



INSTITUTE FOR
GLYCOMICS
ANNUAL REPORT
2019



Institute for Glycomics

Queensland, Australia



Our Mission

Fighting diseases of global impact through discovery and translational science.



Contents

4	About us	56	2019 publications
6	Director's report	64	New grants in 2019
8	Institute highlights	67	Remarkable people
9	Remarkable science	68	Membership in 2019
12	Remarkable achievements	71	Plenary/keynote/invited lectures in 2019
18	Translation and commercialisation	73	Remarkable support
20	Commercialisation case study		
22	Internationalisation		
24	Community engagement		
28	Community engagement case studies		
30	Selected outstanding publications		
40	Research group leader highlights		
54	Our facilities		



Our Vision

To be a world-leader in the discovery and development of drugs, vaccines and diagnostics through the application of innovative multidisciplinary science in a unique research environment.

About Us

The Institute for Glycomics is one of Australia's flagship multidisciplinary biomedical research institutes.

Established in February 2000, the Institute strives to be a world leader in the discovery and development of next generation drugs, vaccines and diagnostics in the fight against diseases of global impact.

The Institute for Glycomics is based at the heart of Griffith University's Gold Coast campus in Queensland and plays an integral role as part of the emerging Gold Coast Health and Knowledge Precinct - a unique global business location for industry development, research collaboration and jobs of the future.

The Institute boasts state-of-the-art facilities combined with some of the world's most outstanding researchers with a significant focus on 'Glycomics', a constantly expanding field that explores the structural and functional properties of carbohydrates (sugars). Glycomics research is conducted worldwide in projects that cut across multiple disciplines, applying new approaches to treatment and prevention of diseases. Our unique research expertise makes us the only institute of its kind in Australia and one of very few integrated translational institutes using this approach in the world.

The Institute's research primarily targets prevention and cures for infectious diseases and cancer, with a focus on translational research which will inevitably have a positive impact on human health globally.

This rich research environment provides exceptional postgraduate education programs for the nation's future scientists.

The Institute engages with industry, other premier research institutes, philanthropic organisations and governments from across the globe to build human capital to provide healthcare solutions to address some of the world's most intractable diseases.



Director's Report

2019 was a busy but exciting year for the Institute for Glycomics. From the laboratory bench to the patient's bedside, translational outcomes are the ultimate goal of the Institute for Glycomics, and our research teams yielded very promising results throughout the year.

In early 2019, we started the year in an exciting way as we were honoured to receive a visit from Australia's Governor-General, His Excellency General the Honourable Sir Peter Cosgrove AK MC (Retd). His Excellency General the Honourable Sir Peter Cosgrove was given a tour of the Institute and updates on the trial of a whole parasite blood-stage malaria vaccine in human volunteers that has yielded safe and immunogenic outcomes.

Our Malaria Vaccine Project reached an impressive milestone in terms of funding in 2019. The Federal Government announced that they would provide \$500,000 to support our ongoing human clinical trials that aim to test the effectiveness of the world-first malaria vaccine candidate named PlasProtect™. This funding, together with \$500,000 that Rotary District 9640 have already raised since 2017, has enabled further evaluation of the malaria vaccine candidate in clinical trials.

Another significant highlight from the first half of 2019 was the Institute for Glycomics officially inducted as a member of the Association of Australian Medical Research Institutes (AAMRI). AAMRI is the peak body for medical research institutes across Australia. Member organisations work on a broad spectrum of human health issues such as preventive health, chronic disease, mental health, immunology and Indigenous health.

It was announced in 2019 that the Institute for Glycomics would share in a multi-million dollar grant to aid ground-breaking gonorrhoea research. The grant was awarded by The National Institute of Allergy and Infectious Diseases (NIAID), one of the National Institutes of Health (NIH). The US\$9.25 million (approximately AU\$13.2 million) grant, over a period of five years, will fund Associate Professor Kate Seib's collaborative research proposal titled Starve and Kill: Engineered Antigens Targeting Nutrient Acquisition Pathways Essential for Gonococcal Infection and Disease.

A scientific breakthrough, led by Drs Benjamin Bailly, Chih-Wei Chang and Professor Mark von Itzstein, provides new hope for the development of an effective treatment of Hand, Foot and Mouth Disease (HFMD). The researchers have discovered potent small molecules that block the early stages of EV71 infection, that causes HFMD, and opens up the potential for novel drugs for treatment. We are hopeful that the findings of this research project will lead to an effective treatment to fight HFMD in its very early stages, and in turn offer peace of mind to millions of children around the world.

A scientific discovery jointly led by one of our research leaders, Dr Thomas Ve, was published in *Science*. Dr Ve's research specifically investigates 'cell suicide' that could lead to treatments for neurodegenerative brain diseases and the development of disease-resistant plants. Further information on this can be found in the 'Selected outstanding publications' section of this report.

The research group led by Professor Michael Good and Dr Manisha Pandey took us a step further in the development of a vaccine candidate with the potential to treat and prevent toxic shock caused by invasive streptococcal disease, which kills more than 160,000 people every year. Additional information can be found in the 'Selected outstanding publications' section of this report.

In a world-first, a team of Institute for Glycomics researchers jointly led by Principal Research Leader Professor Yaoqi Zhou, with other Griffith University researchers, used an artificial intelligence method to better predict ribonucleic acid (RNA) secondary structures, with the hope it can be developed into a tool to better understand how RNAs are implicated in various diseases such as cancer. This advance comes after more than a decade of stagnation in the performance of previous methods to predict RNA structures.

A major scientific and commercialisation highlight in 2019 was the signing of a landmark multi-million deal between the Institute for Glycomics and Grand Medical Pty Ltd, a subsidiary of China Grand Pharma, to develop a new drug to fight human parainfluenza virus (hPIV). For over a decade we have built strong scientific expertise and a robust suite of potent lead drug-like molecules against hPIV. This significant co-development program with Grand Medical Pty Ltd, to deliver a new drug to treat hPIV, represents a significant milestone for the Institute.

In 2019 we were also delighted to see that a new Institute-discovered drug candidate to treat viral arthritis caused by mosquito-borne alphavirus infections, including infections by Ross River virus (RRV) and chikungunya virus (CHIKV) had progressed. The Phase 2A clinical trials of the new drug candidate revealed impressive results, passing both safety and efficacy measures amongst participants with chronic RRV-induced arthralgia who were treated with the injectable pentosan polysulfate sodium (iPPS) drug candidate. At their three-month follow-up, 72.7% of those participants treated with iPPS showed near remission of symptoms in contrast to those participants who were administered with a placebo (14.3%). We are very pleased with this outcome and look forward to the next trial phase.

I would like to take this opportunity to thank our loyal community supporters and donors for their continued interest and engagement in 2019. Community support and philanthropic donations are vitally important in our fight against diseases of global impact. The generous contributions we receive from our donors enables us to purchase new equipment, advance our clinical trials, support our students through scholarships, aid our research scientists through funding of their various research projects, and so much more.

The fight against diseases of global impact is one of the world's most significant challenges; however, I believe that our unique research approach, together with our outstanding research expertise and infrastructure, fully equips us for the battle ahead.

Professor Mark von Itzstein AO
Founder and Director



Institute highlights



3 Major

RESEARCH THEMES

- Cancer research
- Infectious diseases
- Other metabolic diseases

200+
INSTITUTE
MEMBERS



Income Sources FOR 2019

- Research grant funding \$6.2 million
- Industry, philanthropic & other support \$12.1 million



\$1 For \$1

In Philanthropic Funding
Supports Our Research



Community Engagement

- **GLYCOMICS CIRCLE** Empowering women in science
- **BENDIGO BANK PARADISE POINT** A partnership to support the world's future scientists
- **ORDER OF ST JOHN** A partnership in the fight against cancer
- **WOMEN IN RACING** A partnership to support Glycomics research



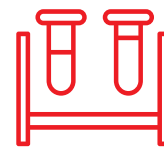
3

PATENTS FILED ON NEW INSTITUTE TECHNOLOGIES



Partnering

- Engagement with over 45 industry partners for basic research, translation and commercialisation



Clinical Trials

- **Phase 2 clinical trial completed by Paradigm Biopharmaceuticals Ltd:** Re-purposed drug for treatment of Ross River Virus-induced arthritis
- **Pilot Phase 1b clinical trial underway by Griffith University:** Vaccine for the prevention of malaria
- **Preparing to enter a Phase 1 clinical trial in Canada:** Vaccine for the prevention of Streptococcus A
- **Preparing to enter a Phase 1b clinical trial in collaboration with Murdoch Children's Research Institute:** Vaccine for the prevention of Streptococcus A
- **Preparing to enter a Phase 2 clinical trial:** Re-purposed vaccine for the prevention of gonorrhoea



14,000+

CITATIONS
(Over 10 Years)

120+
PUBLICATIONS



Remarkable Science

We have twenty-three research group leaders at the Institute, guiding each of their dedicated research teams to new opportunities that can lead to novel drugs, vaccines and diagnostics, translating research into tangible benefits for the global community. Our specialist research programs are centred around cancer and infectious diseases research.

Cancer

The Australian Centre for Cancer Glycomics (A2CG) is one of our Centres of Excellence at the Institute for Glycomics. This unique national resource is dedicated to cancer glycomics research, which involves understanding the role that sugars/carbohydrates play in the development of cancers. Using this knowledge, our researchers can invent new drugs, vaccines and diagnostics to treat, prevent or diagnose cancer.

A2CG was established in 2017 to bring together the Institute's cancer research projects and be the platform for collaboration with the world's leading cancer researchers and clinicians. This unique national resource dedicated to cancer glycomics research is the result of significant funding by Griffith University together with the support of our community.

As the only institute of its kind in the southern hemisphere, the Institute for Glycomics is already an epicentre of glycomics research globally and houses many world-leading carbohydrate researchers. A project with the vision and scale of the A2CG requires substantial human resource, technical knowledge and specialisation. By combining core expertise and infrastructure, the A2CG is a world-class platform for mapping the cancer glycomics and glycoproteomics and translating these discoveries into novel diagnostics and therapies.

The state-of-the-art equipment and infrastructure, coupled with the brightest scientific talent in the field of cancer glycomics and glycoproteomics, makes the A2CG an exciting hub of truly revolutionary cancer research. Our researchers focus on some of the world's most devastating forms of cancer, including (but not

limited to) head and neck, leukaemia, breast, ovarian, prostate, and skin cancers.

In collaboration with other experts from across the globe, our researchers within A2CG made remarkable advances in 2019. The following lists just some of those advances:

- We were pleased to receive a \$100,000 grant by the Ian Potter Foundation towards the acquisition of a cutting-edge Laser Capture Microdissection system (LCM). This new equipment will be integrated into our suite of advanced analytical and imaging technologies. Our Institute is a pioneer of Tissue Imaging Microdissection Glycomics (TiMiG), which enables analysis of individual cells from within complex patient-derived tissue samples. This unique approach is providing new insights into the precise molecular changes in cancers and also has the potential to contribute to our infectious diseases research.

- In September 2019, we were delighted to host a visit by the Australian Government Health Minister, the Honourable Greg Hunt MP. Minister Hunt was particularly captivated by the world-class facilities and projects underway within the A2CG, showing particular interest in the Institute's work in ovarian cancer and advanced imaging technology.
- We commenced a new project in collaboration with clinicians in Hong Kong seeking to determine the mode of action and identify specific active molecules within a traditional Chinese medicine formulation that is being used to treat melanoma. The project, funded by the Tingirana Foundation, anticipates results emerging in 2020.

Infectious diseases

Infectious diseases pose some of the world's biggest health challenges. Our research programs within this area encompass bacterial, viral, parasitic and fungal infectious diseases.

Bacterial infections - The Institute's research into the role of sugars/carbohydrates in diseases caused by bacteria represents new and exciting opportunities for the discovery of next generation antibiotics and vaccines. Many of the bacteria that cause some of the world's most devastating diseases are rapidly developing resistance to antibiotics and to this end we are also developing drugs that break anti-bacterial resistance. Types of bacterial infections included within our infectious diseases research program include Strep A/Rheumatic Heart Disease, middle ear infections, gonorrhoea, melioidosis, meningitis, and gastroenteritis/food poisoning.

Viral infections – Diseases caused by viruses have plagued humanity for time immemorial. Unfortunately, drugs that combat viruses are extremely limited in number and are not broad spectrum. The Institute's research into viral infections such as hand, foot and mouth disease, human immunodeficiency virus (HIV), influenza virus (IV), human parainfluenza virus (hPIV), human metapneumovirus (hMPV), Respiratory Syncytial Virus (RSV), Dengue virus, Ross River virus, chikungunya virus and other emerging alphaviruses, seeks to understand how sugars/carbohydrates are utilised in viral infections so that scientists can identify targets for the development of new drugs that will treat and cure these diseases.

Parasitic infections – Parasitic infections such as malaria still present as important public health challenges in tropical environments, with devastating socio-economic consequences in developing countries. It is now becoming clear that some of these parasites rely on carbohydrate-binding proteins for attachment and invasion of human host cells. Our research in this area will yield useful information for the design of diagnostic tools, vaccines and drugs to fight these diseases.

Fungal infections – *Aspergillus fumigatus* is the most prevalent airborne fungal pathogen in developed countries; and, in immuno-compromised patients, causes the fatal disease, invasive aspergillosis. The Institute's research into this fungal infection will yield useful insights into the design of new anti-fungal drugs to treat it.

iCAIR®

In 2017 we announced the establishment of the International Consortium for Anti-Infective Research (iCAIR®), based within the Institute for Glycomics. This is a major international partnership with the Fraunhofer Institute for Toxicology and Experimental Medicine and the Hannover Medical School, Germany, that was established to develop new anti-infective drugs.



The project aims to discover new treatments to combat respiratory viruses including influenza virus and respiratory infection-causing bacteria and fungi. Infectious diseases and antibiotic resistance are a global, and potentially deadly threat.

Previously effective antibiotics are becoming less and less effective against multi-resistant bacteria, and there is an urgent need to develop new drugs and treatments to combat infection. The biggest hurdle in developing new medications is getting them from the laboratory into clinical trials, bridging the gap from the discovery of new agents to their development by the pharmaceutical industry into potential medications.

Supported by Griffith University, City of Gold Coast and State Government funding, the iCAIR® alliance has established a platform to cover all the steps of a targeted drug development process, from identifying potential points of attack, right through to drug design and efficacy testing. In 2019, we were delighted to announce the signing of a major deal with China Grand Pharma to commercialise the Institute's parainfluenza stream of the iCAIR® program. This deal is further described in the 'Commercialisation' section of this report.

Some of the remarkable advances from across the Institute's Infectious Disease programs in 2019 include:

- In 2016, we were excited to report entering into an agreement with the Melbourne-based, ASX-listed company, Paradigm Biopharmaceuticals Limited, to commercialise research led by Research Leader, Dr Lara Herrero. The discovery that Paradigm's lead drug candidate, injectable pentosan polysulfate sodium (iPPS), has the potential to reduce the debilitating symptoms of Ross River virus (RRV) and chikungunya virus (CHIKV) infections has since progressed through to the completion of Phase 2A clinical trials in patients with chronic RRV-induced arthralgia (joint pain and swelling) in 2019. The outcomes of the trial were outstanding, and Paradigm are now commencing Phase 3 studies and seeking to broaden trials into proving the efficacy of iPPS in the treatment of CHIKV patients in collaboration with the US Department of Defence.

- The Institute's malaria vaccine development program led by Principal Research Leader, Professor Michael Good AO, was awarded a further \$500,000 through the Australian Government Medical Research Futures Fund (MRFF) to further advance our novel malaria vaccine candidate, PlasProtect™, towards clinical trials. These funds build upon more than \$500,000 of donations provided through Rotary District 9640, and \$200,000 provided by the National Foundation for Medical Research and Innovation (NFMRI) also awarded to the malaria vaccine development program in recent time.
- The Australian National Health and Medical Research Council (NHMRC) awarded more than \$2.7 million to Research Leader, Associate Professor Kate Seib, to undertake a study to evaluate whether a vaccine currently used to prevent meningococcal B infections (Bexsero®; GlaxoSmithKline) can also be used to prevent gonorrhoea which is caused by the closely related bacterial pathogen, *Neisseria gonorrhoeae*. The multicentre clinical trial will commence in 2020.



Remarkable Achievements

Institute for Glycomics Director appointed high honour of Officer of the Order of Australia

Professor Mark von Itzstein, Founder and Director of Griffith University's Institute for Glycomics, has been awarded one of Australia's highest honours, officially being named as an Officer (AO) of the Order of Australia in the General Division.

This highly prestigious title, which took effect on 10 June 2019, was approved by the Governor-General, His Excellency General the Honourable Sir Peter Cosgrove AK MC (Retd), in his capacity as Chancellor of the Order of Australia.

The Order of Australia, established in 1975 by Her Majesty Queen Elizabeth II, is the principal means of recognising outstanding members of the community at a national level. "I am humbled by this honour and it belongs to a whole host of people who have made major contributions to both my career and life," commented Professor Mark von Itzstein AO. "I particularly acknowledge the enormous support of Griffith University and our University's Senior Executive as well as the

Queensland State Government's willingness to have a 'can do' attitude. Without it my vision of establishing a unique translational biomedical research institute in Australia would never have happened."

Professor von Itzstein AO has international standing in chemical biology, glycoscience, medicinal chemistry and drug discovery, particularly in the area of anti-infective drug discovery. He has established an internationally-recognised research program that is investigating the discovery of novel anti-microbial drugs, including novel anti-viral drugs and anti-cancer drugs based on carbohydrate-related pathways and the outcomes of these programs are apparent from his publication record.

The contributions of Professor von Itzstein AO to the carbohydrate sciences and medicinal chemistry have been internationally recognised by continued conference invitations and requests to write significant chapters on carbohydrate science and drug discovery and act as a book editor/co-editor. He has published over 240 contributions, has over 7,300 total citations, and continues to publish in some of the world's highest quality journals.

"Professor Mark von Itzstein's contribution to Griffith University, the Gold Coast community, and Australia as a whole, has been demonstrated time and time again within his many roles which include Founder, Director, Professor, inventor, research leader, mentor, and friend. This award is extremely well-deserved," commented Professor Carolyn Evans, Vice Chancellor of Griffith University.

Professor von Itzstein AO is an internationally acclaimed research scientist, whose research led to the discovery of the world's first 'designer' anti-influenza drug, Relenza®. This drug was designed, synthesised and biologically evaluated (*in vitro*) in Professor von Itzstein's laboratory.

This discovery is considered to be a significant outcome and a flagship in glycotherapeutic drug development in the last century and has consolidated the world platform of using carbohydrates and carbohydrate-recognising proteins as drug discovery targets. Relenza® is just one example of so many of his profound contributions to society. "We're excited to see what he will achieve next," added Professor Evans.



VON ITZSTEIN ST



City of Gold Coast has also acknowledged Professor von Itzstein's outstanding life achievements by naming a street after him, befittingly located within the Gold Coast Health and Knowledge Precinct, Asia-Pacific's emerging health and innovation hub and home to Griffith University, ranked in the top 2% of universities worldwide.

Remarkable Achievements

Institute for Glycomics joins peak body for medical research, AAMRI

The Institute for Glycomics became a member of the Association of Australian Medical Research Institutes (AAMRI) in early 2019. AAMRI is the peak body for medical research institutes across Australia. Member organisations work on a broad spectrum of human health issues such as preventive health, chronic disease, mental health, immunology and Indigenous health.

The members' research ranges from fundamental biomedical discovery through to clinical research and the translation of research findings from the laboratory bench to the patient's bedside.

"With a shared vision of providing hope, health and prosperity through health and medical research, we are very enthusiastic about our partnership with AAMRI," Institute for Glycomics Director Professor Mark von Itzstein AO said.

"By utilising our relationship with AAMRI as a trusted source of

authoritative advice and information, and with the Institute for Glycomics' outstanding track record in using our unique approach to discover and develop new drugs, vaccines, and diagnostics, the opportunities are endless."

Griffith University's Vice-Chancellor, Professor Carolyn Evans welcomed the Institute's admittance into AAMRI.

"We are delighted by this news, as it enables this outstanding Institute more opportunities to engage with other significant medical research institutes in Australia," Professor Evans said.

"Griffith University is placed in the top 2% of universities worldwide and is renowned for excellence in world-class biomedical research, expert knowledge and industry connections. The Institute for Glycomics is leading significant medical research translational outcomes and presently has several promising drug and vaccine candidates in human clinical trials."

AAMRI's primary role is to represent its member organisations with a central focus on health and medical research through advocacy, information provision, relationship building and member services.

Professor Vlado Perkovic, AAMRI President, commented on the new partnership, "We're delighted to add the Institute for Glycomics as AAMRI's 51st member and look forward to working with them to promote health and medical research."

"As a national peak body with members across Australia, AAMRI is further strengthened by our new relationship with the talented team at the Institute for Glycomics."

**G26
GLYCOMICS**



Remarkable Achievements



Glycomics Summer Scholarships for 2018/2019

Glycomics Circle Summer Scholarships:

1. Michelle Borg
2. Holly O'Donnell

Glycomics Summer Scholarships:

1. Lucas Catel
2. Malcolm Zou
3. Dusan Marjanovic
4. James Batcheldor
5. Michael Hencz

2019 Research Higher Degree Graduates

- 18 March 2019, Dr Tamim Mosaib, "Glyconanoparticles for Targeting Macrophages to Deliver Therapeutic Agents", supervised by Associate Professor Todd Houston and Dr Milton Kiefel
- 21 June 2019, Dr Andreia Almeida, "The Potential of Glycomics and Glycoproteomics to Improve Cancer Diagnosis", supervised by Associate Professor Daniel Kolarich and Professor Mark von Itzstein AO
- 11 November 2019, Dr Haroon Ahmad, "Mutation in BRCA-1 & 2 Genes Makes the Resultant Mutant Protein More Susceptible to Glycation", supervised by Professor Yaoqi Zhou
- 20 November 2019, Dr Aroon Supramaniam, "Characterising Heparan Sulfate Mimetics as Potential Therapeutics in Alphaviral Diseases", supervised by Dr Lara Herrero and Professor Mark von Itzstein AO
- 18 December 2019, Dr Wai Suet Lee, "Virus/Glycan Interactions; Discovery of Novel Markers of Virus Transmission by Mosquitoes", supervised by Dr Lara Herrero and Professor Mark von Itzstein AO



Translation and Commercialisation

Translation and commercialisation of world-leading science

Following in the footsteps of his success with Relenza[®], Professor Mark von Itzstein's vision when founding the Institute was to create an environment that enables the translation and commercialisation of world leading research, delivering life-saving diagnostics, preventions and cures to those who need them most. This vision remains a driver and focus for all of our members, from undergraduate students to Principal Research Leaders and Administrative support staff.

The Institute's Business Team, led by the General Manager, Dr Chris Davis, has developed a robust platform for commercialisation of Institute technologies, with a particular business model built around licensing and co-development with industry. This approach provides multi-faceted benefit to internal research programs, including financial, technical and commercial guidance from industry partners, as well as ensuring smooth technology transfer to give each technology the best chance of success en route to market. Additionally, the Institute's business personnel support the research cohort with their expertise in

intellectual property, technology packaging, negotiation and deal making, preclinical and clinical technology development and project management.

Over the past five years, the Business Team has developed and focussed on a strategy to drive partnerships in China. This is rooted in recognition of the compatibilities between the Institute's exceptional early-stage biomedical research capability and China's exceptional manufacturing, marketing and distribution capabilities, alongside a nation-wide impetus to grow capacity in biomedical innovation. This strategy has been very successful to date, with four deals completed with Chinese partners in the last four years through the efforts of the Institute's Business Manager (Commercial) Ms Eloise Keeffe, and General Manager. The Institute is well recognised both in Australia and China for their exceptional track-record in partnering with Chinese Biopharma companies and our strategy is strongly supported by all three levels of Government: City of Gold Coast, Queensland Government and Australian Government. The General Manager is regularly invited to participate in Government missions and speak at industry meetings and events to educate others in our success and new opportunities available to them.

In 2019, three major deals were signed with Chinese partners, including a landmark licence and co-development deal with Grand Medical Pty Ltd, profiled in the 'Commercialisation Case Study' section in this report; licence and co-development of a new formulation of our existing Group A Streptococcus vaccine technology to long-term partners Olymvax Biopharmaceuticals Inc.; and a benefit sharing arrangement with a private investor for the development of an HIV vaccine candidate. All three programs return significant funds to the Institute to support research activities for approximately 15 staff, for up to two years. Both Olymvax and Grand Medical have committed to the continued development of their respective licensed technologies, each intending to deliver the product through to market.

Another major commercial achievement in 2019 was the successful completion of a Pilot Phase II study for our drug candidate to treat alpha viral-induced arthritis, which achieved all primary and secondary endpoints. The trial was conducted by our partners at Paradigm Biopharma, to whom we licensed the candidate in 2016. We remain confident that pentosan polysulfate is well placed to be the Institute's first drug to market.



In related activities, we are pleased to report that the drug candidate licensed to Sirtex Medical Pty Ltd reported success in a Phase 1 safety study, as did our malaria vaccine candidate, which is supported by our partners at Rotary. Further, we have been preparing for an additional three clinical trials to be held in 2020: Our Group A Streptococcus vaccine will enter a Phase 1 clinical trial in Canada early in the year, followed by a Phase 1b clinical trial with challenge in Australia at the end of the year; we have also secured funding to evaluate Glaxo Smith Kline meningococcal vaccine, Bexsero, in a Phase 2 study to evaluate efficacy for new indication, gonorrhoea.

Moving into 2020, the Institute will continue to look outwards, particularly to our Asian networks, to partner with international companies who can translate our outstanding science into patient outcomes; supporting our vision to fight diseases of global impact.

Institute for Glycomics trade mission to China in December 2019. Pictured: Ms Julia Zhu, Senior Trade Commissioner, Austrade; Dr Chris Davis, General Manager, Institute for Glycomics; Mr Dominic Trindade, Australian Consulate General Shanghai, China; Ms Eloise Keffe, Business Manager, Institute for Glycomics.

Commercialisation Case Study

Institute for Glycomics partnership with Grand Medical Pty Ltd

A partnership between the Institute for Glycomics and Hong Kong-listed China Grand Pharma's newly established Australian company Grand Medical is working to improve lives through the development of a new drug to treat human parainfluenza virus (hPIV).

Human parainfluenza virus (hPIV) commonly causes upper and lower respiratory illnesses in infants, young children, the elderly, and people with weakened immune systems, including transplant patients, however anyone can get infected. Symptoms of severe lower respiratory illness can include bronchitis, bronchiolitis, croup and pneumonia.

Respiratory tract infections remain the deadliest communicable diseases worldwide, causing more than 3.2 million deaths in 2015 alone. Yet antiviral drugs that target these viruses are drastically underrepresented in the pharmaceutical market. There is currently no therapeutic available to specifically treat hPIV infection.

The Institute signed an exclusive licence and co-development agreement with Grand Medical to co-develop and commercialise the human parainfluenza drug candidate globally. The deal represents the largest pre-clinical antiviral deal in Australia and comprises significant upfront Research & Development and licence fees plus development and sales milestone fees with a tiered royalty on product sales.

The co-development program conducted at the Institute will focus on identifying a potent lead drug candidate, that will subsequently undergo pre-clinical and clinical development in a program led by Grand Medical.

China Grand Pharma is a multi-national pharmaceutical company with major programs in cardiovascular, ophthalmic and ear, nose and throat health. The licence of the Institute's parainfluenza drug candidate is their first entry into respiratory health. China Grand Pharma has rapidly expanded its global footprint in recent years and this partnership is their second in Australia, following acquisition of Sirtex Medical (Institute for Glycomics' partners in Sepsis) in 2018. Formation of Australian subsidiary, Grand Medical Ltd. demonstrated Grand Pharma's commitment to the development of the parainfluenza drug candidate and a long-term strategy to support Australian basic research.



Pictured: Professor Mark von Itzstein AO, Director, Institute for Glycomics; Professor Carolyn Evans, Vice Chancellor, Griffith University; Dr Linda Shi, Director, Grand Medical Ltd; Mr Michael K. Wang, Vice President, Business, China Grand Pharma.

Internationalisation

Global collaboration has been at the forefront of our Institute's mission since inception. It is essential to achieving our vision to bring forward novel drugs and vaccines to the community.

As highlighted throughout this report, we continue to collaborate with other leading research organisations and industry worldwide who share our commitment to fighting diseases of global impact. Our unique research expertise makes us the only institute of its kind in Australia and only one of a handful in the world.

This is backed by a professional and flexible approach to collaboration that makes us an ideal partner. We also maintain extensive connections to industry in the United States and Europe; and our strategic focus on China in most recent years continues to yield outstanding translational research and commercial outcomes.

Some examples of our international collaborative efforts include:

- **Germany** – developing new solutions to respiratory disease through iCAIR[®], the International Consortium for Anti-Infective Research, with partners Fraunhofer ITEM and the Hannover Medical School
- **Canada** – conducting a Phase 1 clinical trial on Professor Michael Good's Strep A vaccine candidate with clinical development partner the Li Ka Shing Institute
- **Switzerland** – discovering new biomarkers for cancers with collaborators at the University of Basel through a unique approach with the view to develop new cancer diagnostics
- **USA** – identifying new therapeutics for drug-resistant bacterial infections with collaborators at the Nationwide Children's Hospital, Ohio
- **Mainland China** – developing a world-first therapeutic for human parainfluenza with industry partner China Grand Pharma, based in Wuhan, through their Australian entity Grand Medical
- **Hong Kong** – identifying the chemotherapeutic properties of Traditional Chinese Medicines (TCM) with Hong Kong-based TCM physicians
- **Denmark** – developing new vaccines for infectious diseases in humans and animals with Statens Serum Institute
- **Italy** – evaluating vaccine candidates with an Italian industry partner
- **Singapore** – developing new drugs against dengue virus infection with collaborative partner National University Singapore





Community Engagement

2019 Institute for Glycomics Grand Ball Night

The Institute for Glycomics held its annual Grand Ball Night on Saturday 12 October 2019 at RACV Royal Pines Resort. The elegant black-tie affair was hosted by Griffith alumni Eva Milic from Channel 9 Gold Coast News, one of the Media Partners of the event.

Hundreds of high-profile, influential guests from Gold Coast and surrounding areas enjoyed a lavish three course meal and five-hour beverage package, including live entertainment from the Hanlon Brothers, exciting raffle prizes, and a live and silent auction.

Guests were entertained by a special feature comedy act by Arj Barker, which was one of the highlights of the night.

Close to \$50,000 was raised through the event, with every dollar going directly towards our research into finding new cures

and preventions for debilitating childhood diseases, examples of which include childhood cancers, virus-induced diseases such as croup, influenza, hand, foot and mouth disease and respiratory stress caused by respiratory syncytial virus (RSV), as well as bacteria-induced middle ear infections, and malaria.

Our focused research in these areas will lead to the discovery and development of new drugs, vaccines and diagnostics to combat such diseases, providing hope for the future of our children.

The 2019 Institute for Glycomics Grand Ball Night attracted some high-level event partners from the Gold Coast community including Principal Partner: Kollosche; Major Partners: Porsche Centre Gold Coast, Morse Building Consultancy, and VO Creative Agency; and Media/Support Partners: Channel 9 News Gold Coast, Gold Coast Bulletin and Luke Marsden Photography.

The Institute welcomes the community's support in making this annual event truly remarkable through sponsorship, the purchase of tickets, or through the donation of raffle prizes and auction items. Every little bit helps us in our fight against some of the world's most devastating diseases.

Our 2019 Grand Ball Event Partners

Principal Partner

KOLLOSCHÉ

Major Partners



PORSCHE

Porsche Centre Gold Coast



Media Partners



Community Engagement



2019 Glycomics Week

The Institute for Glycomics established its annual Glycomics Week during the Institute's 10th anniversary in 2010. It is celebrated annually, and the aims of the event-filled week are to:

- celebrate the Institute's growing significant research successes, and the impact this research has in the world of infectious disease, cancer, vaccine and drug discovery
- acknowledge the invaluable assistance from the Institute's local, national and international friends, donors and supporters
- continue to develop new engagements with local schools, companies and the community.

Glycomics Week encompasses the following important presentations and events:

- **Glycomics Public Forum** "Cancer: The Curse & Cures in the 21st Century", moderated by Gold Coast's ABC radio presenter, Ms Nicole Dyer. The Panel of Experts (Professor Paul Crocker, Dr Nic Crampton, Professor Sue Berners-Price and Professor Nicolle Packer) discussed the local and global impact of cancer in our community. The Public Forum was very well attended by distinguished guests and members of the public.

We welcomed our 2019 Peter Gallagher Memorial Glycomics Scholar, a world leading glycoscientist, Professor Paul Crocker from the University of Dundee, Scotland, who had networking sessions with the Institute HDR students, postdoctoral fellows and Research Group Leaders.

- **Glycomics Student Forum**, with Professor Paul Crocker and Professor Mark Walker (University of Queensland) presenting the Keynote Lectures and acting as judges of the best oral and poster presentations.
- **Institute for Glycomics Grand Ball Night** was held on 12 October at the RACV Royal Pines Resort, attended by Institute and University staff, current and potential Institute supporters and guests.

Glycomics Champions

The Glycomics Champions program is a community outreach training program, specific to the Institute for Glycomics. Our Glycomics Champions are a passionate mix of research students and postdoctoral staff from the Institute who help promote our research to the broader community through organised tours and outreach events.

Our Glycomics Champions host tours for all types of audiences, including philanthropists, Government officials, visiting delegations from overseas institutions, industry representatives, school and undergraduate university students, and community groups.

Their in-depth knowledge and professional verbal communication skills help them to translate our ground-breaking research into Layman's terms to suit any visiting audience.



The Lexus Melbourne Cup Tour visits the Institute

Each year, the Lexus Melbourne Cup Tour celebrates the heroes and stories intrinsically linked to the Victoria Racing Club's 158-year old Lexus Melbourne Cup race and its contribution to the nation's historical and cultural heritage.

The 18-carat gold Lexus Melbourne Cup trophy visits various destinations in an effort to unite communities in events to raise funds for local causes.

We were delighted to welcome the Lexus Melbourne Cup Tour to the Institute for Glycomics in August 2019, providing guests a chance to experience the magic of the iconic Lexus Melbourne Cup Trophy firsthand.



Honorary Fellows

In 2019, the Institute for Glycomics awarded Honorary Fellowships to the following long-standing supporters, in recognition of their unwavering commitment and ongoing support of the Institute's potentially life changing research:

- Ms Jennifer Bartels, Women in Racing
- Ms Baslyn Beel, Women in Racing
- Mr Harry Triguboff AO DUniv and Mrs Rhonda Triguboff, Meriton Group





Community Engagement Case Study

Glycomics Circle – Empowering women in science

The Institute for Glycomics recognises the value of having women in life sciences. For centuries women have made significant contributions to society, profoundly demonstrated by the fact that 52 women in total have been awarded the Nobel Prize between 1901 and 2019, twenty of which were awarded the Nobel Prize in the fields of physics, chemistry, physiology, or medicine.

However, it is also important to acknowledge the barriers that women face and the challenges that they must overcome to be successful if they choose a research career. A gender bias could potentially affect research outcomes and damage women's health. Women make up half the workforce and earn more university degrees than men, yet the gender gap in science persists, to a greater degree than in other professions.

The Institute for Glycomics puts in practice gender balance and actively encourages employment and career progression of

women in science. It is for these reasons that the Institute for Glycomics took the initiative to establish the Glycomics Circle, an impressive group of powerful women coming together with the sole purpose of supporting female scientists at the Institute for Glycomics.

A group of like-minded, ambitious women, members of the Glycomics Circle use their collective wisdom, connections and resources to raise funds and awareness for the Institute's female researchers, students and facilities, and recognise their significant contributions to the Institute's daily fight against diseases of global impact through translational science.

Impressively, members of the Glycomics Circle have collectively raised over AU\$90,000 for female scientists at the Institute for Glycomics. These funds have been utilised in various ways, which include supporting female early career researchers through scholarships, Honours student scholarships, travel opportunities to attend national and international science conferences and competitions, or to aid the purchase of new equipment and consumables.

The Glycomics Circle is always looking for new members to join and help their cause. Members meet together several times a year at special events which include a lovely lunch, or morning or afternoon tea, where they enjoy each other's company and listen to presentations from staff and students on how the Glycomics Circle's financial contributions have aided them in their various research projects.

If you would like to become a member of the Glycomics Circle and support our wonderful women in science, please get in touch with us: glycomics@griffith.edu.au

In 2019 the Glycomics Circle awarded funds to the following outstanding young researchers:

- Ms Holly O'Donnell – Glycomics Circle Summer Scholarship
- Ms Michelle Borg – Glycomics Circle Summer Scholarship
- Dr Larissa Dirr – Glycomics Circle Travel Award
- Dr Victoria Ozberk – Glycomics Circle Travel Award

Community Engagement Case Study



Bendigo Bank Paradise Point Community Bank Branch – A partnership to support the world’s future scientists

Our relationship with the Bendigo Bank Paradise Point Community Bank Branch began back in 2014 and they have been loyal supporters of the Institute for Glycomics ever since.

Their annual contributions help us pave the way for the world’s future scientists through essential scholarship programs. Through their sponsorship of our annual ‘Bendigo Bank Paradise Point Glycomics Summer Scholarship program’, multiple undergraduate students have been given the opportunity to further their research studies under the expert guidance of world-renowned research leaders at the Institute for Glycomics.

Furthermore, the support of Bendigo Bank Paradise Point Community Bank Branch has enabled us to expand our resource capabilities through the sponsorship of a new piece of impressive

research equipment, the Tecan D300e Digital Dispenser. The Tecan D300e Digital Dispenser allows us to automatically dispense any volume into any well of any assay plate, quickly and easily. This amazing piece of equipment eliminates multiple steps from our workflow, allowing us to set up and run assays in a fraction of the time. It minimises manual pipetting, enabling our scientists to focus on more important tasks and reducing repetitive strain injuries. It enhances throughput with simple yet sophisticated software and application-focused wizards, and automatically calculates all concentrations and volumes for faster, simpler plate set-up and dispenses our reagents directly into assay plates and onto cells. This new instrument is shared across multiple biology laboratories and benefits several of our research groups.

The Institute for Glycomics is profoundly grateful to Bendigo Bank Paradise Point Community Bank Branch for their ongoing and vital support. This is a partnership that is helping us shape the world’s future scientists, and one that is positively influencing our critical fight against some of the world’s most devastating diseases.

“Bendigo Bank strengthens local communities by reinvesting in programs for health, education, the environment and many more. We are immensely proud to support the world-class research undertaken by Griffith University’s Institute for Glycomics. Our sponsorship ensures that the Institute and its researchers have access to the most innovative assets as they deliver on their vision of delivering novel drugs and vaccines to the community. We love the ground-breaking research of the Institute and follow their discoveries with great interest and admiration.”

**Tony Jensen, Senior Manager,
Paradise Point Community Bank Branch of Bendigo Bank**

Selected Outstanding Publications

Pandey et al.

Antibodies to the conserved region of the M protein and a streptococcal superantigen cooperatively resolve toxic shock-like syndrome in HLA-humanized mice, Sci Adv 5 (9): eaax3013

A new vaccine candidate developed by Institute for Glycomics researchers has the potential to treat and prevent toxic shock caused by invasive streptococcal disease, which kills more than 160,000 people every year.

“Streptococcal toxic shock syndrome is an acute condition like meningococcus – if you get exposed to the organism you can be dead within a matter of days or less. So, we’re hopeful that what we’ve discovered can help save lives,” program leader and laboratory head Professor Michael Good AO said.

Dr Manisha Pandey, the lead researcher on the study, said streptococcus (Strep A) is the same bacteria group that causes common and non-life-threatening ailments such as school sores and tonsillitis, which are easily spread via coughing, sneezing and sharing food and drinks.

She said in about 1 in 100 cases, the organism enters the body and becomes invasive streptococcal disease (ISD). ISD can be life-threatening, with mortality rates exceeding 25% in even the best-equipped facilities tasked with treating it. When ISD occurs, some strains can make more toxins than others and cause streptococcal toxic shock syndrome (STSS).

STSS occurs when a toxin made by the Strep A organism binds to a human protein on certain cells and activates T-cells in the immune system that prompt a cytokine or highly inflammatory response. This agitates white blood cells which then release potent immune hormones that can result in death.

The international research team, which includes scientists from Melbourne and Edmonton, Canada, used a transgenic (DNA altered genes) mouse model to develop a world-first STSS vaccine candidate – named ‘J8’ – that showed a 1000-1,000,000 fold reduction of the bacterial burden in the spleen and blood after infection.

Antibodies developed from the streptococcal M protein and streptococcal pyrogenic exotoxin (SpeC) also cleared the infection in treated transgenic mice and ablated the mitogenic and inflammatory activity caused by the M protein.

Invasive streptococcal disease and toxic shock are increasing in prevalence around the world and are particularly prevalent among disadvantaged populations – it occurs in remote parts of the state among Aboriginal communities, and mostly affects the very young and very old.

“We were looking at a vaccine candidate to prevent streptococcal infections. At the time we were looking at it to prevent rheumatic heart disease (RHD), which is also caused by Strep A, and thought that the vaccine might prevent streptococcal toxic shock,” Professor Good AO said.

“However, that doesn’t help people who come in who haven’t been vaccinated and those who are acutely ill with toxic shock.

“In our transgenic mice model, we showed that two proteins are important for the disease – Superantigen toxin (SpeC) and the M protein, which our vaccine candidate J8 comes from.

We vaccinated the transgenic mice – and it could prevent toxic shock, but as importantly we were able to make antibodies in normal mice which we could use to treat sick mice. When the transgenic mice became very ill, we treated them with the vaccine antibodies and they recovered overnight – the organisms as well as the toxin were cleared from their blood.”

Now that antibodies have been generated, the next step would be to make monoclonal antibodies (antibodies made by identical immune cells that are clones of a unique parent cell), that could be suitable for a human trial study of J8’s efficacy against invasive streptococcal disease.



Selected Outstanding Publications

Horsefield et al.

NAD(+) cleavage activity by animal and plant TIR domains in cell death pathways, Science 365 (6455): 793-799

Griffith University researchers have played a key role in investigating 'cell suicide' that could lead to treatments for neurodegenerative brain diseases and the development of disease-resistant plants.

Dr Thomas Ve, a lead researcher at Griffith University's Institute for Glycomics and co-senior author on the new *Science* paper, used X-ray crystallography to determine the three-dimensional structure of the SARM1 protein, which is a central player in nerve fibre loss.

"Millions of people around the world are affected by neurodegenerative diseases like Parkinson's, and the breakdown of brain cells is a common factor between them," Dr Ve said.

"SARM1 is key to brain cell breakdown in various neurodegenerative diseases, so a greater understanding of this protein is an important step in the development of drugs that stop or limit this breakdown."

Dr Ve worked closely with fellow Institute for Glycomics

researcher and joint first author on the paper, Dr Yun Shi. The pair used NMR spectroscopy to explore functional features of the protein.

Dr Ve, also an Australian Research Council DECRA Fellow, said this new structural information about SARM1 had the potential to accelerate the development of drugs that target neurodegenerative diseases.

"We are very excited by these findings as they greatly advance our understanding of how SARM1 works at the molecular level," Dr Ve said.

"It provides clues as to how one might target this protein using structure-guided approaches to block axon loss in neurodegenerative diseases."

The SARM1 structure also revealed similarities to cell suicide triggering proteins in plants that provide resistance to many crop diseases, and the research team demonstrated that these proteins, like SARM1, can act as nucleotide-consuming enzymes.

A better understanding of cell death processes may also lead to the development of disease-resistant plants, helping boost yields, minimise waste and bolster food security. Plant diseases account for more than 15 per cent of crop losses per year. Knowing how this process comes about in plants takes researchers a step closer to making effective synthetic resistance proteins that can be used to provide additional protection from crop diseases in Australia and the world.

The team used a combination of structural biology, biochemistry, neurobiology and plant science to analyse cells and proteins, laying the foundation for some potentially ground-breaking innovations.

Institute for Glycomics Director, Professor Mark von Itzstein AO, said this study provided exciting opportunities for the development of drugs to treat neurodegenerative disorders.

"There is an increasing urgency for such drugs given that the general global population is becoming older. The World Health Organization has predicted that neurodegenerative disorders, including those that affect motor function, will become the second-most prevalent cause of death in the next 20 years," Professor von Itzstein AO said.



The research was led by researchers at Griffith University's Institute for Glycomics, University of Queensland, The Australian National University, and CSIRO, with a host of international collaborators in the US, UK and Australia.

Selected Outstanding Publications

Earley et al.

Efficient Blocking of Enterovirus 71 Infection by Heparan Sulfate Analogues Acting as Decoy Receptors, ACS Infect Dis 5 (10): 1708-1717

A new scientific discovery, thanks to one of the research groups at Griffith University's Institute for Glycomics, is providing new hope for the development of an effective treatment of Hand, Foot and Mouth Disease (HFMD).

Led by the Institute's Founder and Director, Professor Mark von Itzstein AO, the research group has discovered potent small molecules which block the early stages of EV71 infection and opens up the potential for novel drugs for treatment.

"We are hopeful that the findings of this research project will lead to an effective treatment to fight HFMD in its very early stages, and in turn offer peace of mind to millions of people around the world, especially concerned parents," Professor von Itzstein AO said.

Enterovirus 71 (EV71) is a large family of viruses that is a major cause of HFMD, a highly contagious, generally self-limiting illness. Although EV71 can infect both children and adults, it is most commonly observed in children under 5 years of age, with those aged under 2 years at higher risk of developing a severe EV71 infection.

As the name suggests, the disease is characterised by mild rashes on the hands, feet and mouth; however, in severe cases, HFMD can lead to meningitis, encephalitis, polio-like paralysis, and even death. There are currently no drugs on the market to effectively treat HFMD.

EV71 has caused outbreaks of HFMD worldwide and has been increasingly prevalent across the Asia-Pacific region, where it has become a major public health issue. In China alone, there were some 9 million cases of HFMD reported between 2008 and 2013, with nearly 2,500 confirmed deaths. More recent findings report that between 1 and 31 July 2018, a total of 377,629 cases of HFMD and four deaths were reported in China, which is a 27% increase from the same period in 2017.

"In recent years there appears to have been a significant increase in HFMD in Asia," said Dr Benjamin Bailly, lead virologist on the study.

In Australia, large outbreaks of EV71 infection have been reported and all outbreaks included cases of patients with severe neurological disease. Significant outbreaks have been reported in major Australian cities over the past three years with childcare centres and kindergartens being at higher risk.

“The increasing incidence of HFMD outbreaks, and the potential for severe complications, is now driving antiviral drug discovery research to combat enterovirus A infection, in particular EV71,” said Dr Chih-Wei Chang, lead chemist and joint senior author on the study.



Selected Outstanding Publications

Singh *et al.*

RNA secondary structure prediction using an ensemble of two-dimensional deep neural networks and transfer learning, Nat Commun **10**: 5407

In a world-first, a team of Griffith University researchers has used an artificial intelligence method to better predict RNA secondary structures, with the hope it can be developed into a tool to better understand how RNAs are implicated in various diseases such as cancer.

Professor Yaoqi Zhou, Professor Kuldip Paliwal, PhD student Jaswinder Singh and Dr Jack Hanson from Griffith's Institute for Glycomics and Signal Processing Laboratory led the research, which was published in *Nature: Communications*.

In all forms of life, ribonucleic acid (RNA) is essential for the coding, decoding, regulation and expression of genes. RNA and DNA are among the four major macromolecules in lifeforms.

The team employed the use of deep learning – a subset of artificial intelligence used to create complex, numerical functions to approximate specific tasks automatically without explicit human instructions – to build a more accurate model of the relationship between RNA sequence and structure.

This advancement comes after more than a decade of stagnation in the performance of previous methods to predict RNA structures.

Professor Zhou hoped this new method would be useful for designing new RNA molecules with therapeutic potentials.

"Imagine if protein and RNA were two people, with protein standing in front of RNA – our focus is naturally on the protein," Professor Zhou said.

"Consequently, despite the fact that the number of proteins are outnumbered by the number of RNA by more than a factor of 10, we are clueless about what these RNAs are for in our human body. That's why we developed this tool: to provide some structural clues. Getting clues is very important because more and more RNAs are implicated in more diseases including various cancers.

"The most exciting aspect is that we can now better link the sequencing information with the structure. Our sequence is encoded in our genomes, but how they are related to their function through the structure is an unknown. Using this deep learning technique we can better link the sequence to the structure and have better clues as to what their function might be. Once we understand how the sequence encodes the structure and therefore function, we can design the RNA to do it for a particular purpose, such as new drugs or molecular sensors."

In order to develop the method, the team had to expand on existing data sets for known RNA structures by sourcing approximated computational data, then refine the automated training method with the exact data.

Dr Hanson said only having access to less than 250 non-redundant known RNA structures among about 30 million



unknown was a challenge that only the use of their deep learning method could address.

“Deep learning was used in this research to model the fundamental relationship between an RNA’s nucleotide sequence and the pairing of these nucleotide bases in its functional structure,” he said.

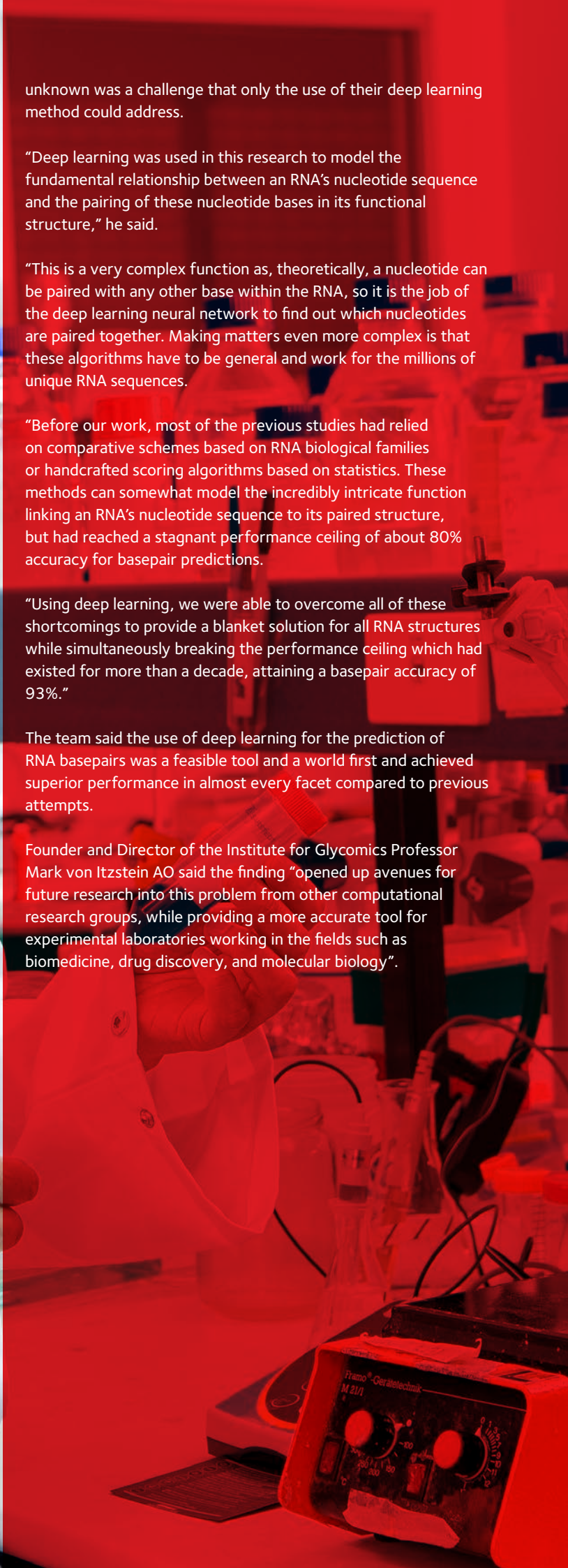
“This is a very complex function as, theoretically, a nucleotide can be paired with any other base within the RNA, so it is the job of the deep learning neural network to find out which nucleotides are paired together. Making matters even more complex is that these algorithms have to be general and work for the millions of unique RNA sequences.

“Before our work, most of the previous studies had relied on comparative schemes based on RNA biological families or handcrafted scoring algorithms based on statistics. These methods can somewhat model the incredibly intricate function linking an RNA’s nucleotide sequence to its paired structure, but had reached a stagnant performance ceiling of about 80% accuracy for basepair predictions.

“Using deep learning, we were able to overcome all of these shortcomings to provide a blanket solution for all RNA structures while simultaneously breaking the performance ceiling which had existed for more than a decade, attaining a basepair accuracy of 93%.”

The team said the use of deep learning for the prediction of RNA basepairs was a feasible tool and a world first and achieved superior performance in almost every facet compared to previous attempts.

Founder and Director of the Institute for Glycomics Professor Mark von Itzstein AO said the finding “opened up avenues for future research into this problem from other computational research groups, while providing a more accurate tool for experimental laboratories working in the fields such as biomedicine, drug discovery, and molecular biology”.



Selected Outstanding Publications

Semchenko et al.

The Serogroup B Meningococcal Vaccine Bexsero Elicits Antibodies to Neisseria gonorrhoeae, Clin Infect Dis **69** (7): 1101-1111

Gold Coast scientists have moved a step closer to finding a vaccine for gonorrhoea, which took on superbug status in 2018. A research team including experts from Griffith University and Public Health England have pinpointed the potential for a meningococcal B vaccine named Bexsero to generate protection against the sexually transmitted disease which affects more than 100 million people worldwide each year.

“Some strains of the bacteria *Neisseria gonorrhoeae* are now resistant to all antibiotics typically used to treat gonorrhoea, and unfortunately vaccine development for gonorrhoea has been very challenging,” Associate Professor Kate Seib from Griffith University’s Institute for Glycomics said.

“Gonorrhoea is a significant public health problem in Australia where the rates of infection have increased by 63% during the past five years. If left untreated, gonorrhoea can lead to

complications including pelvic inflammatory disease, adverse pregnancy outcomes, neonatal complications, and infertility.

“We urgently need new ways to treat and prevent gonorrhoea, and this work provides a new opportunity to progress gonococcal vaccine development.”

Reduced rates of gonorrhoea were previously observed in New Zealand, following a vaccine campaign with the MeNZB meningococcal B vaccine, as reported in *The Lancet* in 2017. Associate Professor Seib is now building on the independent findings of this earlier study to determine if the meningococcal B vaccine, Bexsero, could offer a feasible approach to the prevention of gonorrhoea. Bexsero was licensed in 2013 and contains the same outer membrane vesicle (OMV) antigen associated with the New Zealand MeNZB vaccine plus three additional recombinant antigens.

“We have shown that gonorrhoea has many proteins that match the OMV antigens in both the MeNZB vaccine used in the New Zealand campaign and the Bexsero meningococcal vaccine.”

Serum from Bexsero-vaccinated humans recognises the gonococcal counterparts of the antigens, which supports the finding that the MeNZB vaccine could have generated protection against gonorrhoea. The antigen NHBA, which is present in Bexsero but not MeNZB, is conserved in gonorrhoea strains and is strongly targeted by serum from Bexsero-vaccinated humans. This could provide additional cross-protection against gonorrhoea, above that predicted for MeNZB.

“It could potentially be better,” she said. “We have been working to identify the full set of gonorrhoea proteins targeted by Bexsero and determine exactly how this immune response could protect against gonorrhoea.”

Professor Mark von Itzstein AO, Director of Griffith University’s Institute for Glycomics, said gonorrhoea is now recognised as a major issue by the World Health Organization.

“This is particularly due to the emergence of drug resistance. The research undertaken by Associate Professor Kate Seib presents exciting opportunities for new vaccine discovery to tackle this world problem.”



Highlights from our Remarkable Group Leaders

In 2019, our work that targets human hand, foot and mouth disease has also delivered significant outcomes (Earley *et al.*, *ACS Infectious Diseases*, 2019). Hand, foot and mouth disease is caused by a number of viruses including enterovirus 71. In our antiviral drug discovery program targeting this virus, we have discovered potent inhibitors that efficiently block enterovirus 71 infection. This class of inhibitors are now under further investigation to provide improved efficacy and drug candidates that we can advance to preclinical trials.

Finally, we continued our work in the development of ionobiotics that break drug resistance to current antibiotics. We have now discovered two new classes of compounds that have improved activity and in 2019 our ionobiotic research was awarded a National Health and Medical Research Council Development grant to enable us to expand this exciting program over the next three years.



Professor Mark von Itzstein AO
Principal Research Leader

Human parainfluenza virus (hPIV) remains a significant clinical problem that impacts children, the elderly and immune-system weak individuals such as transplant patients alike and has neither drugs nor a vaccine available. As a consequence of our decade-long research into hPIV, we have now discovered very potent drug-like compounds that efficiently block infection by this virus. In 2019, based on a number of filed patents, we entered into a significant co-development program with Grand Medical Pty Ltd to optimise these drug-like molecules ready for human clinical trials.



Professor Michael Jennings
Principal Research Leader

The Jennings research group focuses on understanding how carbohydrates influence key steps in infectious disease and using this information to find new strategies to prevent and treat disease.

In 2019, the group published a study on carbohydrates as cellular receptors for toxins made by *Clostridium difficile*, a major cause of hospital-acquired infections.

Further published studies investigated the roles of carbohydrates in disease processes of Group A streptococcus (skin and systemic infections), *Shigella flexneri* (diarrhoea), *Pseudomonas aeruginosa* (infections in burns and cystic fibrosis), *Haemophilus influenzae* (middle ear infections, chronic obstructive pulmonary disease and pneumonia). *Haemophilus influenzae* is exquisitely adapted to life in its human host. A study published in *mBio* (Preston *et al.*, 2019), revealed how this bacterium has evolved to preferentially utilise and decorate itself with human specific carbohydrate structures mechanisms of adapt to the human host and evade immune responses.

In 2019 the group also reported a novel vaccine antigen that may have use in a vaccine to prevent disease caused by the pathogenic *Neisseria* species (meningitis, STIs).



Dr John Attack
Associate Research Leader

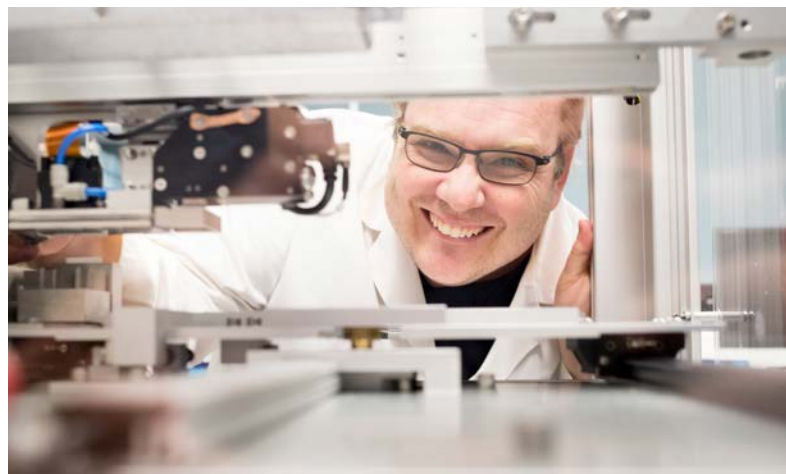
Following the founding of Dr John Attack's independent research group in 2018 with the award of an Australian Research Council Discovery Project, 2019 saw the group expand, with the addition of post-doc Dr Greg Tram, and PhD student Ms Nusrat Nahar. Dr Tram is leading work in *Streptococcus suis*, an important pig pathogen, and a leading cause of bacterial meningitis in humans. Ms Nahar is building capacity in understanding gene expression and virulence factor production in the major pig pathogen *Actinobacillus pleuropneumoniae*.

Second year PhD student Mr Zak Phillips continues his excellent progress studying gene regulation in human pathogens *Streptococcus pneumoniae* and non-typeable *Haemophilus influenzae* (NTHi). Mr Phillips won second prize for best student talk during Glycomics Week 2019, and gave an oral presentation at BacPath15 in Perth, the premier bacterial pathogenesis conference in Australia. The start of 2019 saw the publication of Mr Phillip's first paper, and the first paper from the Attack lab (Phillips *et al.*, *Infection & Immunity* **87**[5]), where they demonstrated that invasive NTHi strains modify their outer surface in specific ways, providing valuable knowledge informing NTHi vaccine development.

The Attack research group published two reviews in widely respected international journals *Biochemical Society Transactions* (Phillips *et al.*, *Biochem Soc Trans* **47**[4]:1131-1141) and *Microbiology* (Phillips *et al.*, *Microbiology* **165**[9]:917-928) where they updated the field to the progress made in understanding phase-variable genes and phasevarions,

mechanisms used by bacteria to randomise gene expression.

In recognition of his growing reputation and expertise, Dr Attack was made a Fellow of the Australian Society for Microbiology, and an Associate Research Leader in the Institute for Glycomics, in 2019. Dr Attack was invited to present at leading national and international conferences, including the International Veterinary Vaccinology Network annual meeting (London, UK, Jan 2019), Lorne Infection and Immunity (Lorne, Vic, Australia, Feb 2019), and the 20th International Symposium on Recent Advances in Otitis Media (Los Angeles, USA, June 2019).



Dr Chris Day
Associate Research Leader

The Day laboratory focuses on understanding host-pathogenic interactions reliant on carbohydrates. To achieve this the Day lab interacts with the many labs throughout the Institute. In 2019, the Day lab published work in conjunction with the Jennings, Seib, Korolik and Tiralongo research groups on a wide variety of subjects including bacterial pathogenesis and inflammation, with studies published in *Nature Chemical Biology*, *FASEB Journal* and *mBio*.

A recent study published with the Jennings and Morona (University of Adelaide) labs investigated the role of carbohydrates produced by both the host and the bacteria *Shigella flexneri* for adherence to initiate infection. This work further confirmed an underappreciated phenomenon in bacterial pathogenesis, carbohydrate-carbohydrate interactions, that Dr Day highlighted several years ago.

In 2019, the Mak, Jennings and Day labs were awarded a grant by the Australian Centre for HIV and Hepatitis Virology Research to further their collaborative work on HIV.



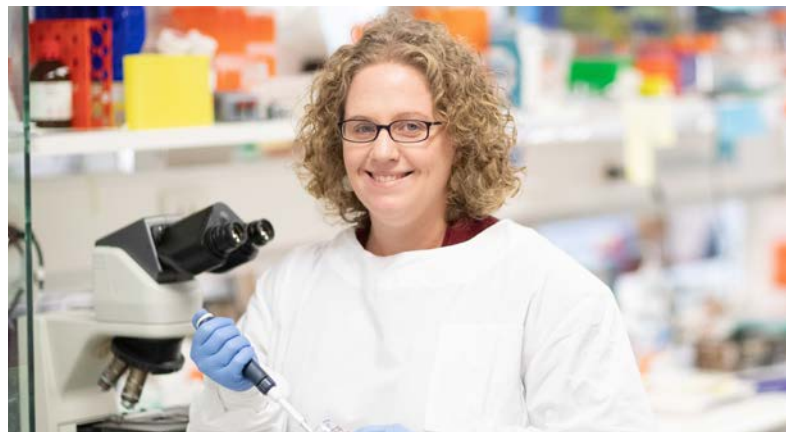
Professor Michael Good AO

Principal Research Leader

The Laboratory of Vaccines for the Developing World had a very busy year in 2019. The Good research group's first malaria vaccine trial in human volunteers was published (in *BMC Medicine*), demonstrating that the vaccine that had previously been shown to be highly effective in mice, was also highly immunogenic in humans. The research group is now in the midst of a human challenge study in which vaccinated volunteers are being given a live malaria infection and closely followed to determine whether they are protected. This study is being done in collaboration with clinical colleagues at the Gold Coast University Hospital. The group is also developing a freeze-dried preparation of the vaccine that will be suitable for easy deployment in malaria-endemic regions of the world. Using technology that was used in their malaria vaccine studies, the group has shown that they can also protect against the closely related parasites of the genus, *Babesia*. These parasites affect humans and also cattle in tick-infested tropical regions of the world.

The group's streptococcal vaccine work is progressing rapidly, with plans for a major clinical trial being presented to the Canadian regulator for approval to proceed in Canada. This vaccine has received significant support from many sources including NHMRC, the Heart Foundation and the Applied Virology Institute (University of Alberta). Streptococcus is a major cause of premature death and morbidity the world over, but most particularly amongst indigenous peoples and those living in impoverished communities, where it causes high rates of rheumatic heart disease and serious invasive infections including toxic shock.

Professor Good would like to thank the entire lab and the leadership team of Dr Danielle Stanisic and Dr Manisha Pandey. The Institute for Glycomics' Business Team has also done a remarkable job in raising the profile of the lab's research and thus attracting significant commercial interest.



Dr Danielle Stanisic

Associate Research Leader

This year Dr Stanisic has continued to oversee the Institute's world-first clinical trial to evaluate the effectiveness of the novel chemically attenuated whole parasite malaria vaccine in collaboration with Dr John Gerrard and clinicians from the Gold Coast University Hospital. This trial was made possible through financial support provided by the National Foundation for Medical Research and Innovation and Rotary. It is anticipated that the results from this study should be available in late 2020.

In 2019, Dr Stanisic and Professor Good were the grateful recipients of a Medical Research Future Fund (MRFF) "Accelerated Research" grant (\$500,000) which is allowing further development of the whole parasite malaria vaccine into a field-deployable vaccine formulation that will be suitable for use in malaria endemic areas. Two new students joined the Malaria Vaccine Development Program in 2019 and are supervised by Dr Stanisic: Ms Winter Okoth (PhD student) who is working on a project to further develop the field-deployable vaccine formulation and Mr Taymin Du Toit-Thompson (Masters student) who is working on a whole parasite vaccine approach that targets the malaria parasite stage that is infective to mosquitoes. Taymin's project will provide the first evaluation of a whole parasite transmission blocking malaria vaccine in pre-clinical models and is being undertaken in collaboration with Dr Patrick Duffy at the National Institutes of Health in the US.

The Malaria Vaccine Development Program was also joined by a new post-doctoral researcher, Dr Reshma Nevagi, who will continue the optimisation of our field-deployable vaccine formulation through the MRFF grant. Dr Nevagi was also a recipient of a 2020 Griffith University New Researchers Grant which she will use to continue to develop their novel controlled infection immunisation vaccine approach which involves co-administering live malaria parasites and an effective anti-malarial drug and this is being developed in collaboration with Professor Istvan Toth at the University of Queensland.

Ms Hanan Al-Nazal completed her very successful PhD studies into the development of a whole parasite vaccine to target the *Babesia* parasite, a close relative of the malaria parasite. The *Babesia* parasite causes cattle tick fever and is a major issue for Australia's livestock industry as well as also infecting and causing disease in humans, particularly in the US and Europe. The research group wishes her all the best in her future activities. In recognition of her contribution to the Institute, her leadership

role within the Malaria Vaccine Development Program, and her growing reputation in the field of whole parasite vaccines, Dr Stanisc was promoted to Associate Research Leader in 2019. She was invited to present the novel approach to the development of a whole parasite Babesia vaccine at a special symposium at the Annual American Society for Tropical Medicine and Hygiene in Washington DC, USA at the end of 2019.



Dr Manisha Pandey
Associate Research Leader

One of the major highlights for the Strep team has been the significant progress with the vaccine development program. The Clinical Trial Preparation team lead by Dr Manisha Pandey and with significant input from team researchers, Dr Simone Reynolds, Dr Victoria Ozberk and Ms Jessica Dooley, has successfully completed a formal toxicology study for the conjugate injectable vaccine – a major milestone towards human clinical trials. The documents are currently being finalised for submission to the regulatory bodies and the team hope to start a clinical trial, with our clinical partners the Li Ka Shing Institute, Canada, within the next few months.

In addition, the toxicology study for their second lead vaccine formulation (based on prime-pull strategy) has also commenced. The funding support from the National Heart foundation Australia will enable them to test these vaccines in a controlled human challenge model that they recently established in collaboration with MCRI, VIC with NHMRC funding. The funding support from the Snow foundation is continuing and enabling the research group to achieve these goals.

In addition, a commercial vaccine co-development program with Olymvax Biopharmaceuticals, China is supporting the research group to further develop their conjugate vaccine approach. Dr Sharareh Eskandari and Ms Ainslie Calcutt are successfully meeting the timelines and progressing the project. As per the 'technology transfer' component of this project, Dr Victoria Ozberk, visited Olymvax Biopharmaceuticals to train the Olymvax researchers in China.

The publication highlight of the year was their publication in the journal *Science Advances* (IF 12.8), a leading international journal, describing that their Strep A vaccine can prevent, and vaccine induced antibodies can treat, a deadly disease (toxic shock syndrome) caused by the Strep A organism. These findings hold high hopes for both a vaccine and for a cure. The team will

continue to take this work forward with the hope to be able to have a treatment for a deadly disease such as toxic shock syndrome.

Dr Manisha Pandey, in recognition of her grant successes and achievements in streptococcal research, was appointed as an Associate Research Leader. She has also been a recipient of the Glycomics Research Excellence award for mid-career researcher in 2020.



Professor Sue Berners-Price
Principal Research Leader

The focus of research in the Berners-Price group has been to continue to develop projects under the new research theme of Metalloglycomics – the study of defined coordination compounds with oligosaccharides. One example is the recent demonstration that the strong binding of polynuclear platinum complexes to sulfated-oligosaccharides provides a new approach to glycan-based targeting, based on disruption of the heparan sulfate (HS)/heparanase interaction, through metalloshielding of critical sulfate residues involved in recognition.

Highlights for 2019 include a study published in *Inorganic Chemistry* (58, 7146-7155, 2019) that explored the aquation and subsequent covalent binding of the trinuclear clinical agent Triplatin with D-glucosamine residues containing varied *O*-sulfate and *N*-sulfate or *N*-acetyl substitutions, which represent monosaccharide fragments present within the repeating disaccharide sequences of cell surface HS. The results emphasize the relevance of glycans in bioinorganic chemistry and underpin a fundamental molecular description of the HS-Pt interactions that alter the profile of platinum agents from cytotoxic to metastatic in a systematic manner.

Professor Sue Berners-Price was a Plenary Lecturer at the 15th International Symposium on Applied Bioinorganic Chemistry, Nara, Japan and a Keynote Speaker at the 19th International Conference on Biological Inorganic Chemistry (ICBIC19) in Interlaken, Switzerland. She is also the current President of the Society of Biological Inorganic Chemistry.



Associate Professor Kate Seib

Research Leader

Associate Professor Kate Seib's lab focuses on identifying and characterising vaccine candidates for bacterial pathogens such as *Neisseria gonorrhoeae* (causes the sexually transmitted infection gonorrhoea, which can lead to infertility), *Neisseria meningitidis* (causes sepsis and meningitis) and *Moraxella catarrhalis* and non-typeable *Haemophilus influenzae* (causes middle ear infections and exacerbations of chronic obstructive pulmonary disease).

Highlights of 2019 include Associate Professor Seib's invitation to participate in the first WHO gonococcal vaccine consultation in Geneva in January, where she contributed to discussions to guide future development of a much-needed gonococcal vaccine to combat the high levels of antibiotic resistant *N. gonorrhoeae* strains that are emerging worldwide.

She was also successful in gaining funding from several major grants for her gonococcal work, including the NIH U19 grant 'Starve and Kill: Engineered Antigens Targeting Nutrient Acquisition Pathways Essential for Gonococcal Infection and Disease'. This is a 5-year, US\$9.3 million grant of which she is a co-principal investigator and the lead of Project 3: 'Understanding and optimizing the potential public health impact of a gonococcal vaccine'. She was also recently awarded a NHMRC Clinical Trials and Cohort Studies Grant as the Lead Investigator (Chief Investigator A). This is a 4-year, AUD\$2.7 million grant titled 'A multicentre randomised controlled trial evaluating the efficacy of the meningococcal B vaccine, 4CMenB (Bexsero), against *Neisseria gonorrhoeae* infection in gay and bisexual men'. These projects, and other ongoing work within the Seib lab that has characterised several potential vaccine targets for gonorrhoea, will significantly contribute to disease prevention.



Professor Yaoqi Zhou

Principal Research Leader

One central focus of Professor Zhou's research is to elucidate the relation between sequence, structure, and function of proteins and RNAs. Knowing the intrinsic structures of molecular machines such as RNAs and proteins is the first step to understand how they work and figure out how to fix them if something went wrong and caused diseases.

Currently, one can only see (determine) these molecular structures by using sophisticated tools such as X-ray diffraction, nuclear magnetic resonance, and cryo-electron microscopy. However, these methods are costly and not effective for many RNA and proteins. The highlight of Professor Zhou's 2019 publications was the world-first application of deep learning techniques for direct sequence-based prediction of RNA secondary structure (*Nature Communications*, **10**, 5407 (2019)). The method breaks the performance ceiling of the current methods for secondary-structure prediction by accounting for basepairs associated with tertiary interactions.

In addition to sequence-based prediction, Zhou's group employed artificially generated functional sequences by deep mutational scanning to capture evolution signals of the distances between two nucleotide bases. His group showed that nearly 100% accuracy can be obtained for the full basepair structural pattern of two ribozymes studied. The result suggests the possibility that deep mutational scanning in combination with high throughput sequencing alone can be used to infer highly accurate structures for proteins and RNAs without using expensive equipment. This work (*Nucleic Acids Research*, 2020) opens a new door for solving the structures for some RNAs and proteins that are difficult to be determined by existing techniques.



Professor Victoria Korolik

Research Leader

The Korolik group is currently focused on studying the role of bacterial chemotaxis in pathogenicity and bacteria-host interactions, specifically, on deciphering ligand binding specificities of transmembrane chemosensory proteins of *Campylobacter jejuni*, *Campylobacter fetus* and *Helicobacter pylori*.

Recent breakthroughs of the Korolik group are highlighted by the discovery of a novel class of bacterial chemosensors with broad ligand specificities that may be related to sensing of the host molecules, and thus, may play a role in host-bacterial interactions.

The group is currently developing a new research area focused on biofilm formation and its role in disease transmission for campylobacters and a new collaboration involving glycan-binding proteins of *Vibrio cholera* is being established.

The group has published four refereed papers in 2019, highlighted by an invited review in *Trends in Microbiology* and a research paper in *Plos Pathogens*. Professor Victoria Korolik acted as a member of the organising committee of the 2019 *Campylobacter, Helicobacter and Related Organisms* international meeting in Belfast, Ireland where she co-chaired and presented a symposia lecture sponsored by the Gates Foundation, "Campylobacters without borders".



Professor Johnson Mak

Research Leader

In 2019, the Mak lab continues its work in HIV biology. Dr Belinda de Villiers and Dr Chandan Kishor continue with their efforts on the virology and protein biochemistry aspects of the group's work, in particular focusing on the role of sugar in HIV infection and the biophysical properties that governs HIV particle formation.

The Mak lab has also contributed to work that is published in high impact journal *Science Advances* showing the relationship between HIV and lipids during particles formation. In collaboration with Professor Michael Jennings and Dr Chris Day at the Institute, the Mak lab has been awarded a grant from Australian Centre for HIV and Hepatitis Research to test a drug that can potentially impede the establishment of HIV latency.

In 2019, the Mak lab also worked with Associate Professor Alan Liew at Griffith Institute of Integrated Intelligent Systems in using artificial intelligence to interrogate the structural determination of viral protein. Their joint student, Mr Joshua Russell has made promising observations that will enable this project to move forward. Mr Russell was also a recipient of one of the top 2019 US-Australia Fulbright Fellowships, which will pay for him to pursue graduate study in one of the top US universities for his work of machine learning in Biomedical Research.





Professor Nicolle Packer

Principal Research Leader

In 2019 Professor Nicolle Packer was active in completing the establishment of a now fully functioning Advanced Mass Spectrometry Facility with the Kolarich team. As a Chief Investigator in the ARC Centre of Excellence in Nanoscale Biophotonics (CNBP), and now with the Institute for Glycomics being a new CNBP node, she has been involved in the acceptance that glycosylation analysis is key to the understanding of the mechanisms of pain, cardiovascular disease and reproduction, with several interdisciplinary collaborations with the University of Adelaide, SAHMRI and RMIT yielding exciting results in these areas.

Through Professor Packer's interaction with the National Research Infrastructure Scheme (NCRIS) Biplatforms Australia, the Institute for Glycomics is currently being considered as the provider of glycomics analysis as one of the platforms of 'omics technologies being built to support research in Australia.

Professor Packer and Dr Everest-Dass are continuing their NHMRC Project grant in collaboration with Dr Sandersen-Smith at the University of Wollongong, with a second paper from this project being published in the FASEB journal "Human glycan expression patterns influence Group A streptococcal colonization of epithelial cells".

Continuing her aim of increasing the focus of glycomics in the research community, Professor Packer is serving as Guest Editor of a Special Issue on Glycomics and Glycoproteomics in the new RSC journal, *Molecular Omics*, as well as for a special issue on Glycoinformatics for the *Beilstein Journal of Organic Chemistry*.

In 2019 she became an elected member of the Human Proteome Organization (HUPO) Council and continued her role as Chair of the Human Glycoproteomics Initiative (HGI) where an interlaboratory comparison of mass spectrometric data obtained from complex glycoproteomics experiments has been completed and is in preparation for publication. She was also on the organising committee for the successful 2nd Australasian Glycoscience Symposium held in conjunction with a glycoprotein-filled HUPO 2019 World Congress held in Adelaide.

In the glycoinformatics space, she is an Advocate for the NIH Glygen project and is an Advisor to the newly established GlySpace Alliance of the three major international glycan-related database integration projects: Glycomics at ExPASy Switzerland, GlyGen of the US National Institutes of Health, and GlyCosmos of the Japan Science and Technology Agency.



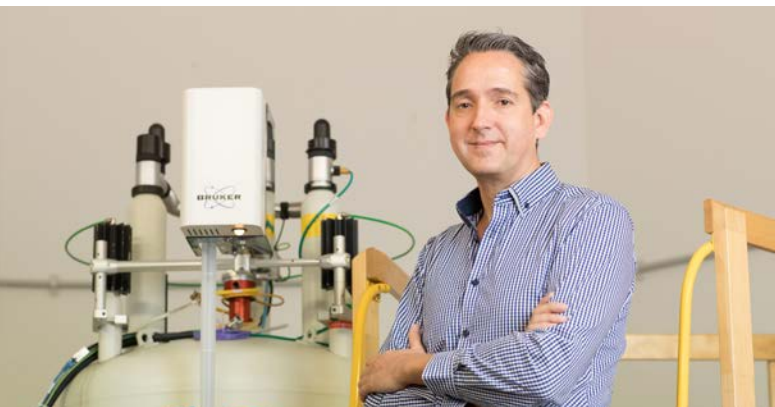
Associate Professor Daniel Kolarich

Research Leader

2019 was an exciting year. The Advanced Mass Spectrometry facility is up and running, providing various research teams across the Institute and beyond with unique and exciting data. Significant progress was made in the synthetic *N*-glycopeptide area (Alagesan *et al.*, *MethodsX* and *Glycoconjugate Journal*, 2019), and a number of new national and international collaboration partnerships have been formed that are promising to deliver thrilling new insights into the role that glycosylation plays in health and disease.

Associate Professor Kolarich was granted a Mizutani Foundation Research Grant, a prestigious Glycoscience award, for a project investigating and identifying the transferase responsible for a new type of modifications on *N*-glycans, and as part of a team with colleagues from across Griffith University, the Kolarich group were successful in obtaining a Menzies Health Institute Queensland collaboration grant 2019 to decipher the glyco-code in head and neck cancer.

2019 was also a year of conferences. Associate Professor Kolarich has been elected as Vice Chair for the next Gordon Conference in Glycobiology, and Dr Kathirvel Alagesan as a Chair for the next Gordon Research Seminar. Associate Professor Kolarich was active in the organising committee of the 25th International Symposium in Glycoconjugates, held in Milano, and the 2nd Australasian Glycoscience Symposium held in Adelaide, which were both a great success. Associate Professor Kolarich was also an invited speaker to a number of national and international conferences.



Associate Professor Thomas Haselhorst Research Leader

The Haselhorst group continued its work in 2019 on determining the structure and dynamic of glycans and their binding receptors, in the context of immunity and host-pathogen interactions. In particular, the group has focused on elucidating the structure and dynamic of glycan-glycan interactions by NMR spectroscopy and molecular modelling methods in collaboration with Professor Michael Jennings within the framework of a joint ARC grant. The group was able to solve several structures of high-affinity glycan-glycan complexes and multiple manuscripts describing these structural and dynamic properties are in preparation.

The group has made further advances in establishing the first virtual glycan array platform that will be tested and verified in 2020. Ms Danielle Lee commenced her HDR studies in the Haselhorst group with the focus on developing novel antifungal treatment options to combat invasive Aspergillosis together with Associate Professor Joe Tiralongo's research group. This project is part of the international research alliance iCAIR® (Fraunhofer International Consortium for Anti-Infective Research) between the Institute for Glycomics, Fraunhofer ITEM (Fraunhofer Institute for Toxicology and Experimental Medicine) and the Medical School Hannover (MHH) in Germany, with the focus of bringing early stage compounds into regulatory development for market approval.

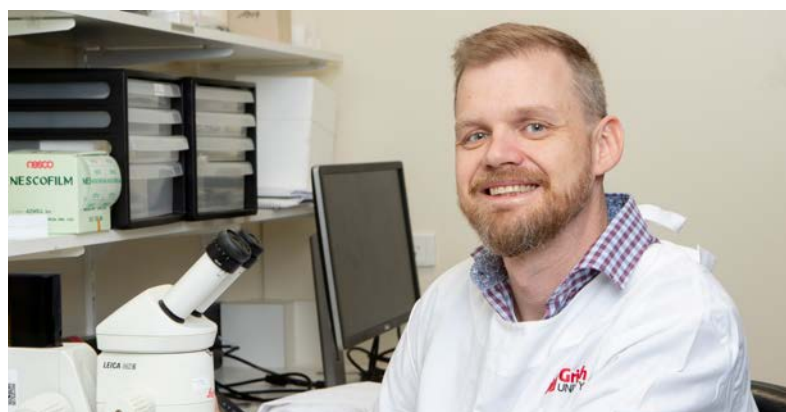
A significant review article on the glycobiology of human fungal pathogens was published by the Haselhorst/Tiralongo research groups in 2019 (Lee, DJ, O'Donnell H, Routier FH, Tiralongo J, Haselhorst T. Glycobiology of Human Fungal Pathogens: New Avenues for Drug Development. *Cells*. **2019**;8(11):1348. doi:10.3390/cells8111348).

In 2019, the Haselhorst group was successful in attracting funding from the Australia-Germany Joint Research Co-operation Scheme, an initiative of Universities Australia and the German Academic Exchange Service (DAAD) for the support of international academic co-operation. Within the framework of this exchange grant, collaboration with Professor Sørge Kelm at the University of Bremen will continue in 2020/2021 to develop a dual functional drug delivery system with targeted cell specificity and enhanced cellular uptake for the treatment of B cell-derived lymphomas.

The Haselhorst group also continued to work with the von Itzstein and Houston research groups on research funded by Sugar Research Australia (SRA) toward methods to improve sugar cane production.

In total, the Haselhorst group published four journal articles and numerous conference abstracts.

In 2019, Associate Professor Haselhorst was NHMRC panel member for the Ideas Grant Scheme, part of the organising committee and Chair of the Australian-German Science and Innovation Day, QLD representative of the Australian Association of Alexander von Humboldt Fellows, Research Ambassador and scholarship review panel member of the German Academic Exchange Service (DAAD), editorial board member of *Scientific Reports* (Nature Publishing Group) and the Magazine of the Australian and New Zealand Society for Magnetic Resonance (*ANZMAGazine*).



Dr Thomas Ve Early Career Research Leader

Dr Ve is using structural information obtained on proteins of medical relevance, to better understand their functions and identify new therapeutic strategies.

Dr Ve's group is using an integrated approach combining structural techniques such as X-ray crystallography and cryo-EM with biochemical/biophysical and cell-based functional assays, and the major focus of the research involve characterising the biology and translational potential of the SARM1 protein, a key executioner of neuronal cell-death and axon degeneration. This research is also complemented by work on proteins involved in innate immunity signalling pathways, and viral host-cell entry and inhibition.

In 2019, Dr Ve published a co-senior author paper on SARM1 in *Science* and established a commercial research program with a US-based biotech company focused on developing therapeutics for neurological disease.

Additional 2019 highlights include publication (with collaborators) of four peer-reviewed journal articles, and invited talks at the 2019 Canadian Glycomics Symposium (keynote), and CRYOZ.



Associate Professor Joe Tiralongo

Research Leader

In 2019, highlights from the Tiralongo group included the continuation of a significant collaboration with Integra HealthCare, funded through both Griffith University and Integra HealthCare that generated a patent and a publication in 2019.

In addition, work was completed on an Industry-based ARC Linkage funded project in collaboration with BioDiem Pty, with a publication generated from a master's candidate now in preparation. The group also welcomed a new PhD candidate to work on the development of novel anti-fungal drugs in a collaboration with the Medical School of Hannover and Fraunhofer Institute, Germany.

The Tiralongo research group's reputation in the stem cell community and their expertise in stem cell glycobiology was highlighted by an invited student talk, role on the organising committee and appointment of Associate Professor Tiralongo as Chair of a symposium on Glycobiology of Stem Cells and Regenerative Medicine at the TERMIS-AP+ABMC7 Conference, Brisbane in October 2019.

The Tiralongo group's work in advancing the use and accessibility of nano- and micro-technology in glycobiology was highlighted by an invited lecture at the 8th Annual Conference of AnalytiX in Osaka, Japan in 2020. Work conducted by another PhD candidate as part of the group's nano- and micro-technology in glycobiology program has led to key breakthroughs that are currently being assessed for commercialisation potential and under review for publication in a leading journal. Additional publication highlights in 2019 include papers published in *Plos One*, *Cells*, and *Infection and Immunity*.



Associate Professor Todd Houston

Research Leader

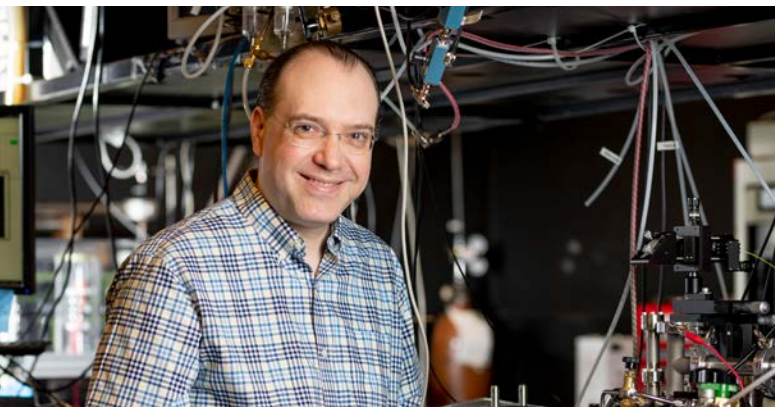
In collaboration with the von Itzstein and Haselhorst research groups, the Houston group completed a significant 4-year research project with Sugar Research Australia to identify an agent responsible for floc formation during sugar production and develop a material to aid in its removal.

Dr Tamim Mosaib was awarded his PhD for development of glycodiverse nanoparticles and demonstration of their application to macrophage drug delivery. Mr Brody Foulkes submitted his master's thesis for work on treatment of the protozoal disease Leishmaniasis. PhD student Mr Dylan Farr has completed the synthesis of a suite of antimicrobial compounds for testing against tuberculosis and MRSA.

In 2019, the Houston research group published a novel method for amidine synthesis in *Organic & Biomolecular Chemistry* based on research by former PhD student, Dr Brigid Pappin and current PhD student, Mr Taylor Garget. The amidine is an important functional group found in a number of bioactive molecules.

The Houston group also published a significant review in *Advanced Drug Delivery Reviews* on the use of glyconanoparticles in the delivery of antimicrobial agents to infected macrophages. A number of infectious organisms (bacterial, fungal, protozoal, viral) invade and proliferate within these immune cells allowing them to evade host surveillance.

In the coming year, the Houston group will continue to develop drug delivery methods toward macrophages using novel glycodiverse nanoparticles.



Associate Professor Erik Streed

Research Leader

The Streed Biophysics group is a joint laboratory between the Institute for Glycomics and the Centre for Quantum Dynamics, which works towards developing techniques from quantum physics to application in the life sciences.

The links between these two research groups is now physically tangible with the installation of a direct optical fibre connection between Gold Coast and Nathan laser laboratories in support of a DST funded PhD project.

The Streed group also continued their collaboration with the Tiralongo group in applying ion trapping techniques to individually levitate natural and fluorescently labeled yeast cells through an Honours project supported by the Glycomics Circle.



Dr Milton Kiefel

Research Leader

The Kiefel research group focuses on developing new chemistry methods to facilitate the synthesis of biologically active molecules.

In 2019, the Kiefel group continued their efforts at developing novel pathways to efficiently synthesise higher order carbohydrates that are directly associated with bacterial virulence. This work has specifically targeted the synthesis of both 8-carbon and 9-carbon acidic sugars that are found in pathogenic bacteria and is ongoing in their laboratory.

A key breakthrough in 2019 was the discovery of a new method to efficiently synthesise a class of fungal natural products that have anticancer activity. This novel cascading tandem dimerization reaction was published in 2019 (*J. Org. Chem.*, 2019, **84**, 15226), and has provided access to some new compounds that have some interesting biological activity. Research into exploiting this unique chemical reaction for constructing some novel compounds with potential anticancer activity will form the basis of a new PhD project starting in 2020.

Other research, in collaboration with Professor Tony Carroll (School of Environment and Science), resulted in the synthesis of some novel natural products that have interesting antimicrobial activity, whilst research with Professor Eddie Zhang (School of Environment and Science) that explores the development of novel polymers as components of next-generation batteries, is continuing.





Dr Lara Herrero

Research Leader

The past year has seen some exciting developments for the Herrero group, most notably being the completion of their double blind, placebo controlled, phase II clinical trial. The clinical trial, driven by collaboration between Paradigm Biopharmaceuticals Ltd., Advance QLD fellowship and the Herrero Lab, has found promising results demonstrating pentosan polysulfate may be a viable treatment for Ross River virus-induced disease. Overall results showed; 1) Clinically and statistically significant reduction of joint pain/arthritis, 2) Clinically and statistically significant improvement in hand grip strength, and 3) Clinically and statistically significant improvement in overall quality of life. The exploratory endpoints are focused on biomarkers and this is currently underway, headed by Dr Penny Rudd, as one aspect of the Advance QLD Fellowship. They hope in the next few months to have more news regarding the biomarker work.

In addition to these exciting results, the Herrero lab also farewelled three PhD students (Dr Eloise Stephenson, Dr Joyce Lee and Dr Aroon Supramanian), all who successfully finished their studies and graduated with their well-deserved PhDs.

Publications in high ranking journals including *Arthritis and Rheumatology*, *mBio* and *Parasites and Vectors* along with continuation of more clinically focused research finished the year off strong.



Dr Darren Grice

Research Leader

In 2019 highlights included continued significant commercial collaboration with the Tiralongo research group and Integra Health P/L, investigating carbohydrate structures responsible for therapeutic immunological activity in medicinal mushrooms.

Work also continued in collaboration with the von Itzstein research group on the assembly and study of PROTACs (proteolysis targeting chimeras), designed to act as therapeutic anticancer agents. In conjunction with this, one student has now been awarded their Masters of Medical Research (MMedRes) degree.

Work was completed in collaboration with Dr Ian Peak and Associate Professor Jenny Wilson (School of Medical Science) on the assembly and initial immunological activity assessment of a pilot conjugate vaccine (carbohydrate-based) for the prevention of middle ear infection in children. From his work on this project, one student was awarded his PhD and a subsequent paper was published in the scientific research journal *Vaccine*.

Significantly, the Grice group has now secured further funding from The Earbus Foundation of WA for a 4-year PhD scholarship and associated project funds to continue this important research. Research closely related to this project has also been ongoing, where bacteria closely related to those involved in middle ear infection are being investigated for their unique surface carbohydrate architecture and the connection with their ability to infect humans and cattle. This work was conducted by one PhD, one MMedRes and several undergraduate research project students.







Our Facilities

Our state-of-the art amenities facilitate our world-class research.

Some of the impressive facilities within the Institute for Glycomics include:

Physical Containment Level 3 (PC3) Facility

The Institute for Glycomics houses the only Physical Containment Level 3 (PC3) facility at Griffith University. The 180m² plus facility is dual certified by the Office of the Gene Technology Regulator (PC3) and the Department of Agriculture, Water and the Environment (BC3) and capable of handling high risk pathogens. The facility consists of dedicated laboratory and animal facilities (in collaboration with the Bioscience Service Centre) that allows our researchers to safely evaluate new therapeutic drugs or potential vaccines for viruses and bacterial pathogens that currently pose a significant risk to humans or the environment.

The multi-level facility is designed so that each laboratory space is individually HEPA filtered which can be operated independently

of adjacent areas. Each space is equipped Biological safety cabinets, incubators and associated laboratory equipment to allow rapid reconfiguration for either virus or bacterial pathogen research. This flexibly allows the researcher to respond to new and emerging pathogens.

Glycobioanalytical Facility

Our Glycobioanalytical Facility includes the Glycomics Array Facility and a Bioanalytical Suite.

- Glycomics Array Facility – established in 2006, this facility comprises a microarray manufacturing suite. The Array Facility has experience, expertise and instruments for the manufacture of contact printed microarray slides. Routinely printed slides include glycan, lectin (carbohydrate-binding protein), as well as custom arrays including amino acid, DNA, oligonucleotide, peptide and antibody arrays.
- Bioanalytical Suite – this Suite has the instrumentation to enable researchers a one-stop shop for identification of a binding profile and the further characterisation of these interactions through the implementation of surface plasmon resonance or isothermal titration calorimetry, and whole-cell-based assays through flow cytometry.

Advanced Mass Spectrometry Facility

A multi-million dollar investment by Griffith University allowed the establishment of a new glycomics and glycoproteomics focussed Advanced Mass Spectrometry Laboratory, embedded at the Institute for Glycomics.

As part of the Australian Centre for Cancer Glycomics (A2CG) a major focus of this Mass Spectrometry laboratory is to push the boundaries in biomedical research and working towards the discovery of new cancer diagnostics, drugs and vaccines, which will have global impact.

This purpose-built laboratory currently hosts three state-of-the-art high-end mass spectrometers catering for different challenges in cancer and disease glycomics:

1. rapifleX™ tissue imager
2. Orbitrap™ Fusion™ mass spectrometer
3. amaZon speed ion trap mass spectrometer

We are using these modern technologies to understand and translate the glycome changes occurring in cancer to identify new therapeutic targets, develop novel diagnostics for precision medicine and gain a better general understanding of cancer biology.

We are also offering one-stop services and solutions for industrial glycomics and glycoproteomics challenges and questions, with the team having over 60 combined years of experience in analytical glycobiology, glycomics and glycoproteomics.

Separations Science Facility

The Separations Science Facility provides an analytical service to internal and external clients. It houses four HPLC systems ranging from UHPLC single quad MS-ESI to a semi-preparative HPLC system along with various detectors: diode array, refractive index, evaporative light scattering and fluorescence.

HPLC is a separation technique based on a solid stationary phase and a liquid mobile phase. It is a useful technique for separating ions or molecules that are dissolved in a solvent, loaded onto a column and then separated and analysed by applying more solvent and using various detection methods.

We specialise in HPLC purifications and method development for products, which have never been analysed before, or a problematic HPLC method that requires optimisation or troubleshooting.

ZymeBank Facility

Provides enzymes that support both internal and external research projects. By cloning into various mammalian or bacterial expression vectors, ZymeBank is able to produce enzymes essential for glycan synthesis in high quality and purity.

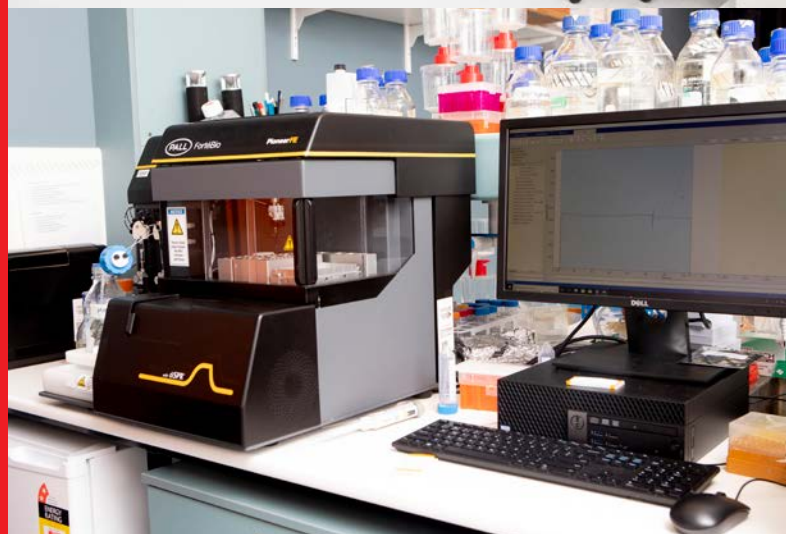
ZymeBank offers:

- ready to use enzymes
- expression plasmids (in-house cloned)
- molecular cloning
- protein expression and purification
- assay development

Other Facilities

Other specialist resources within the Institute include computational chemistry and visualisation, nuclear magnetic resonance (NMR) spectroscopy, protein X-ray crystallography, advanced microscopy and imaging, PC2 and GMP-compliant laboratories, and an irradiation facility.

The Institute's cutting-edge drug and vaccine discovery and development resources are available to external research groups and industry.



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New Grants in 2019

Grant Name	Project Name	Investigator	Total Grant
Heart Foundation - Stroke Prevention Grant	Testing the efficacy of vaccines to prevent infection with group A streptococcus – the causative agent of rheumatic heart disease-related stroke	Professor Michael Good AO, Dr Michael Batzloff, Dr Manisha Pandey, Dr Mehfuz Zaman, Dr Simone Reynolds	\$2,790,000
NHMRC - Project Grant	Novel Drugs to Reduce the Human Scabies Burden	Dr Simone Reynolds, Dr Katja Fischer (QIMR)	\$1,368,859
NHMRC - Project Grant	Enhancing vaccine immunity: modelling with Streptococcus	Dr Manisha Pandey, Dr Simone Reynolds	\$828,516
City of Gold Coast Investment Attraction Program	Support the establishment of the Fraunhofer International Consortium of Anti-Infective Research (Fraunhofer iCAIR®) Research Partnership	Professor Mark von Itzstein AO	\$750,000
Advanced Queensland - Industry-Linked Translational Research Consortium	Support of the operation of the Fraunhofer International Consortium for Anti-Infective Research (Fraunhofer iCAIR®) Centre	Professor Mark von Itzstein AO	\$700,000
Medical Research Future Fund (MRFF) - Accelerated Research Program	A vaccine for malaria: An Australian concept and development strategy	Professor Michael Good AO, Dr Danielle Stanisic	\$500,000
Australian Research Council Linkage	A memory powered engine	Associate Professor Erik Streed, Dr Andre Carvalho, Professor Joan Vaccaro, Dr Stephen Barnett, Dr Luke Uribarri	\$390,000
NHMRC Early Career Fellowship	Human parainfluenza and influenza virus hijack the host cell glycosylation machinery to facilitate infection – potential new antiviral drug targets	Dr Larissa Dirr	\$327,192
Griffith University Infrastructure Grant	High-throughput drug-structure informed drug discovery pipeline	Dr Thomas Ve, Professor Mark von Itzstein AO, Professor Michael Good AO, Professor Glen Ulett, Professor Michael Jennings	\$300,377
Tingirana Foundation Limited Grant	Traditional Chinese Medicine Melanoma Research	Professor Mark von Itzstein AO	\$220,000
National Institutes of Health (NIH) - USA	Project 3: Understanding and optimizing the potential public health impact of a gonococcal vaccine	Associate Professor Kate Seib	\$176,387

Grant Name	Project Name	Investigator	Total Grant
NHMRC - Project Grant	Molecular basis and inhibition of TIR-domain function in Toll-like receptor and neuronal cell-death pathways	Dr Thomas Ve	\$150,000
Ian Potter Foundation Medical Research Grant	Pioneering Tissue Microdissection Glycomics for Better Patient Outcomes	Professor Mark von Itzstein AO	\$100,000
Australian Centre for HIV and Hepatitis Virology Research Grant	Repurposing approved medications as oral delivery host targeting inhibitors of HIV transmission	Professor Michael Jennings, Professor Johnson Mak, Dr Christopher Day	\$91,000
National Institutes of Health (NIH) - USA	<i>Vibrio cholerae</i> c-diGMP signaling: Motile to biofilm transition and transmission	Professor Victoria Korolik	\$82,306
GCH and GCHF RGS Small Project Grant	MenGO: Does the licensed meningococcal vaccine Bexsero® provide cross-protection against gonorrhoea	Associate Professor Kate Seib	\$75,481
NHMRC Research Equipment Grant	Support NHMRC Standard Equipment Grant	Dr Thomas Ve	\$57,318
2019 Collaborative Interdisciplinary Grants Scheme	Cell surface glycoproteins as markers of diagnosis and of prognosis in head and neck squamous cell carcinomas: targets for future therapy	Emeritus Professor Newell W Johnson, Associate Professor Daniel Kolarich, Dr Nicolas West, Dr Arun Everest-Dass, Professor Alfred Lam	\$54,262
Australian Centre for HIV and Hepatitis Virology Research Grant	Repurposing widely prescribed and safe drugs to block the establishment of HIV latent macrophages reservoir	Professor Johnson Mak, Professor Michael Jennings, Dr Christopher Day	\$50,000
National Foundation for Medical Research and Innovation Research Grant	Liposome delivery of a chikungunya virus vaccine candidate: a solution to vaccine production bottlenecks	Dr Adam Taylor, Dr Mehruz Zaman, Professor Suresh Mahalingam	\$50,000
ARDC- Transformative data collections	Improvements in standardisation of storage and representation of glycomics data collections	Dr Matthew Campbell, Professor Michael Jennings, Dr Malcolm Wolski	\$49,999
Integria Healthcare (Australia) Pty Ltd Industry Partner	Exploring the immunomodulatory effect of fungal beta-glucans	Associate Professor Joe Tiralongo, Dr Darren Grice	\$40,000
Mizutani Foundation for Glycoscience	Identifying the human bisected <i>N</i> -acetylglucosamine modifying glycosyltransferase	Associate Professor Daniel Kolarich, Dr Kathirvel Alagesan, Dr Chi-Hung Lin	\$35,330

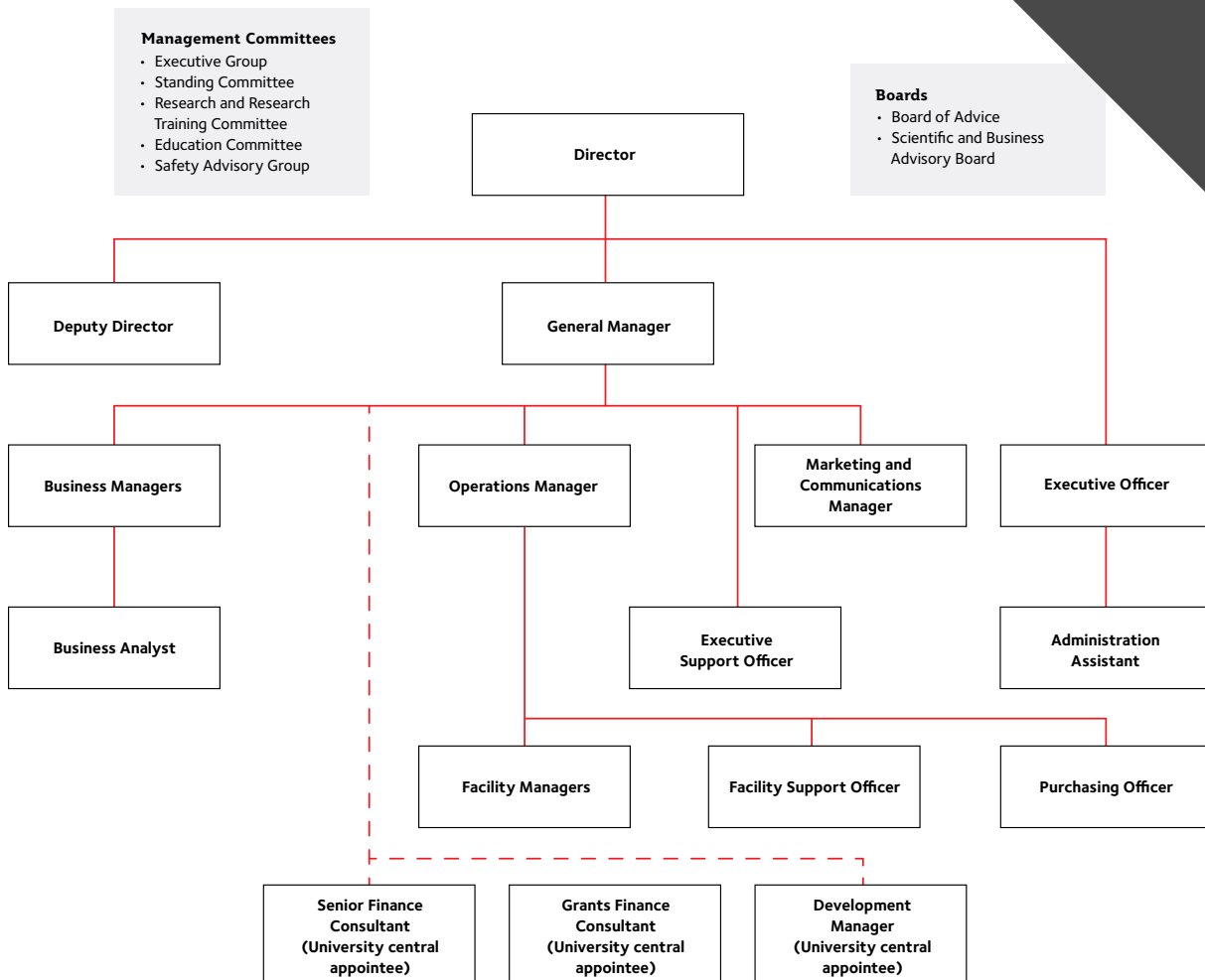
Grant Name	Project Name	Investigator	Total Grant
University of Adelaide	Spinal cord MALDI Imaging analysis	Dr Arun Everest-Dass	\$28,800
Australia-Germany Joint Research Cooperation Scheme	Dual functional drug delivery system for the treatment of Non-Hodgkin's Lymphoma	Associate Professor Thomas Haselhorst	\$24,800
Griffith University New Researcher Grant	Mass spectrometry imaging of biomolecules using multiplexed photo-cleavable probes	Dr Arun Everest-Dass	\$19,900
Australian Dental Industry Association (ADIA)	Characterisation of Treponema denticola chemoreceptors	Professor Victoria Korolik, Dr Nada Slakeski, Dr Stuart Dashper	\$19,000
ARC Discovery Project (including Fellowship)	Mimicking the perivascular niche with boronolactin-based biomaterials	Associate Professor Joe Tiralongo	\$18,000



Remarkable People

We have more than 200 experts and support members contributing to our world-class research, all of which possess a wide range of knowledge within their various fields of expertise. Ground-breaking medical research requires a host of exceptional people coupled with state-of-the-art facilities.

Institute for Glycomics organisational structure



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Professor Michael Jennings (Deputy Director)
Dr Chris Davis (General Manager)
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Mr Arjuna Abitbol
Mr Mehelet Abraha
Dr Jodie Abrahams
Ms Aysha Achman
Mr Haroon Ahmad
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Ms Hanan Ahmed Najem Al-Nazal
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Mr Kisshanpyar Anand
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Dr Benjamin Bailly
Mr Sandeep Balaganessh
Mr James Batcheldor
Dr Michael Batzloff
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Mr Callum Bennett
Professor Sue Berners-Price

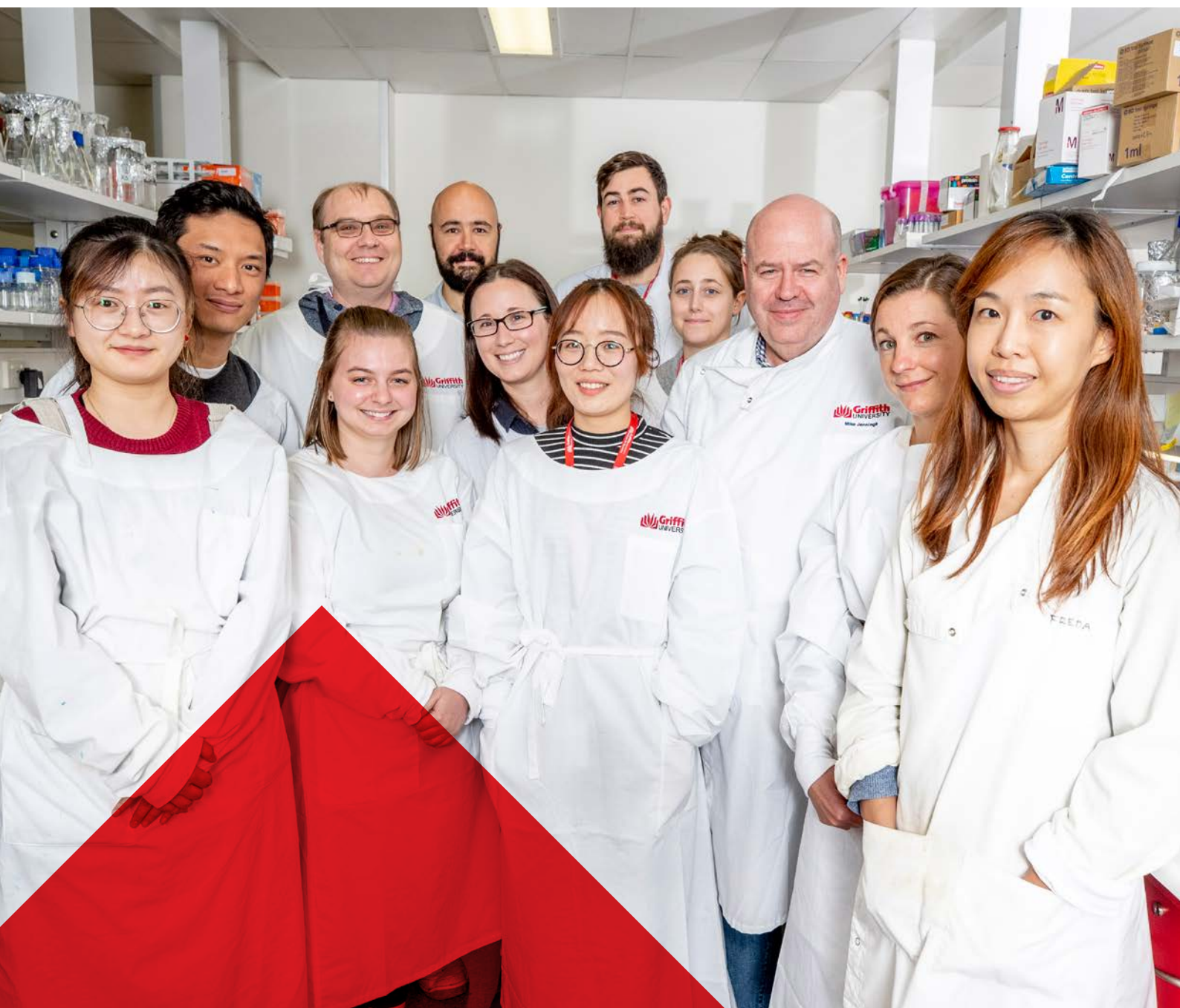
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Mr Ailar Omler
Dr Victoria Ozberk
Professor Nicolle Packer
Ms Elina Panahi
Dr Manisha Pandey
Dr Mauro Pascolutti
Dr Ian Peak
Ms Verena Pendlmayr
Dr Samuel Perry
Mr Zachary Phillips
Mr Gergely Pipa
Dr Yee Suan Poo
Dr Jessica Poole
Dr Rajaratnam Premraj
Ms Jilsy Punnasseril
Ms Shambhavi Rao
Dr Xuguang Ren
Dr Simone Reynolds
Mr Tarran Roles
Dr Michael Rolph
Ms Faith Rose
Mrs Carley Rosengreen
Ms Ashleigh Ross
Mr Nicholas Rosser
Mr Cyrill Roth
Ms Harmony Rowe
Mr Jack Rowlatt
Dr Penny Rudd
Mr Joshua Russell
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Dr Mehruz Zaman
Dr Jian Zhan
Mr Tongchuan Zhang
Mr Zhe Zhang
Ms Yuan Zhang
Professor Yaoqi Zhou
Dr Kai Zhou
Ms Angie Zhou



Plenary – Keynote – Invited Lectures in 2019

9-10 January 2019; International Veterinary Vaccinology Network (IVVN) Conference 2019, London, UK; **Dr John Attack**

24-25 January 2019; 18th Fraunhofer Seminar Translational Airway Research, Models of Lung Disease, Hannover, Germany; **Professor Mark von Itzstein AO**

24-25 January 2019; 18th Fraunhofer seminar 2019 “Models of Lung Disease”, Hannover, Germany; **Dr Patrice Guillon**

28-30 January 2019; GlycoBioTec2019, Berlin, Germany; **Professor Mark von Itzstein AO**

6-8 March 2019; Light Microscopy Australia 2019 National Meeting, Brisbane, Australia; **Dr Ali Zaid**

10-15 March 2019; 2019 Glycobiology Gordon Research Conference – Biological Means to Build, Decipher and Interpret the Complexity of the Glycome, Lucca (Barga), Italy; **Dr Arun Everest-Dass**

10-15 March 2019; 2019 Glycobiology Gordon Research Conference – Biological Means to Build, Decipher and Interpret the Complexity of the Glycome, Lucca (Barga), Italy; **Associate Professor Daniel Kolarich**

2-3 May 2019; Centre for Nanoscale BioPhotonics (CNBP) Mid-Year Workshop 2019, Melbourne, Australia; **Dr Arun Everest-Dass**

14-15 May 2019; Infection and Inflammation Conference, Vancouver, Canada; **Professor Victoria Korolik**

15-17 May 2019; 2nd Molecules Medicinal Chemistry Symposium, Barcelona, Spain; **Dr Yun Shi**

15-17 May 2019; 2nd Molecules Medicinal Chemistry Symposium, Barcelona, Spain; **Professor Mark von Itzstein AO**

15-17 May 2019; Canadian Glycomics Symposium, Banff, Alberta, Canada; **Dr Thomas Ve**

15-17 May 2019; Canadian Glycomics Symposium, Banff, Alberta, Canada; **Dr Larissa Dirr**

15-17 May 2019; Canadian Glycomics Symposium, Banff, Alberta, Canada; **Prof Michael Jennings**

16-18 May 2019; Australasian Society for Infectious Diseases Annual Meeting, Darwin, Australia; **Dr Simone Reynolds**

20 May 2019; Pint of Science Festival, Helensvale, Gold Coast, Australia; **Associate Professor Kate Seib**

20 May 2019; Pint of Science Festival, Helensvale, Gold Coast, Australia; **Associate Professor Joe Tiralongo**

2-5 June 2019; 15th International Symposium on Applied Bioinorganic Chemistry (ISABC15), Nara, Japan; **Professor Sue Berners-Price**

25–27 June 2019; Beilstein Glycoinformatic Symposium, Limburg, Germany; **Dr Matthew Campbell**

25 June 2019; Indian Institute of Science, Bangalore, India; **Dr Arun Everest-Dass**

30 June–3 July 2019; Australian Society for Microbiology (ASM) National Conference, Adelaide, Australia; **Associate Professor Kate Seib**

14–17 July 2019; STI and HIV 2019 World Congress, Vancouver, Canada; **Associate Professor Kate Seib**

14–16 July 2019; The 7th SNU International Bioinformatics Workshop 2019, Seoul, South Korea; **Professor Yaoqi Zhou**

1–2 August 2019; 19th Annual Brisbane Immunology Group Retreat, Twin Waters, Sunshine Coast, Australia; **Dr Lara Herrero**

1–4 August 2019; Workshop on Computational Biology: from molecules to systems, Songshan Lake, Guangdong Province, China; **Professor Yaoqi Zhou**

11–16 August 2019; 19th International Conference on Biological Inorganic Chemistry (ICBIC-19), Interlaken, Switzerland; **Professor Sue Berners-Price**

8–11 September 2019; CHRO 2019 – the 20th Campylobacter, Helicobacter and related Microorganisms conference, Belfast, Northern Ireland; **Professor Victoria Korolik**

14–19 September 2019; 2nd Australasian Glycoscience Symposium (AGS) & 18th Human Proteome Organisation World Congress (HUPO), Adelaide, Australia; **Professor Nicolle Packer**

17–19 September 2019; South Pacific Congress Australian Institute of Medical Scientists, Gold Coast, Australia; **Dr Danielle Stanisc**

1–3 October 2019; The Australian Society for Biochemistry and Molecular Biology Conference 2019, Perth, Australia; **Dr Larissa Dirr**

14–17 October 2019; Tissue Engineering and Regenerative Medicine International Society (TERMIS –AP) Asia Pacific Conference, Brisbane, Australia; **Associate Professor Daniel Kolarich**

21–21 October 2019; ARDC Data and Services Summit' workshop part of the eResearch Australasia Conference, Brisbane, Australia; **Dr Matthew Campbell**

25 October; Frontiers in Bio-Nano Science (FBNS) 2019 Innovation Forum, Brisbane, Australia; **Professor Michael Good AO**

26–30 October 2019; International Symposium on Pharmaceutical/Molecular Machine/Device Design and Synthesis (PMMDS 2019), Guangzhou/Jiangmen, China; **Professor Mark von Itzstein AO**

30 October; Queensland Cardiovascular Research Network, Brisbane, Australia; **Professor Michael Good AO**

30 October–2 November 2019; HKU–Pasteur Cell Biology Course on Proteomics, Hong Kong, China; **Associate Professor Daniel Kolarich**

14 November 2019; Australian Institute for Bioengineering and Nanotechnology (AIBN), Brisbane, Australia; **Associate Professor Daniel Kolarich**

16–18 November 2019; 15th Indo–Australian Biotechnology Conference, Adelaide, Australia; **Associate Professor Daniel Kolarich**

19 December 2019; American Society for Tropical Medicine & Hygiene (ASTMH) Annual Scientific Meeting, Washington DC, USA; **Professor Michael Good AO**

2–6 December 2019; 5th International Conference on Protein and RNA Structure Prediction, Punta Cana, Dominican Republic; **Professor Yaoqi Zhou**

9 December 2019; The Burnet Oration, Australian Society for Immunology (ASI) Annual Scientific Meeting, Adelaide, Australia; **Professor Michael Good AO**



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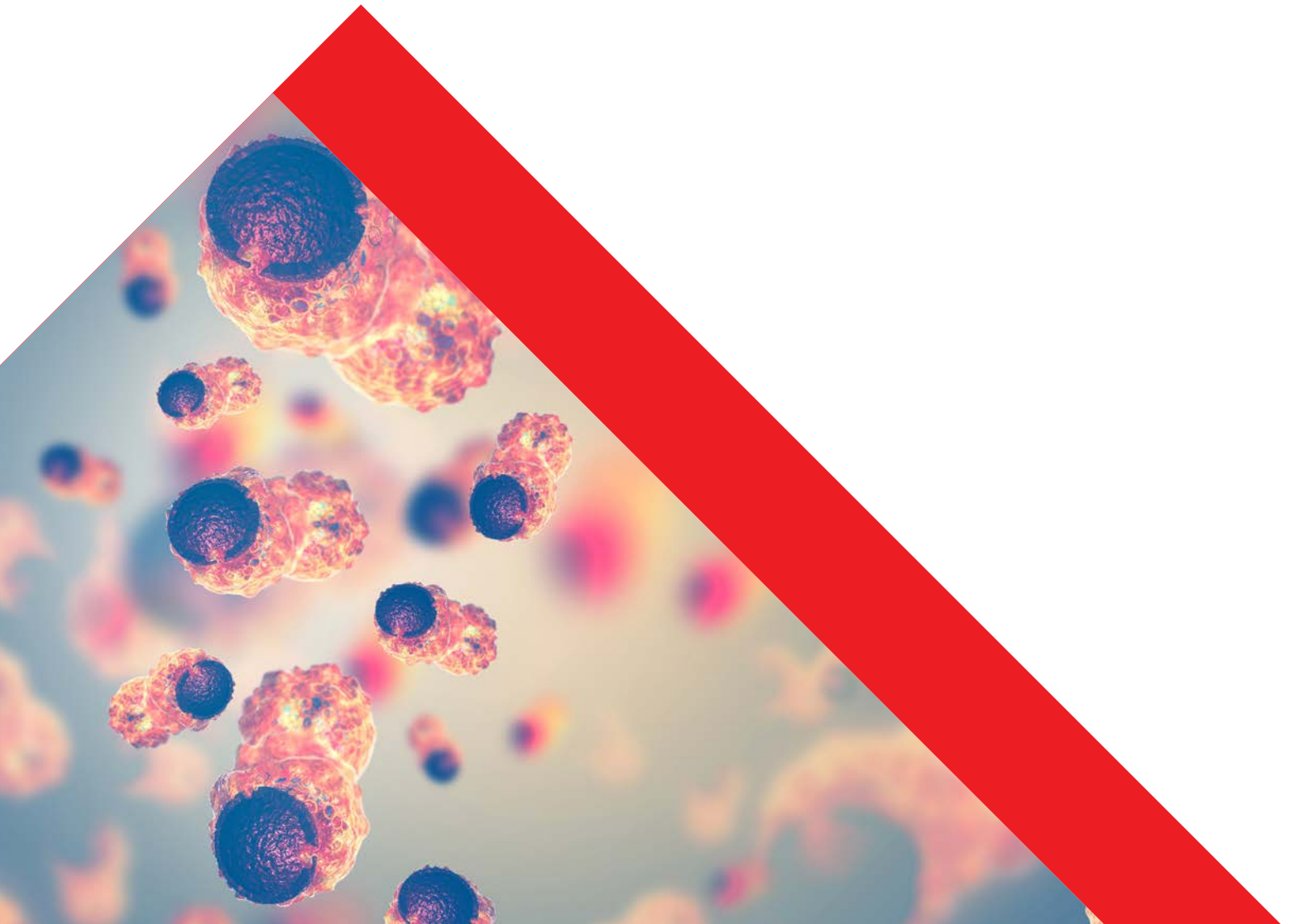
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Our Vision for the Future

We have now ended the second decade of the 21st Century. Moving into the third decade, the Institute has now positioned itself to achieve great things in fighting diseases of global impact. We have attracted a world-leading critical mass of talented researchers from all over the world and the Institute has established state-of-the-art research facilities. Our resolve to solve diseases that have no solutions remains our mission and 2020 promises to see the Institute's researchers make significant breakthroughs that will deliver our translational research vision.



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