.au/research-leadership/del-monte-nieto-group

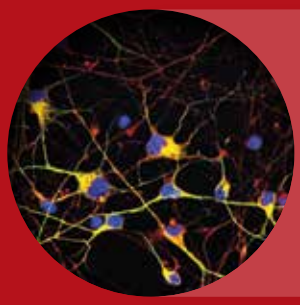
Immunity and regeneration

Lieschke	www.armi.org.au/research-leadership/lieschke-group
Martino	www.armi.org.au/research-leadership/martino-group



Stem cells and regeneration

Laslett	www.armi.org.au/research-leadership/laslett-group
Nagy	www.armi.org.au/research-leadership/nagy-group
Nilsson	www.armi.org.au/research-leadership/nilsson-group
Polo	www.armi.org.au/research-leadership/polo-group
Zenker	www.armi.org.au/research-leadership/zenker-group



Neural regeneration

Bourne	www.armi.org.au/research-leadership/bourne-group
Kaslin	www.armi.org.au/research-leadership/kaslin-group
Merson	www.armi.org.au/research-leadership/merson-group
Nillegoda	www.armi.org.au/research-leadership/nillegoda-group

Organ engineering and synthetic biology

Janovjak	www.armi.org.au/research-leadership/janovjak-group
Rossello-Diez	www.armi.org.au/research-leadership/rossello-diez-group

Contact Details

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

Peter Currie
Director
+61 3 9902 9602
peter.currie@monash.edu

Silvio Tiziani
Director, External Strategy and Planning,
Australian Regenerative Medicine Institute
+61 4 1853 6209
silvio.tiziani@monash.edu

Please contact the above for more detailed information on the material presented in this document or to request an introductory presentation.

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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.

Inkube8 Design

Opyl

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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