Appendix 1: Research Examples and Case Studies

Examples of research projects demonstrating the benefits to Australia of international research collaborations:

- **Protecting Wheat Crops from Rust: University of Sydney (Australia) and the Indian Agricultural Research Institute (India)**[1]

The three wheat rusts (fungal diseases) can decimate global wheat production and so are among the world's most feared plant pathogens. Rust epidemics, particularly stripe (yellow) rust epidemics, are the most globally damaging, have extended their footprint in recent years into warmer areas where historically rust was not problematic. This has been caused by an unprecedented adaptation of the stripe rust pathogen to warmer temperatures and a general ability of the pathogen to cause more disease, more quickly.

Crop control of rust is achieved by either fungicides or genetic resistance. Using gene technology is by far the most economical and environmentally sound approach and has been the focus of a collaborative research program between Australian and Indian scientists. Indian and Australian researchers have been working together to uncover ways to broaden stem rust resistance and are now focussing on stripe rust resistance. These efforts have already resulted in new stem rust resistance genes being identified, one of which is effective against a broad range of rust strains. Rust resistance genes have now been transferred to two Australian and two Indian wheat backgrounds.

The research is a critical step in future proofing the food supply in both countries.

- **Microscopic Scanner: Australian National University (Australia) and US industry**[2]

In collaboration with leading experts in the US and Australia, Australian National University engineers have built an advanced microscope using barcode laser scanner technology that can film moving blood cells and neurons firing in living animals.

This sophisticated microscope will enable scientists to analyse complex medical problems ranging from blood disorders and cancer to neurological disorders. It uses technology that is similar to retail barcode scanners and office laser printers. "It can speed up or slow down to capture the slow-moving cells in a blood stream or live neurons firing rapidly in the brain" said the project's lead researcher Dr Steve Lee, a biomedical optics engineer. A typical barcode scanner bounces a laser beam off a polygonal mirror with up to 10 facets to register patterns. The researchers used a more powerful laser, and a 36-facet polygonal mirror. The image resolution is the same as conventional, commercially available microscopes, but the speed is doubled, capturing videos at 800 frames per second and functioning as a real time imaging solution. The researchers used advanced electronics and a flexible, customised open-source software. The microscope took just over a year to build.

Dr Lee is now collaborating with a US-based industry optics partner to further expand the capability of his team's invention.

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[1] See Go8 publication, *Excellence in India*, https://go8.edu.au/files/docs/article/go8_excellence-in-india_web.pdf

[2] See Go8 publication, *Allies in Excellence*, https://go8.edu.au/wp-content/uploads/2019/04/Allies-In-Excellence.pdf

- **Crop plants that defend themselves against their own insect pests: University of Melbourne (Australia) and the International Centre for Genetic Engineering and Biotechnology (India)**[3]

As part of the global movement to remove toxic sprayed insecticides from the agro-environment, Australian/Indian research is now taking forward caterpillar resistant cabbage and cauliflower plants developed by its team toward commercialisation in India. The research team also aims to add aphid control for use in India in cabbage and cauliflower, and for canola pest control in Australia.

Several aphid species are major disease transmitters for crop plants in the Brassica family (which includes cabbage, cauliflower, Brussels sprout, canola, kale and broccoli). The most novel aspect of the ongoing research project has been to attempt control of the insect by the crop plant itself, using RNA interference (a process which turns off or silences vital genes in the insect pest) and to add this to the already developed biotechnology system for caterpillar control. The technique involves putting short DNA sequences into plants which will generate RNA molecules. When the insect (aphid in this case) sucks the sap of the plant it picks up the complementary RNA, which binds to the aphid RNA – rather like a Velcro strip – in a process that inactivates the gene and either kills or incapacitates.

The team has identified multiple aphid gene targets for RNA interference. Both caterpillar and aphid control are major priorities in these crops in India and Australia and there is a great deal of preliminary interest from seed companies in taking any breeding lines that are developed forward to eventual commercialisation.

Examples of collaborations demonstrating the critical importance to Australia of international funding:

- **Nanopatch and Vaxxas**

This highly significant Australian vaccine technology – that may be a game changer in addressing pandemics, including COVID-19 – enjoys the support of many international partners instrumental to its growing success.

Developed by Professor Mark Kendall at the University of Queensland, the Nanopatch vaccine delivery system relies on accessing and targeting outer skin immune cells through vaccine coated microprojections invisible to the naked eye, assembled on a one-centimetre square patch.

The projections are short enough to avoid the deeper nerve cells that feel pain – but more importantly **the vaccine is formulated in dry form, removing the need for vaccine refrigeration**.

In 2011, UQ's main commercialisation company UniQuest established the company Vaxxas Pty Ltd to commercialise the technology.

The company has recently secured a deal with the Queensland State Government for an undisclosed sum to manufacture its technology at a new facility in Northshore Hamilton, expected to generate up to 139 new jobs over 10 years. The Queensland Government Premier noted Vaxxas expects to manufacture enough kits to deliver 300 million doses each year and contribute $487 million to the Queensland economy over 10 years.

[3] See Go8 publication, *Excellence in India*, https://go8.edu.au/files/docs/article/go8_excellence-in-india_web.pdf

It has also benefited from Federal government funding including though the Industry Growth Centre MTPConnect which awarded $500,000 for the establishment of a manufacturing and training facility at the Translational Research Institute where the company has been headquartered since 2014[4], as well as from Australia venture capital funds Brandon Capital and OneVentures.[5]

However, Vaxxas also works with and relies on key international partnerships, with its success including a partnership with global pharmaceutical company Merck (known as MSD outside Australia) from 2012[6]. In June 2020, MSD and Germany's Harro Höfliger announced an A$18 million investment in Vaxxas Pty Ltd.[7] Vaxxas has also announced an alliance with Harro Höfliger to develop a production line.[8]

Vaxxas will also receive $30 million through the US Government to test its technology and support pandemic deployment of the patch. Initially, the focus will be on a pandemic influenza vaccine, however Vaxxas will also investigate opportunities to improve the performance of other pandemic vaccines including against COVID-19[9,10].

Vaxxas also benefits from funding from the Bill & Melinda Gates Foundation and the World Health Organisations.[11]

Vaxxas Chief Executive David Hoey stated in an interview on 2 September 2020 with Drug Delivery Business News: [12]

> "In the influenza vaccine study that we published a few months ago, we showed that going down to one-sixth of a dose of the vaccine on the patch produced the same result as full dose by needle and syringe. And so, in a pandemic context, you can produce many more doses of the vaccine more quickly from the limited vaccine stocks. Once the vaccine is printed on the patches, it's in a dry format, and the flu vaccine was stable for 12 months at 40 °C (104 °F) and we only went out to 12 months. You can have a device that essentially could make many more doses more quickly in a pandemic response. You're able to use logistics like U.S. Postal, FedEx or UPS to distribute to homes where people could do self-administration. Self-administration is something that we were actually interested in examining pandemic aside in our next flu study."

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[4] https://www.tri.edu.au/Vaxxas

[5] https://www.afr.com/companies/healthcare-and-fitness/fresh-funds-for-qld-needle-free-vaccine-tech-start-up-vaxxas-20201004-p561wg

[6] https://www.tri.edu.au/Vaxxas and https://www.mtpconnect.org.au/Category?Action=View&Category_id=155

[7] **https://www.austrade.gov.au/international/invest/investor-updates/2020/us-pharma-giant-backs-uoq-vaccination-device-in-a-18-million-boost**

[8] https://www.brandoncapital.com.au/2020/05/28/harro-hofliger-and-vaxxas-announce-alliance-to-develop-industrial%E2%80%90scale-aseptic-processing-line-for-vaccine-products-based-on-vaxxas-high-density-microarray-patch-hd%E2%80%90map/

[9] https://www.uq.edu.au/news/article/2020/10/uq-congratulates-vaxxas-30m-partnership

[10] Vaxxas CEO reported as saying it was also in talks with undisclosed groups to fast-track its technology for COVID-19 (https://www.afr.com/companies/healthcare-and-fitness/fresh-funds-for-qld-needle-free-vaccine-tech-start-up-vaxxas-20201004-p561wg)

[11] https://www.tri.edu.au/Vaxxas

[12] https://www.drugdeliverybusiness.com/could-vaxxas-tiny-patches-enable-a-better-covid-19-vaccine/?utm_source=TrendMD&utm_medium=cpc&utm_campaign=Drug_Delivery_Business_TrendMD_0

- **Collaboration between the University of Melbourne, the Royal Melbourne Hospital and the Florey Institute of Neuroscience and Mental Health, funded by DARPA (US Department of Defense's research unit) on brain-machine interface technology that could be used to help paraplegics and quadriplegics walk again**[13]

The research involves a matchstick sized device, a "stentrode", implanted into a blood vessel next to the brain's motor cortex, bypassing the need for complex brain surgery. The stentrode picks up electrical signals from the brain and codes them into a computer, which then sends a signal to an exoskeleton attached to the arms or legs, enabling movement.

The stentrode could also benefit people with Parkinson's disease, motor neurone disease, obsessive compulsive disorder and depression and could even predict and manage seizures in epileptic patients.

This work was initially funded by DARPA, the NHMRC, the US Department of Defense, US Office of Naval Research Global, the Australian Defence Health Foundation, the Brain Foundation.

- **University of Western Australia and US biotechnology company Sarepta Therapeutics**[14]

The world's first disease-modifying drug for sufferers of Duchenne Muscular Dystrophy (DMD) is now on the market in the United States after accelerated approval in 2016 by the US FDA.

The injectable drug, Eteplirsen, was originally developed at the University of Western Australia which then licenced it to US biotechnology company Sarepta Therapeutics. Sarepta funded the required clinical trial process.

DMD is a rare and fatal muscle-wasting disease, a severe form of muscular dystrophy that occurs without a known family inheritance. It affects one in 3500 boys worldwide. Normal disease progression results in the patient becoming wheelchair-bound by age 12 and dying by age 30. Eteplirsen is the first treatment that addresses the cause of the disease and the hope is that it will slow its progression and keep patients mobile for longer, with improved quality of life. Those affected by DMD have a genetic defect and do not produce dystrophin a protein required for muscle health. Their muscles, including heart and lungs gradually waste.

- **Monash University and Janssen Biotech, for research on coeliac disease**[15]

Monash and Janssen have signed a multi-year research collaboration agreement to advance the understanding of the immune mechanisms underpinning coeliac disease and inform the development of new methods of diagnosis and treatment. The research will be led by Professor Jamie Rossjohn from the Monash Biomedicine Discovery Institute. The collaboration was facilitated by Monash Innovation, part of the Enterprise portfolio at Monash University, and by Johnson & Johnson Innovation LLC.

Director of the Monash Biomedicine Discovery Institute, Professor John Carroll, said the collaboration brings together leading researchers and industry partners to tackle this major health issue that affects so many individuals around the world.

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[13] https://pursuit.unimelb.edu.au/articles/moving-with-the-power-of-thought

[14] See Go8 publication, *Allies in Excellence*, https://go8.edu.au/wp-content/uploads/2019/04/Allies-In-Excellence.pdf

[15] https://www.monash.edu/discovery-institute/news-and-events/news/2020-articles/monash-university-announces-research-collaboration-with-janssen-to-tackle-coeliac-disease

- **University of Queensland and Boeing**[16]

Boeing Research and Technology Australia moved its Brisbane based team into a centre at the University of Queensland St Lucia campus in 2017. The centre brought together Boeing and University of Queensland researchers together to collaborate on advances in aerospace. The centre involves a high-tech student interaction display area complete with augmented-reality technology, computer labs and collaborative spaces.

At the launch, Boeing said they would:

> …work together with University of Queensland researchers and students in areas such as engineering, human movements, neuroscience, chemistry, physics and psychology. "Projects earmarked for investigation include studies in unmanned aircraft and autonomous systems, aircraft simulator technologies, manufacturing technologies, and cabin disease transmission…"[17]

Boeing and the University of Queensland also offer a range of PhD scholarships in the areas of Engineering and Computing, and Science and Mathematics.[18]

Examples of research that might not have occurred if Australia's foreign interference measures were not carefully calibrated:

- **First genome sequence of COVID-19 (China)**

University of Sydney Professor Edward (Eddie) Holmes was part of the consortium led by Chinese researcher Professor Yong-Zhen Zhang, Fudan University, that published the first genome sequence of the virus on 10 January 2020.

The genome sequence, which drills down the DNA makeup of the virus including its bases (nucleotides), confirmed it was an entirely new virus and provided critical clues to understanding the virus, its behaviour, and its sources. The consortium included Shanghai Public Health Clinical Center & School of Public Health, the Central Hospital of Wuhan, Huazhong University of Science and Technology, the Wuhan Center for Disease Control and Prevention, the National Institute for Communicable Disease Control and Prevention, and the Chinese Center for Disease Control, all of which are key Chinese research institutions in tackling the coronavirus outbreak.

Researchers at the Peter Doherty institute in Melbourne built on this work, being the first outside of China to successfully grow the virus in a lab from a patient sample, meaning Australian scientists and partners internationally had real control material to help test for the virus and assess effectiveness of trial vaccines such as University of Queensland's candidate.

- **Older diabetes sufferers at greater risk from COVID-19 (China)**

Work by Professor Paul Zimmet AO (Monash University) in an international team including Peking University Professor Linong Ji found that found elderly people with diabetes who contract COVID-19

[16] https://www.uq.edu.au/news/article/2017/06/boeing-opens-research-centre-uq
[17] https://australianaviation.com.au/2017/06/boeing-research-and-technology-australia-opens-new-centre-at-university-of-queensland/
[18] https://scholarships.uq.edu.au/scholarship/boeing-uq-research-alliance-phd-scholarship

are at a much higher risk of dying from the disease – and the virus may trigger the onset of diabetes in normally healthy people. Their work has been published in Lancet Diabetes and Endocrinology.

Examples of research that has been developed for Australian national benefit but unexpectedly become dual use:

- **Monash University and Amaero Additive Manufacturing**[19]

Monash University's world-leading strengths in laser-based additive manufacturing processes (3D printing), based on its own research, have resulted in the start-up Amaero Engineering to commercialise this technology.

It is a major success story for Australian research impacting industry. Amaero International launched on the ASX in December 2019, raising $8 million on a heavily subscribed IPO, with a market value of nearly $35 million. Partners include Boeing, Airbus, Raytheon, Northrup Grumman, BAE Systems, Safran, Thales Group and Virgin Australia.

The research enables aerospace components, including jet engines, to be built at speed using a technique focused on metallic manufacture. Amaero was established in 2013 so at the time the research took place, the Defence Trade Controls Act was not fully operational.

However, if the research were to be initiated today, a consideration would be whether the research also has potential military applications and therefore require a Defence Export Controls permit.

Additive manufacturing is not a controlled technology on the Defence Strategic Goods List. While there are controls in place for various alloys, those used in Monash additive manufacturing are not covered as they do not meet all the specific criteria listed in the DSGL.

However, the Department of Defence has included additive manufacturing as an area of consideration in its 2019 list of sensitive technologies.

Given its continuing work in additive manufacturing, Monash University has regular discussions with the Department of Defence regarding the regulatory requirements and potential application of the Act to its research in this area as well as the provision of training here and overseas on the technologies developed. Monash has also submitted other projects to the Department involving various additive manufacturing techniques. To date however, the consistent advice from the Department has been that a permit is not required.

This is an example of where due diligence, and conscientious consideration of the potential ramifications are applied by the university to ensure that the Act is not inadvertently breached.

It is also an example of where the commercial benefits and linkages with major industry successfully occur, with foreign enterprise, to Australia's benefit. It is consistent with the Government's aspiration for Australian research and universities to engage further with industry and build new opportunities for our economy.

[19] Details from Monash Go8 DTC Expert Ref Grp member Simon Barrett, cc Rebekah Brown

ANU AI tool for Defence Trade Controls assessment

The ANU is developing an artificial intelligence tool to identify research activities that are listed in the Defence Strategic Goods List (DSGL) as a means of streamlining the pre-screening of research that may need to be regulated under the Defence Trade Controls Act.

The tool is in alpha version.

It uses text mining and machine learning techniques, and a scoring system to match key phrases as well as the semantic similarity score, between publications and the content of the DSGL listed items.

So far it has been shown that the system is able to determine relevant DSGL item(s) with about 90% accuracy based on the datasets available. Researchers with no risky publications are identified quite accurately.

However, a lot more data is required to validate and improve the robustness and performance of the system. The Go8 is working to assist the ANU access data from across the eight universities so that the tool can be progressed to the next stage.

The tool conducts examination of both the researcher and the document in determining possible relevance.