Australian Academy of Science

1. **Your submission has called for the development of a domestic mixed RNA manufacturing ecosystem. Would you be able to expand on what you see the federal government's role being in achieving that outcome, and do you think there are risks associated with a lack of federal co-ordination, with states going it alone?**

There are four key elements to consider when developing a domestic mixed manufacturing ecosystem: the product pipeline; early-stage manufacturing; clinical stage manufacturing; and commercial manufacturing. The Academy sees the core role for the federal government as industry support and attraction, and policy reform. For each element, the federal government could consider the suggested approaches outlined below:

1. **Fundamental research**
   - Support early-stage innovation in biomedical RNA based research to feed the product pipeline and grow the sector, to ensure the manufacturing sector is prepared with products for the future. This could be through a targeted funding scheme, an ARC Centre of Excellence, or other special initiatives.
2. **Early-stage manufacturing**
   - Provide subsidised support to enable research advancement and translation via the National Collaborative Research Infrastructure Strategy (NCRIS) or a similar model.
   - Support for both enzymatic and chemical synthesis of RNA based products.
   - Include support functions, such as analytics and sterile filling.
   - Include direct funding of a national translation manufacturing network into the NCRIS roadmap. The network should be in coordination with states and host institutions.
   - Support research and development for the manufacturing process, such as making RNA and lipid nanoparticles better, more customised, targeted, stable, higher volume, with better purification, etc.
   - Use Advanced Manufacturing and MTP Connect growth centres for targeted funding of existing Australian and new spinout small and medium enterprises in this space.
3. **Clinical stage manufacturing**
   - Extend research translation support and phase–appropriate current Good Manufacturing Practice (cGMP) via NCRIS or similar.
     - Expand funding to NCRIS facilities to enable high quality clinically enabling material.
   - Implement a strategy to support potential commercial contract development and manufacturing organisation (CDMO) partners to set up operations in Australia.
4. **Commercial manufacturing**
   - Develop an industry attraction mode, supporting successful pharmaceutical companies to establish commercial facilities domestically to enable local and regional manufacturing.
     - Investigate best practice from leading nations, such as Singapore and South Korea, to develop an aggressive strategy for industry attraction and growth beyond historical policies.

- Support infrastructure to enable 'tech transfer' in an innovative manufacturing process from a licensed product – i.e., a commercial entity that would operate under license.
- Support sophisticated CDMO entities who can operate under license for commercial scale manufacturing (i.e., Lonza, Thermo, Catalent etc.) and create policies to support industry attraction. An exemplar model is North Carolina's Research Triangle Park.

Risks that may materialise if there is a lack of national coordination in this process include breakdowns in external communication, a lack of coordination between states leading to duplication of effort, competition from regional players, and a lack of financial backing to achieve the scale of investment required.

It should be noted that some states have already made substantial commitments to RNA manufacturing and associated technologies. This may cause barriers to achieving national coordination if states are already locked into specific pathways.

A national research strategy should also be supported to drive a future pipeline of research and translational outcomes. Such a strategy would help attract leading scientists and companies to Australia. The list of RNA research priorities developed at the National RNA Science and Technology Roundtable would help form the basis for a future strategy. The full proceedings from the roundtable can be found here. The Academy stands ready to assist with developing a national strategy for RNA science and technologies.

2. **Your submission has called on the federal government to review cluster funding rates for tertiary courses as a matter of some urgency. Obviously, there is some concern there about the impact that the current system is having on university capacity to deliver STEM education and research. Could you expand upon what you see as the current challenges with cluster funding, and how you think those challenges might best be resolved?**

The Job-ready Graduates Package reduced the cluster funding rates for many STEM subjects from 2021 (see the table below).

Discipline Cluster	2020 Funding rates			**2021 Funding rates**			Difference
	Student Contribution maximum	Commonwealth contribution amount	Total	Student Contribution maximum	Commonwealth contribution amount	Total	
Science	$9,527	$18,920	$28,447	$7,950	$16,250	$24,200	-$4,247 -17.5%
Engineering	$9,527	$18,920	$28,447	$7,950	$16,250	$24,200	-$4,247 -17.5%
Mathematical Sciences	$9,527	$10,821	$20,348	$3,950	$13,250	$17,200	-$3,148 -18.3%
Environmental Sciences	$9,527	$24,014	$33,541	$7,950	$16,250	$24,200	-$9,341 -38.6%
Law, Accounting, Administration, Economics or Commerce	$11,155	$2,198	$13,353	$14,500	$1,100	$15,600	+$2,247 +14.4%
Humanities, Society and Culture	$6,684	$6,116	$12,800	$14,500	$1,100	$15,600	+$2,800 +17.9%
Education	$6,684	$11,260	$17,944	$3,950	$13,250	$17,200	-$744 -5.6%
Clinical Psychology	$6,684	$13,308	$19,992	$3,950	$13,250	$17,200	-$2,792 -16.2%

English	$6,684	$6,116	$12,800	$3,950	$13,250	$17,200	+$4,400 +33.2%
Mathematics or Statistics	$9,527	$10,821	$20,348	$3,950	$13,250	$17,200	-$3,148 -18.3%
Visual and Performing Arts, Professional Pathway Psychology or Professional Pathway Social Work	$6,684	$13,308	$19,992	$7,950	$13,250	$21,200	+$1,208 +5.7%
Built Environment, Computing, Allied Health, Other Health	$9,527	$10,821	$20,348	$7,950	$13,250	$21,200	+$852 +4%
Nursing	$6,684	$14,858	$21,542	$3,950	$16,250	$20,200	-$1,342 -6.6%
Foreign Languages	$6,684	$13,308	$19,992	$3,950	$16,250	$20,200	+208 +1%
Engineering, Surveying or Science	$9,527	$18,920	$28,447	$7,950	$16,250	$24,200	-$4,247 -17.5%
Environmental Studies	$9,527	$24,014	$33,541	$7,950	$16.250	$24,200	-$9,341 -38.6%
Agriculture	$9,527	$24,014	$33,541	$3,950	$27,000	$30,950	-$2,591 -8%
Pathology	$9,527	$24,014	$33,541	$7,950	$27,000	$34,950	+$1,409 +4%
Medicine, Dentistry or Veterinary Science	$11,155	$24,014	$35,169	$11,300	$27,000	$38,300	+$3,131 +8%

First semester 2021 undergraduate applications and offer data indicates that since the introduction of the Package, there has been limited impact on application and offer patterns:

- Health saw a 12.6% increase in applications and a 7.8% increase in offers, primarily driven by increased applications for Nursing. This was one of the fields which saw reduced student contributions because of the Package. However, there may have also been increased interest in nursing and other health studies due to COVID.
- Other STEM related fields of education that saw increased applications were Agriculture, Environmental and Related Studies (7.3%), Information Technology (2.2%), and Engineering and Related Technologies (2%). Still, again it is unclear whether these changes have any relation to the Package.
- Natural and Physical Sciences had a less expensive student contribution in 2021 saw a slight decline in applications (-1.6%) and offers (-0.6%), suggesting the Package may have little impact on increasing students undertaking crucial STEM studies.
- Despite being one of the areas to see increased student fees, Society and Culture still saw a 1.2% increase in applicants. This continues a trend in increasing application in this area from previous years. Society and Culture was also the area to receive the largest number of offers (25.5% of all offers).
- Fields of education with increased student contributions in 2021 that also saw declines in applications included Management and Commerce (-8.1%) and Creative Arts (-6.1%). Both also saw declines in offers. However, these continue a trend in declining applications from previous years, so it does not mean the Package necessarily influenced these changes.

While the initial data suggests there have been limited impacts of the Package on application and offer patterns so far, they still have the potential to lead to lower enrolments of STEM students in the long term.

Universities have since reported job cuts and course changes, impacting staffing levels in STEM areas – particularly mathematics, physics, and chemistry. These result from legislated changes in cluster funding rates and student contribution levels and the pandemic's ongoing impact on universities.

STEM graduates are a critical component of the skilled workforce needed to establish and expand an advanced manufacturing sector in Australia. Given this, cluster funding rates should be reviewed to ensure that declining funding per STEM student does not create a perverse incentive for universities to train fewer STEM students.

Additionally, teaching and research are deeply interconnected, with the delivery of a high-quality university science curriculum reliant on research and high-quality research reliant on research training.

3. **You've also called for the introduction of a program to transition early and midcareer researchers into the manufacturing system. The need to enhance connections between academia and the manufacturing industry has been a common focus of many submissions to this inquiry. Would you be able to expand on what such a program might look like, and whether there are any comparable schemes that you are aware of which might provide a model to follow?**

As our submission highlighted, a generation of researchers is being lost. A diminished research capability will mean we are less prepared and able to respond and adapt to future emergencies. As Australia recovers from the pandemic's wide-ranging impacts, the science and research system that has served the nation well must be placed on a more sustainable and secure basis.

There is a range of opportunities to secure the career pathways of EMCRs. These include covering the gap in the pipeline, including offering more Discovery Early Career Researcher Awards or Future Fellowships; continuing and funding a greater diversity of schemes for industry and academia collaboration; and a program to transition EMCRs who have lost positions during the pandemic into roles that will allow their STEM skills to be of use, including in the manufacturing sector.

One mechanism for this may be graduate or post-graduate research industry placement programs to expand HDR graduates' skills and employability and foster research industry collaboration to promote research translation and commercialisation. These could be internship or rotation job schemes where academics can have the opportunity to 'test the waters' in a role while being supported as part of a larger program that can help that transition.

Dedicated mentoring opportunities with mentors from the manufacturing industry may help researchers navigate and understand a different environment. This could be partnered with training opportunities that will allow them to recognise their transferable skills and how these skills apply in an industry setting. Existing programs such as the Industry Mentoring Network in STEM hosted by the Australian Academy of Technology and Engineering should be supported.

The Academy recommends that any programs introduced should not impose an age or experience level limit in the program. Allowing people from different experience levels to join the program would benefit the manufacturing industry by bringing different types of knowledge and skills.

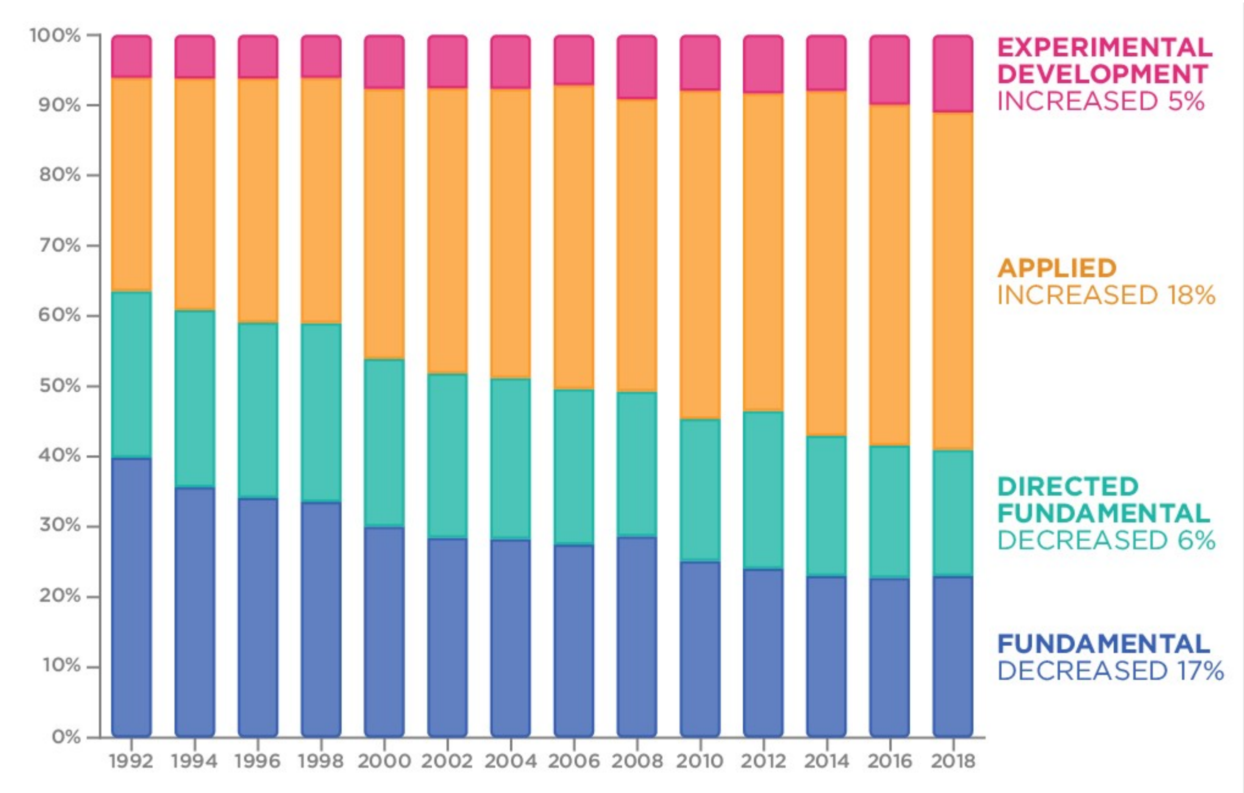
A focus on increasing collaborations between small and medium enterprises (SMEs) and academia will be critical, as SMEs dominate Australia's economic structure and are the most likely to develop and keep IP in Australia. The pathway to engage with SMEs must involve knowledge brokering, connecting organisations, industries, and researchers, and harmonising partnership enablers, including IP arrangements. Successful models such as Interface in Scotland, or the Small Business Innovation and Research program in the United States, can provide a model for an organisation that specialises in developing relationships between businesses and academics.

4. **Your submission has asked the government to ensure that investment in 'fundamental research' (as distinct from experimental development, applied, and directed fundamental) does not fall below 22% of overall R&D investment. Could you expand on the distinction between these types of research, and why you see investment in fundamental research as critical to enabling further success in the Australian manufacturing sector.**

Research and development activities in Australia are classified into four broad categories (names in parentheses are as defined by the Australian Bureau of Statistics):

- Fundamental (pure basic): experimental and theoretical work undertaken to acquire new knowledge without looking for long-term benefits other than the advancement of knowledge.
- Directed fundamental (strategic basic): experimental and theoretical work undertaken to acquire new knowledge directed into specific broad areas in the expectation of practical discoveries
- Applied: original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of fundamental research or to determine new ways of achieving some specific and predetermined objectives
- Experimental development: systematic work, using existing knowledge gained from research or practical experience, which is directed to producing new materials, devices, policies, behaviours or outlooks; to installing new process, systems and services; or to improving substantially those already produced or installed.

As noted in the Academy's submission and highlighted in the figure below, Fundamental research has received a declining share of university and government support for decades, primarily due to shifts in policy priorities to support commercialisation of research, rather than fundamental and discovery research. Care needs to be taken to ensure that policies to support commercialisation in manufacturing do not come at the expense of further knowledge generation.



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Growth opportunities for the manufacturing sector stem from the research sector, and a strong research sector requires support of the full spectrum of research activities; from fundamental research, which is focused on knowledge development, through to translational research, which aims to deliver new products and processes. Concerningly, the amount that businesses in the manufacturing sector spend on R&D has halved as a percentage of GDP in the past 15 years.

Although Australian science covers the full spectrum of research activities, recent trends in government funding to support work with anticipated practical and commercial outcomes has meant that research has become less focused on knowledge generation (i.e. pure fundamental research).

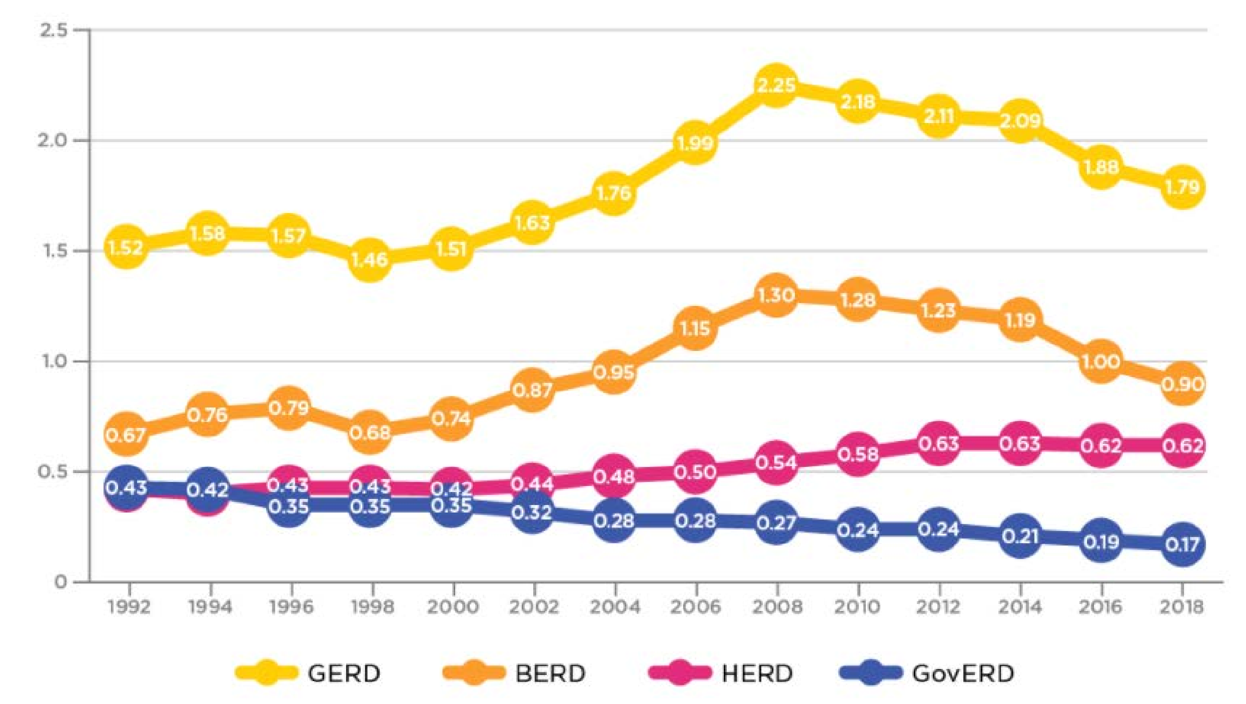
Patient and consistent government funding of fundamental research is also needed to ensure Australia develops world-leading technologies. The fruits of fundamental research and knowledge generation are often not immediately realised but can become immensely important for long-term economic and productivity growth. [1]

5. **Following on from the earlier question about fundamental research, do you think that the level of R&D support provided by the federal government more broadly is as strong as it could be, and do you think that is as well targeted as it could be, to achieve the goal of supporting a domestic manufacturing sector?**

Adequate, patient investment in fundamental science is critical to realise the transformational benefits of Australian science fully. Fundamental science has driven revolutionary transformations of society, such as the rapid growth of computer-based intelligence and the discovery of the genetic basis of life. The Academy has consistently argued that Australia needs to lift its investment in research and development, up to 3 per cent of GDP, from 1.79 per cent in 2019.

Australia is losing the global science and research race. Australia's R&D intensity is below the OECD average of 2.5% (2019) and lower than many of our peer nations. For example, in 2019, Israel's R&D intensity rose to 4.9% and Korea's to 4.6%. The US and Germany also sat above 3% in 2019 at 3.1% and 3.2%, respectively. China's R&D intensity rose to 2.2% in 2019, and while the UK sat below Australia in 2019 with an R&D intensity of 1.76%, the UK Research and Development Roadmap released in 2020 sets the target to increase UK investment in R&D to 2.4% of GDP by 2027.

Over the last decade, the percentage of Australia's GDP spent on R&D has fallen. The combined percentage of GDP from government and university R&D expenditure was the same in 2018 as it was in 1994, however since 1994, the government contribution has fallen, and universities have made up the difference.



Graphic republished from 'How is Science Funded in Australia' by the Australian Academy of Science. Data sourced from the Australian Bureau of Statistics.

Research funding from government does not cover the full cost of research. This gap was estimated to be approximately $4.6 billion in 2018, which has been filled by funding from other sources, predominantly international education revenue. This gap has critical consequences on national research capability, putting at risk the scale and capacity of Australian research to serve the interests of the nation.

The COVID-19 pandemic has illustrated how unsustainable this funding model is. The impact of COVID-19 on universities and businesses could impact future growth in support of scientific research. The Australian Governments one-off $1bn additional funding for universities through the Research Support Program has been welcomed but will end on 31 December.

References

1. Industry Innovation and Science Australia. Driving effective Government investment in innovation, science and research. (2021).