THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

# Auckland Bioengineering Institute

## Postgraduate Prospectus

ACHIEVE THE AMAZING

# Welcome to Auckland Bioengineering Institute

**Our vision is to apply the principles of engineering and mathematics to human physiology so that new approaches to medical diagnosis and therapy can be developed.**

Auckland Bioengineering Institute (ABI) is a world leader in the development of standards and software for physiological modelling, and associated models, instrumentation and experimental methods. It the only research institute in the world with the ability to integrate bioengineering research across all aspects of human (and animal) physiology. It also provides a vibrant and supportive environment for innovation in medical device technologies, having spun out over 10 successful companies in the last five years.

This prospectus will provide you with an overview of our research activities and will give you an idea of what you can study at ABI.

ABI is one of two large-scale research institutes at the University of Auckland, bringing together research staff in ABI with research staff who teach in the Faculties of Engineering, Medical and Health Sciences, and Science. They share a common interest in developing engineering approaches to the understanding of biological systems in order to provide a basis for new approaches to medical diagnosis and therapy.

At ABI, PhD students have a unique opportunity to become involved in our Doctoral Training Programme. This is the only one of its kind in New Zealand, and offers modules to equip students with key technical and professional skills that they need for their degree, and exposure to commercial and clinical environments for their future career. As a consequence, graduates from ABI can be found not just in academia but also in business and commercial research organisations.

We have a vibrant research culture and a thriving multi-cultural international postgraduate population. Postgraduate students at ABI come from a wide range of academic backgrounds including applied mathematics, software development, electrical engineering, industrial engineering, computer science, physics, biomedical sciences, and physiology. Our multidisciplinary team approach means that students have opportunities to learn skills across disciplines and are often part of international collaborations.

Whether you have a desire to improve healthcare systems, develop new medical devices, make a new discovery, or work in a commercial environment, ABI can provide you with opportunities for all of this.

Please take the time to read this prospectus and check out our website to gain further insights into our work. We look forward to welcoming you to ABI in the near future.

**PROFESSOR PETER HUNTER**
Director, Auckland Bioengineering Institute
The University of Auckland


ACHIEVE THE
AMAZING

# Why study with us?

ABI is a world-renowned research institute with an emphasis on translating innovative research into real solutions that have the potential to improve the health and wellbeing of New Zealanders and people around the globe. As a student at ABI, you will have the opportunity to not only study at New Zealand's leading University, but you will also potentially work alongside world-class researchers in their fields.

## Research-based degrees

ABI offers both masters projects as part of a Masters in Engineering (ME) with a thesis in Bioengineering, and PhD programmes. These research-based degrees enable students to not only experience a career in research, but also take away with them valuable skills gained whilst working in the field.

## Training and support throughout your studies

At ABI, we highly value our postgraduate student culture and are dedicated to providing our postgraduates with the best possible training. We offer the only Doctoral Training Programme in New Zealand that equips students with skills for a career not just in academia, but also in teaching, industry and commercial research. As a student at ABI, you are able to take part in this training programme and to get practical industry experience.

## World-class research

ABI is home to some of the brightest minds in New Zealand – our researchers were some of the first in the world to develop computer models of human organs and new innovative medical devices. The work done at ABI is cutting edge, exciting and extends beyond conventional bioengineering research. ABI has developed award-winning technology including a human-powered submarine, and utilised the same technologies that are used in the film industry to generate avatars for navigating the healthcare system.

## Internationally recognised researchers

ABI enjoys close affiliations with world-class institutions around the world including Oxford University, Harvard University, the Massachusetts Institute of Technology (MIT), the University of Sheffield, the University of Melbourne and the National University of Singapore (NUS). Students at ABI have access to global networking to support their projects, providing them with a wealth of ideas, expertise, resources, and unique opportunities for research visits and collaborations.

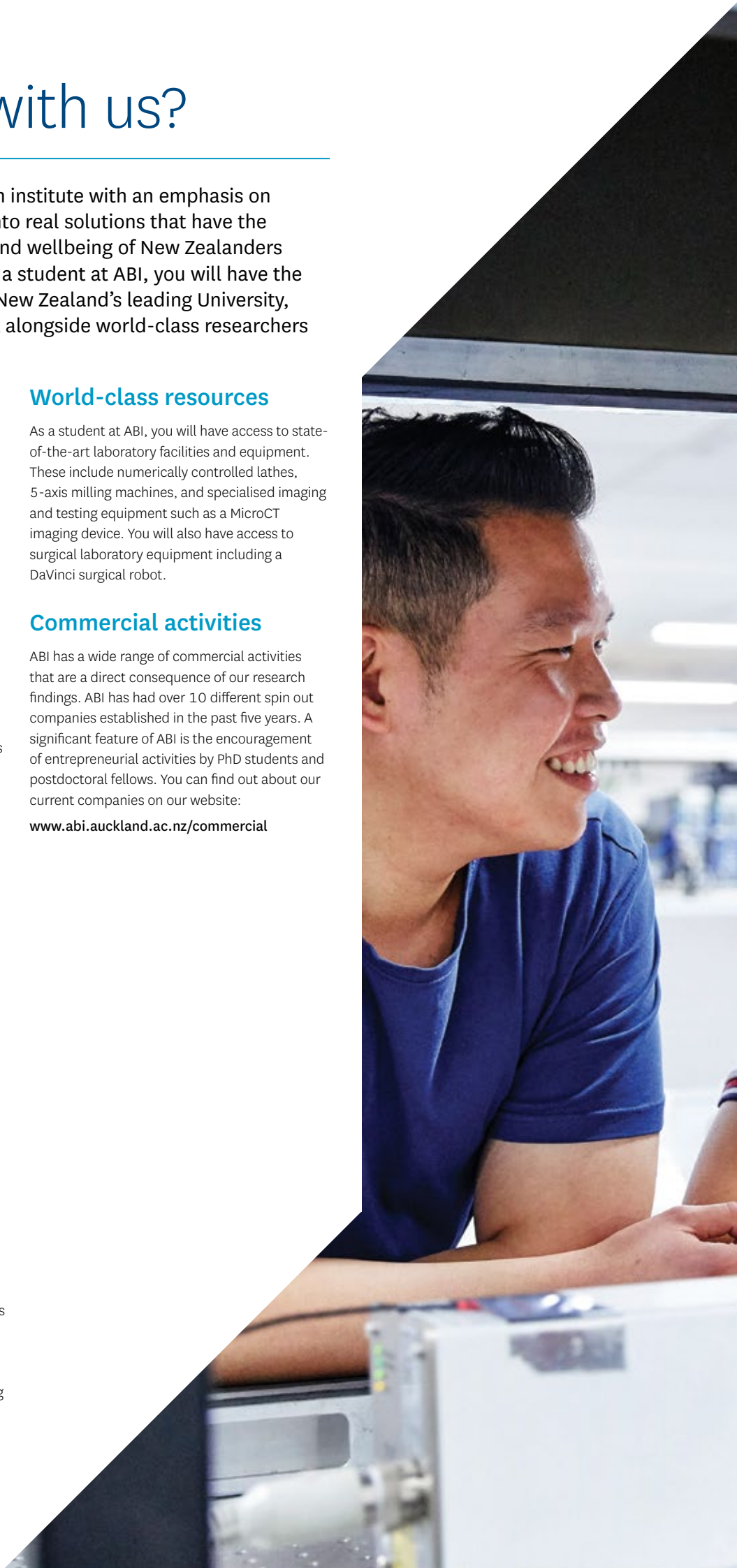
## World-class resources

As a student at ABI, you will have access to state-of-the-art laboratory facilities and equipment. These include numerically controlled lathes, 5-axis milling machines, and specialised imaging and testing equipment such as a MicroCT imaging device. You will also have access to surgical laboratory equipment including a DaVinci surgical robot.

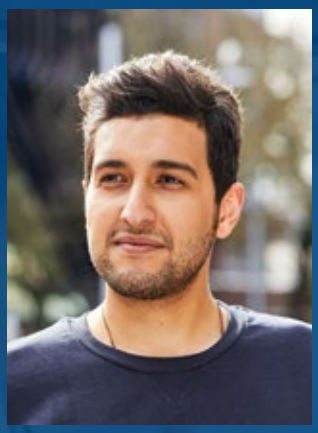
## Commercial activities

ABI has a wide range of commercial activities that are a direct consequence of our research findings. ABI has had over 10 different spin out companies established in the past five years. A significant feature of ABI is the encouragement of entrepreneurial activities by PhD students and postdoctoral fellows. You can find out about our current companies on our website:

**www.abi.auckland.ac.nz/commercial**



"Doing a PhD at ABI is the most enjoyable experience, it's the perfect balance between challenge and freedom: the challenge to achieve, with the freedom to do it my own way."



*"Even as a very young child, I always wanted to be a polymath when I grew up. I decided to do a PhD in Bioengineering because I believe that bioengineers use a wide range of skills including maths, engineering, physiology, computer, and art to solve a particular problem and/or to invent.*

*"In my PhD project, I make computer models of human lungs. I have created a statistical model that can predict a human lung shape even in the absence of a medical image. This helps to derive a better understanding of the lung structure-function relationship.*

*"I came to Auckland when I was 12 years old. Originally, I did think I wanted to go overseas to do my PhD. But I realised that I could work alongside some of the world's leading bioengineers, internationally recognised and highly regarded researchers right here at home."*

**Mahyar Osanlouy**
*PhD candidate in Bioengineering*

# Key research goals

## Digital models for personalised healthcare

Healthcare is increasingly moving towards personalised health plans for individual patients. The ability to model individual organ systems, then integrate this into whole body systems and provide comparisons across injury and disease states will change the face of healthcare for the future.

## Medical device technology (diagnostic and assistive devices)

The ability to provide novel tools for clinicians to diagnose and treat patients will lead to better healthcare outcomes and reduce healthcare costs.

## Human modelling applications in entertainment, communications and transport

Entertainment, including movies and gaming, now requires increasingly sophisticated models of human and animal anatomy and physiology. Responsive human avatars also provide powerful interfaces for communication between humans and computers for advertising.

Transport and mobility in the future will increasingly rely on human interfaces that require personalised human body models, and as vehicles become more efficient, there is a need to model the humans within them.

## Contributions to New Zealand's primary industries (nutrition, wool, red meat, dairy)

Multi-scale modelling of wool is used to predict mechanical, moisture and thermal properties of knitted fabric from the measured properties of the fibres. Increasingly, what we wear makes a difference, particularly in areas such as elite sports, race car driving, diving, flying and space exploration. Modelling fabric's interaction with our body and even our naturally occurring bacteria could lead to the development of new products that enhance performance or even provide energy to power devices.

"With the Cardiac Myometer, we are able, for the first time ever, to follow all five of the sub-cellular events, beat by beat, in living heart tissue under either normal or diseased conditions."

Assoc Prof Taberner was one of the first researchers to be appointed to ABI as a young emerging scientist in 2002. He is now the lead investigator of the cardiac team which is developing a device to measure the five key aspects of a heart beat simultaneously. The Cardiac Myometer can measure calcium pulses, the force of cell shortening, energy expenditure, heat produced and oxygen consumption, all at the same time.

**Associate Professor Andrew Taberner**
*Principle Investigator,*
*Bioinstrumentation Laboratory*

# ABI research projects

## Bioinstrumentation Laboratory

The Bioinstrumentation Laboratory is world-renowned for its ability to develop novel instruments for use in healthcare. Current projects include painless needle-free blood sampling and injection of therapeutic agents (e.g. insulin), and a combined mobile-bed/wheelchair for use in hospitals, homes and aged-care facilities that uses state-of-the-art electromechanical actuators for helping patients get in and out of bed, and prevent accidental falls, bed sores, and low back/spinal injury to nursing staff who handle heavy patients.

## Biomedical informatics

Leading-edge informatics methods are being used to develop strategies to link all the sources of an individual's healthcare records including GP visits, blood tests, hospital care and specialist treatment. This will lead to new personalised models of care by linking quantitative modelling processes to electronic health records.

ABI is leading the world in the development of the Physiome Project, with the ultimate aim of bringing all of physiology (from molecular level processes to whole organ and whole body behaviour) under a quantitative multiscale modelling umbrella. This has the potential to enable knowledge about normal and pathological processes to be linked with real-world healthcare data, with genomic and environmental aspects to deliver more predictive and personalised decision support tools. This could be linked to personal physiological data, via smartphone-coupled sensors, to provide a rational basis for tracking changes in healthcare status for an individual.

## Biomimetics Laboratory – mimicking biology

Researchers have discovered how to couple electric charge to soft rubbery materials and developed wearable stretchy sensors and soft energy harvesters that can sense and collect power from human movement. StretchSense, a commercial spin-out company, is now licensing the lab's sensing and energy-harvesting technology for wearable applications.

Further research is exploring how electric charge can be turned on and off with stretch and how to use our switches to build strain-sensitive devices that can pump medication subcutaneously or directly assist natural pumps such as the heart. We are also exploring how these switches may be able to operate like the axons of nerves to restore muscle activity.

## Brain and nervous system (Laboratory for Animate Technologies)

Two-time Oscar winner Associate Professor Mark Sagar and his team are developing highly realistic facial animation technologies for producing interactive avatars based on neural network models of the human brain. This research will lead to applications in healthcare, robotics and human-machine interfaces and provide very substantial future business opportunities for New Zealand companies. A company called Soul Machines has been spun out from this lab.

## Cardiac and cardiovascular system

ABI researchers are world leaders in developing computerised models of cardiac function. Computer modelling and new catheter-based sensors are being developed to diagnose and treat atrial arrhythmias.

Our goal is to provide cardiologists with risk assessment tools, based on low cost portable ECG and ultrasound scans, that help them decide which of their patients are high-risk and should be sent for further tests, versus which are low-risk and do not require immediate treatment.

## Gastrointestinal system

ABI is developing non-invasive tools for accurately diagnosing the electrical dysfunction associated with various forms of severe indigestion. This includes high-resolution mapping of gut electrophysiology, including automated signal processing and model-based analysis and visualisation software. We are designing and developing medical devices to validate the models that will eventually be able to be used in clinical practice.

ABI researchers are also building models of transporters in the small intestines of infants that are involved in nutrient uptake from milk, and working with world-leading nutritionists to apply this in premature babies to validate models of infant milk nutrition.


"ABI's reputation, international collaborations and the opportunities I have had within my PhD have definitely given me an advantage in building my own international networks."

*"My research centres around trying to understand tissue property changes in heart failure using three-dimensional mathematical models. ABI has been at the centre of the heart modelling discipline from its infancy, which makes it a really exciting place to study at. It puts my work at the cutting edge of our understanding of the human heart.*

*"A doctoral qualification at ABI opens up international doors – as part of my PhD project, I am already involved with an international collaboration in a team of clinicians in New York. I have had the opportunity to travel to the United States and Asia for conference trips, meet other leading researchers in the field, and spark lasting relationships which could lead to potential research collaborations in the future."*

**Jenny Wang**
*PhD candidate in Bioengineering*

## Implantable devices

An electric heart pump can provide life support for patients with heart failure. Today's pumps need a wire poking through the skin to connect to a power source to keep the pump working. Infection around the wire is common. If we could eliminate the need for wires and develop wireless power transfer technology across the skin we would reduce infection risk and allow the pump to be charged overnight so the pump can run all day without cables and connections. This work is being carried out in conjunction with leading clinicians and pump companies in New Zealand, the US and France.

## Lungs and respiratory system

Currently it is very difficult to separate early signs of impending chronic obstructive pulmonary disease (COPD) from the physiologically normal changes in lung structure and function that occur with age. The ABI-developed lung model is recognised internationally as being the most sophisticated model of the lung available, and there is no other group worldwide in a better position to make this clinical advance.

## Musculoskeletal system

The musculoskeletal research group has gained international recognition for the development of the Musculoskeletal Atlas Project. This is a software framework to virtually test orthopaedic devices and streamline the process of FDA regulation. In New Zealand, this has accelerated the manufacture of 3D-printed titanium hip implants through patient-specific modelling. ABI continues to be the world leader in the virtual testing of musculoskeletal implants and in the combination of musculoskeletal modelling coupled with development of wearable wireless sensors for analysing performance for both clinical assessment during rehabilitation and improved performance in sports.

## Physiome Project

The human genome project provides a map of all human genes. The function of the proteins encoded by these genes is dependent on the particular environment in which they operate and the physical laws that the physiological systems must obey. Modelling is the only way to capture this 'phenotype'. Biological systems are extremely complex and models must be based on standards and be reproducible. The international Physiome Project, led by ABI, is developing the community standards, open source software and model repositories to ensure that physiological modelling has a firm foundation that will underpin healthcare across many domains including both drug development at the molecular level and medical device development at the tissue and whole body scale.

## Skin research

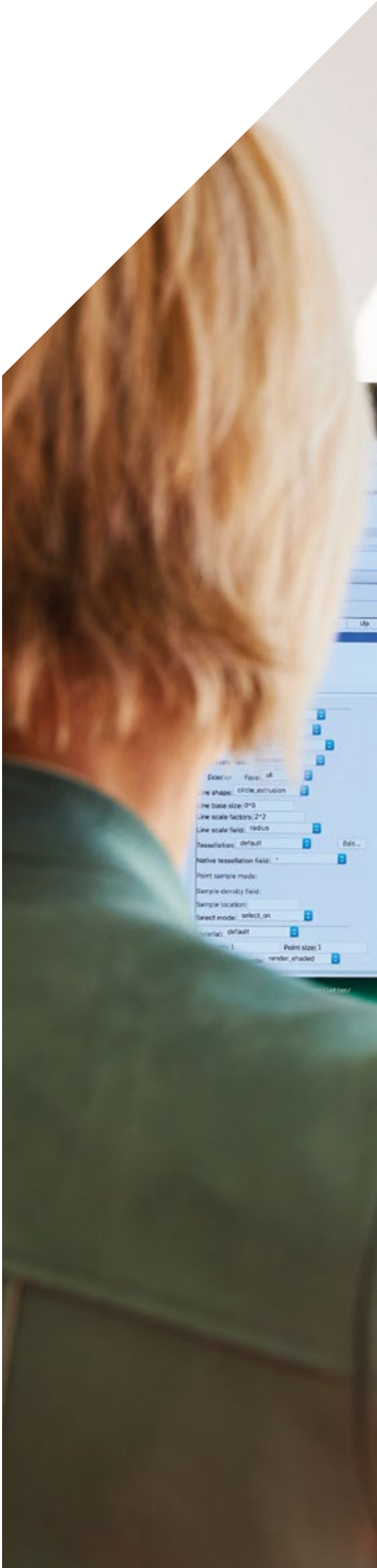
The skin is the largest organ in the human body. It prevents fluid loss, protects against pathogens, regulates temperature, and is sensitive to temperature, deformation, and injury – yet it has been little studied in comparison with other organs in the body. It also supports a widely diverse microbial environment that can become a major source of cross-infection in hospitals. ABI is using electronic/mechanical/optical instrumentation along with modelling capabilities to better understand how the skin functions.

## Women's health

One in three women will suffer from urinary incontinence. The Women's Health team at ABI have developed a "Fitbit" device for the pelvic floor. This simple technology could resolve urinary incontinence in up to 80% of sufferers.

Almost 300,000 women die each year from complications in pregnancy and childbirth. We are using computational models of the key organs of pregnancy to better understand the timing and progression of pathological pregnancies and childbirth. We have developed sophisticated models that are tailored to predict the progression of childbirth for individual mother and child, enabling better options to be considered before problems arise.

Breast cancer is one of the most common cancers affecting women. Early identification and appropriate treatment are key to lessening the burden of this cancer. We have developed computational models of breast tissue to remove uncertainty in tumour tracking between the images used for diagnosis and treatment in breast cancer (x-ray mammography, ultrasound, magnetic resonance imaging). We aim to revolutionise breast cancer diagnostics and treatment procedures by incorporating these models into a customised clinical work flow.



"At ABI I have direct access to world-class researchers who have a great open door policy, making it really easy to get advice and bounce ideas around."

*"As an undergraduate student, I went to a lecture by Associate Professor Thor Besier on biomechanics. I was fascinated by his work on the application of muscoskeletal modelling in modern medicine. I was so inspired that I specialised in biomedical engineering for my bachelors degree and Prof Besier is now my masters thesis supervisor. My project is about modelling the forces within and across the human hip joint. The results from this project could potentially improve surgical design and technique for hip replacement surgery.*

*"I get to pretend that the massively complex human body is a machine. I find it fascinating that I can simplify the body into a system of pulleys and hinges. By doing this, I am able to generate a model of how the hip joint works. The data generated from my model will allow us to then manipulate the model to develop personalised joints for individuals.*

*"I chose to come to ABI because I realised that most of the exciting work I was reading about was actually done here and not overseas. At ABI I have great resources around me, including my own desk, an espresso machine just 15 steps away and direct access to world-class researchers.*

*"ABI is also a great place to learn about not only research, but also commercialisation. It is like a nursery for startup companies, which means there are a lot of other opportunities for me.*

*"I believe that a masters degree in bioengineering from ABI will set me up for a fantastic future, and I am excited to see where it leads me."*

**Duncan Bakke**
*Masters candidate in Bioengineering*

# Pathways to study

A good academic record can open up many opportunities for you at ABI. We welcome applications from students with a background in the following subjects and disciplines:

- Engineering
- Computer science
- Mathematics
- Physics
- Bioengineering
- Biomedical sciences

## Specialisations on offer

Your project can be focused on one of the four research themes or our twelve research areas of focus, or can also span across the multiple different areas. ABI encourages the application of translational skills across disciplines, this is often one of the key components in bringing research from the benchtop to the bedside.

## Unique multidisciplinary approach

At ABI, you will often find that research spans across multiple different areas; this kind of cross-collaboration ensures that we have a holistic view of a research problem that we are trying to solve. This is an important element in ABI's research culture, and is often evident in the projects that we craft for our students – while playing to your strength and expertise, our cross collaboration with other research teams will complement your project with the relevant resources to enable you to obtain the best outcomes possible.

## Summer studentships

Summer studentships are short-term research scholarships that can give undergraduate students exposure to research life and help you think about pursuing postgraduate study. In a summer studentship, you would conduct a research project under supervision for 10 weeks over the summer months. ABI offers a number of these studentships. For more information visit our website: **www.summer.ac.nz/abi**

"I am proud to be a graduate of the University of Auckland, and specifically ABI. It was an easy transition for me to go from course-based learning to world-class research. I developed key skills that can be translated to all aspects of the job market and stay competitive in an ever-changing world."

Peng Du completed his Bachelor of Engineering (Honours) in Biomedical Engineering and PhD in Bioengineering, both from the University of Auckland.

In 2011, he joined the Gastrointestinal Research Group at ABI as a Research Fellow.

In 2012, Peng won the Vice Chancellor's Prize for Best Doctoral Thesis and was awarded a Marsden Fast Start Grant, and a Rutherford Foundation New Zealand Postdoctoral Fellowship in the same year.

In 2013, he received a University of Auckland Early Career Excellence Award.

In 2015, he was awarded one of the prestigious Rutherford Discovery Fellowships.

**Dr Peng Du**
*Research Fellow,*
*Gastrointestinal Research Group*

# Scholarships

## Funding opportunities

Postgraduate study is often a major financial commitment and the university endeavours to assist you with this through the scholarships and awards offered to postgraduates students every year. Criteria for scholarships include academic excellence, financial hardship, ancestry, gender, and students with disabilities.

For international PhD students, there are no additional fees; you will pay the same fees as New Zealanders as long as you reside in New Zealand during the period you are enrolled in your PhD.

For more information on scholarships, visit **www.scholarships.auckland.ac.nz**

## University of Auckland Doctoral Scholarships

These scholarships are awarded to students with an excellent academic track record. You may be guaranteed this scholarship if you are a domestic student with a grade point average (GPA) of 8.0 or above in your qualifying programme from a recognised university or an international student with a GPA of 8.0 or above in your qualifying programme from a New Zealand university.

If you are a Māori or Pacific student, you may be guaranteed this scholarship if you have a GPA of 7.5 or above from your qualification at a New Zealand University.

Domestic and international applicants may still be considered for this scholarship if you have a GPA of 7.0 or above.

## University of Auckland Research Masters Scholarships

You may be guaranteed this scholarship if you are a domestic student with a GPA of 8.0 or above in your qualifying programme from a recognised university.

If you are a Māori student you may be eligible for a University of Auckland Māori Postgraduate Scholarship if you have a GPA of 7.5 or above from your qualification at a New Zealand University.

If you are a Pacific student you may be eligible for a University of Auckland Pacific Postgraduate Scholarships if you have a GPA of 7.5 and above from your qualification at a New Zealand University.

Visit **www.auckland.ac.nz/makethegrade** for more information.

## ABI scholarships

ABI offers scholarships for masters students. To find out more visit:
**www.abi.auckland.ac.nz**

## Other funding

Many of our researchers have grant funding that includes a PhD or masters stipend. Projects with such funding can be found on:
**www.findathesis.auckland.ac.nz**

# How to apply

## Research-based Masters or PhD studies

Ensure that you meet entry requirements – check our website for criteria:
**www.abi.auckland.ac.nz**

You will need a minimum GPA of 5.0 for entry into the masters programme, and generally a minimum GPA of 7.0 for the PhD programme.

## Find a project and a supervisor

If you have met the entry requirements, you can start by exploring our research areas to see which area you are most interested in:
**www.abi.auckland.ac.nz/our-research**
**www.abi.auckland.ac.nz/projects**

Alternatively, you can search for the research projects available at the ABI at:
**www.findathesis.auckland.ac.nz**

Once you have found an area of interest, you should contact one or more supervisors to discuss potential research topics. Alternatively, you can contact our postgraduate advisor Dr Justin Fernandez (**j.fernandez@auckland.ac.nz**), who can help you find a suitable supervisor and guide you through the application process.

When you have a confirmed supervisor and research project, you can apply for your masters/PhD programme by following the guidelines on this page:
**www.abi.auckland.ac.nz/apply-now**

The postgraduate team welcomes you to ABI and we are here to support you to achieve your goals.

Postgraduate life at ABI is a healthy balance of academic training, outreach activities, University service and engaging social events. You should have no problem fitting into our collegial environment and I hope you find your time here both rewarding and career fulfilling.

Throughout the year ABI has many outreach activities where we showcase our research to the community. Our research is increasingly becoming linked to commercial outcomes and many ABI postgraduate students complete masters and doctoral degrees linked to industry. You will find many of our commercial partners began as start-up companies in ABI.

If you are considering postgraduate study at ABI please feel free to contact our postgraduate team for more information and opportunities about postgraduate life at ABI.

Best Wishes

**Justin Fernandez PhD**
*Associate Director Postgraduate ABI*

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# Auckland Bioengineering Institute


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