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Office of Science

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Mr Ian Blayney MLA
Chairman
Economics and Industry Standing Committee
Parliament of Western Australia
PERTH, Western Australia, 6000

Dear Chairman

Thank you for the invitation to provide a submission to your inquiry into technological and service innovation in Western Australia.

As Chief Scientist of Western Australia, I am concerned that Australia is not taking science and innovation seriously enough. If it focused on these areas, Perth has a real opportunity to transform itself into a centre of innovation and creativity. Such a transformation requires joint effort from universities, government, industry and the community.

In February this year, I convened a series of meetings over two days to discuss the ways science and innovation can be used to diversify and strengthen Australia's economy. Over 100 attendees representing stakeholders from across the State's innovation system participated. Key themes that emerged from these discussions were:

1. Australia needs to change to a culture of innovation and entrepreneurship.
2. Western Australia can support a culture of innovation through developing networks.
3. There is a need to encourage greater collaboration between industry and research.
4. Stakeholders want leadership and facilitation from Government.

The attached document outlines these key themes in more detail. It includes supporting evidence that I have collected in my role as Chief Scientist, and examines models of development currently being used internationally. I hope the information provides some insights into how science and innovation can lead to new industries.

I believe we have a real opportunity to enhance the Western Australian economy. I am pleased to provide this submission, and look forward to receiving any updates on the outcomes of this enquiry.

Best wishes

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1. **Australia needs to change to a culture of innovation and entrepreneurship.**

Science and innovation are recognised internationally as key for boosting productivity, creating better jobs, enhancing competitiveness and growing an economy. International evidence also shows that increases in research and development (R&D) substantially boost per capita growth and drives economy-wide growth which flows on to workers and communities. Other nations are investing heavily in science as they see that it is crucial to their future. For example in 2014 the United Kingdom Treasury released *"Our Plan for growth: science and innovation*", the government's 10 year strategy with a bold vision to make the UK the best place in the world for science and business.

- ***The speed of technological change is accelerating. Australia must redefine itself rapidly, or risk losing its current position of strength, and missing new opportunities for future growth.***

I believe we are at a critical juncture in Australia's evolution. There are critical decisions that will define this nation and these decisions need to be made immediately. It is imperative that we embrace the rapid changes occurring globally, and continue to be a world leader in science – this is vital for our future immediate, medium and long-term.

There have been numerous reports that indicate Australia must continue to invest in this area and must act decisively and swiftly, for example:

- *The 2015 Intergenerational Report* recognises that the world is a highly competitive place and that this country must become more efficient, innovative and adopt new technologies. Technology is changing the way we interact with each other and how we live our lives. It is changing the face of business, markets, governments and social engagement. Technological advances, such as advanced robotics, 3D printing and self-navigating vehicles have the potential to unlock massive improvements. Harnessing future opportunities to support innovation, adopt new technologies, facilitate foreign trade and investment and foster competition can boost future productivity growth and living standards.

- In the landmark document *Science, Technology, Engineering and Mathematics – Australia's Future (2014)* the Australian Chief Scientist stated, "*The reality is we can't relax. We must understand that we will get the future we earn"*. The report also stated that in Australia, 65 per cent of economic growth per capita from 1964 to 2005 can be ascribed to improvements in our use of capital, labour and technological innovation.

- The Australian Councils of Learned Academics (ACOLA) Review: *Securing Australia's future – role of science in lifting productivity (2015)* noted that there is an urgent need for Australia to increase innovation to lift productivity and build future industries. The report stressed, *"Time is not on our side. In the past ten years, other countries have moved ahead of us".* Addressing the findings of this report will help to reposition Australia as a competitive economy based on a highly productive innovation system.

- The 2014 McKinsey report: *Compete to prosper: improving Australia's global competitiveness*, stated that purposeful action is required – complacency, on the other hand, risks a painful correction for the nation through rising unemployment, falling wages and lower living standards. The report also notes that the time to act is

now and that Australia must go for growth. Other countries are moving and the window of opportunity will not remain open indefinitely.

- The 2014 Deloitte report: *Building the Lucky Country #3 Positioning for prosperity – catching the next wave* stated that Australia needs a sense of urgency, long-term thinking and clarity, and that the country should focus its scientific research on areas of potential economic gain. Looking forward, business and government leaders need to ask searching questions about where our future prosperity will come from. As a nation, Australia will achieve higher economic growth if it is not complacent and adopts a sense of urgency about the need for growth, embeds long-term thinking in the way business decisions are made and pre-emptively skills people for the emerging jobs of the future.

- The 2014 StartupAUS *Crossroads Report: Developing a Vibrant Startup Ecosystem* described Australia at the crossroads, with an unprecedented opportunity to transition from an economy based on resources, primary industries and domestically-focused businesses to one based on high-growth knowledge-intensive businesses that can compete globally in an increasingly technology-driven world. It makes the case that as a nation, Australia needs to take immediate and far-reaching steps to address market failures that are impeding the growth of our startup ecosystem.

If Perth is to become a city of scientific and technological excellence we need to value skills and inventiveness, we need to enable business and government to deliver better products and services and we need open and innovative people who can compete in a global economy. In May 2015, in an opinion piece for the West Australian newspaper, I stated that "*This is our moment - we have to grasp this opportunity. If not future generations will rightfully look back and say 'what were they doing when they had this golden opportunity"*. In that article I also relayed a chilling quote from Lord Alec Broers, former President of the Royal Academy of Engineering and Chairman of the Science and Technology Committee of the House of Lords. To paraphrase *"The pace of technology is relentless and nations that do not keep up and invest in this area will be consigned to a second world."*

2. Western Australia can support a culture of innovation through developing networks *(Our strengths).*

Western Australia has become a world leader in mining, petroleum and agricultural industries, all strongly based on science. In addition, the application of science in processing methods has allowed the State to mine large, low-grade mineral deposits and become a world leader in technology, as well as exports. Agriculture is also an area in which Western Australia excels. The State's agricultural and fisheries sectors are highly innovative by world standards, especially in dry-land farming and sustainable seafood production.

Western Australia is also one of the hottest spots worldwide for terrestrial and aquatic biodiversity and Perth is an internationally-recognised centre for radio astronomy. Western Australia also has a strong base and proud history of medical research and translation, underpinned by extensive collaboration between government, universities, medical research institutes and the private sector.

Using a variety of different measures Australia ranks highly among nations for science and innovation. (see Table 1).

Table 1: International Measures of Science and Innovation.

Measure	Ranking
2015 Global Creativity Index (talent, technology, and tolerance)	1st/139
2014 Global Innovation Index (economies' innovation capabilities) *Ranking of specific inputs enabling innovation* • *Australian Universities (5th)* • *Research Institutions (11th)* • *Infrastructure (7th)* • *Human Capital and Research (7th)* • *Research and Development (8th)*	17th/139
2013 Bloomberg Global Innovation index (R&D intensity, productivity, researcher concentration, manufacturing capability, tertiary efficiency, patent activity)	13th/ 215

Australia has five Universities ranked in the top 100 globally, and 16 Universities in the Top 100 less than 50 years old. For a nation with 0.3% of the world's population, Australia generates 3% of new knowledge each year, placing it 9th in the Organisation for Economic Co-operation and Development (OECD) rankings. This country also has produced an impressive number of Nobel Laureates, especially in the medical sciences.

Australia's research institutions also have a solid reputation for quality and rank favourably with other leading innovative countries, supporting the country's position as a source of world-class research and innovation. Australian researchers produce 5.5 per cent of the world's most cited publications, and the country ranks as one of the top in terms of the number of articles published in highly influential journals as a percentage of population. Australia also has a strong intellectual property protection regime, quality-enabling ICT infrastructure, high levels of R&D investment and a generous R&D tax incentive.

- ***Australia's science base is strong, as shown by its high public-sector expenditure on R&D, the high international ranking of its Universities and publication rates in top scientific journals (OECD Science, Technology Industry Outlook 2012)***

For Australia, the fundamentals for a "knowledge nation" are in place. However in my opinion, the nation needs a clear, long-term (generational) strategy for science, integrating academia with industry, and the rest of society. Australia must develop a long-term national plan with a vision to support not only the generation of new knowledge, but also to promote scientific realignment towards industry and economic outcomes. These approaches are consistent with the Federal Government's *"Industry Innovation and Competitiveness agenda"*, and the "*Boosting Commercial Returns from Research"*.

- ***Collaboration is increasingly important and a significant area of opportunity for the State.***

Collaboration, partnerships and co-investment across governments, industry, universities and the research sector will provide the interdisciplinary skills and infrastructure required to address the State's scientific challenges, as well as create exciting new opportunities.

Already Western Australia has in existence some great examples of partnerships across the State's priority area eg in radio astronomy the International Centre for Radio Astronomy Research; in marine science, the Western Australian Marine Science Institute; and in mining, the Minerals Research Institute of WA. Recently the Western Australia Advanced Health Research and Translation Centre, a collaboration between all of State's hospitals, medical research institutes, Universities and Government has been established. A Western Australian Biodiversity Institute will be launched later this year that will bring together over 15 partners from across government, industry and the research sector. All of these partnerships will facilitate more strategically focussed agendas in each of the State's priority areas.

- ***This country could become a highly attractive destination for innovators from across the world if Australia's cities are viewed as centres of creative and innovation.***

One advantage of the Australian population being concentrated in a limited number of metropolitan areas is critical mass, thereby increasing opportunities for innovation and creativity. As defined by the University of Toronto's, Martin Prosperity Institute, it is necessary to create a vibrant atmosphere in which the new "creative class" can thrive. The basic thesis is that occupations in science, engineering, education, computer programming, research are described as a key driving force for economic development.

I believe that for the Australian "creative class" to thrive, there are 2 key ingredients for success. First there is a need to provide an appropriate physical environment. This could include the creation of science parks, incubators, accelerators and innovation hubs in a coordinated manner, which would enable scientists to become more entrepreneurial. Second, it is essential that these clusters or hubs provide the emotional environment that supports and encourages risk-taking, coupled with sound mentoring.

If these ingredients are satisfied, the chances of creating new jobs from unknown industries are increased markedly. Research conducted by the Kauffman Foundation (2011) indicated that over the past 2 decades, new job growth in the USA has been driven by companies less than 5 years old. This highlights the importance of the entrepreneurial start-up sector to the US economy. By providing the right environment there is no reason why Australia cannot be equally successful at encouraging new job creation through the innovative start-up and SME sectors. Conversely, the Australian "creative class" is highly mobile and likely to move elsewhere if they are unable to achieve their aspirations locally.

3. **There is a need to encourage greater collaboration between industry and research *(The Challenges)***

Australia's economy has been extremely successful for many decades, but now faces some serious challenges. As Chief Scientist of Western Australia, I am deeply concerned that Australia is a great risk of succumbing to the "*Curse of the Natural Resources"* (Sachs and Warner, European Economic Review, 2001) often synonymously described as the *"Dutch disease".* The underlying proposition in this study is that countries "blessed" with natural resources find their cost of living escalates, exports become more expensive and other industries become uncompetitive. Disturbingly, complacency sets in, resulting in decreased innovation and entrepreneurial activity.

Australia's ability to translate research into commercial or practical outcomes is weak. The 2014 Global Innovation Index ranks Australia poorly for innovation efficiency index (81st), knowledge diffusion (78th), graduates in science and engineering (73rd), high and medium technology manufacturing (54th) and patents (40th). Ratings from the OECD (2013) also indicate that Australia has difficulty capitalising on its public investment in research, Australian companies rate poorly for collaboration with academia and that there is insufficient transfer of knowledge between researchers and business.

- ***Australia ranks 29th out of 30 OECD countries on the proportion of large businesses and small to medium enterprises (SMEs) collaborating with public research institutions on innovation.***

The proportion of Australian researchers working in business and industry is significantly lower in Australia than in other countries. Currently, Australia trains a large number of high quality scientists, with 60% securing jobs in academia. This contrasts with North America and Europe where 60% go into industry. In order to retain this talent, Australia needs to develop a culture that values industry links and create industries where these high technology jobs are required.

Australia also ranks poorly on the percentage of total research publications that are co-authored by industry and the research sector. One reason industry engagement with academia poor is that industry finds it difficult to navigate the structures of research organizations, and often find it hard to identify researchers interested in solving their real-world problems. Industry can also view academics as cynically seeking a source of funds for their research, without genuinely contributing towards the partnership and solving problems that industry need addressed.

A second reason for weak industry / academia linkages is the drivers of University success. The metrics for measuring success are based largely on publications and grant success, with few incentives for academics to engage with industry. This model is great for high impact papers and international rankings, but it is not conducive for industry engagement. Universities have the potential to play a much greater role in supporting industry and structural changes, such as new funding mechanisms that reward industry engagement, are required.

The German Fraunhofer system, Europe's largest applied research organisation, gears its research efforts entirely to practical outcomes. As a result, the work undertaken by researchers has a significant impact on industries and job creation. In Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has been relied on heavily to bridge the gap between academia and industry. However, in my opinion, CSIRO has drifted closer towards academic measures of success and away from industry engagement.

Australia has also invested considerable funding in the Cooperative Research Centres (CRC) Programme. Having participated in the review of the CRC program, I feel that this scheme needs to be revamped as many CRC's have pursued academic excellence at the expense of delivering much anticipated new industries. Australia should settle on appropriate funding models, and ensure that long-term consistent funding is maintained, so that applicants can focus on the objectives rather than trying to understand constantly changing guidelines. Realignment towards industry is crucial, and valuable lessons could be learnt from the German Fraunhofer system.

- ***Australia ranks second last of 17 OECD countries on new-to-the-world innovation, preferring instead adopt or modify existing innovations.***

To my mind, Australia has become an increasingly risk-averse nation. Regulations and funding schemes that support safe, incremental projects have reduced the nation's capacity for major advances. Great benefits can accrue from riskier projects, and much can be learnt from "failure". It is time to encourage risk taking across the board, and clear signals must be disseminated that "failure" is an acceptable part of learning.

It is imperative that we reduce impediments to facilitate industry growth. One example where Australia has been extremely successful because of an efficient regulatory system is in Phase I clinical trials. As Director of the Western Australian Institute for Medical Research (now the Harry Perkins Institute) a wholly-owned subsidiary company called Linear Clinical Research was established to develop early Phase clinical trials. Australia's burgeoning Phase I clinical trials industry enjoys an international competitive edge, in part, because of the rapid turnaround time for regulatory approval. Coupled with a world-class health system, high calibre staff, excellent data collection and a lower Australian dollar, this nation's Phase I system represents great value for money to the global pharmaceutical and biotechnology industries.

- ***75 per cent of the fastest growing occupations now require STEM skills***

Another significant challenge facing Australia is having a suitably trained workforce with Science, Technology, Engineering and Mathematical (STEM) skills. A 2015 report released by the Centre for Economic Development Australia stated that more than five million jobs (almost 40 per cent of Australian jobs) will not exist in the next 10 to 15 years due to technological advancements. This is in line with the Australian Chief Scientist, Professor Ian Chubb's observation that approximately 65 per cent of Australia's economic growth in the 40 years up to 2005 came from improvements in the use of capital, labour and technological innovation. STEM is vital to the nation's future and the demand for STEM will only continue to grow as we compete in a global economy.

I am concerned by the decrease in high school students undertaking science and mathematics subjects. A disconnect also exists between employer's needs and courses provided high schools, and the higher education sector. These issues have been highlighted by several publications including a 2013 study *Choosing science – understanding the decline in senior high school science enrolment* that identifies students' inability to see themselves as scientists, the perceived lack of jobs in science and low pay as components of the inter-related factors which affect their decision making.

A multifaceted approach across all sectors is required to address this emerging challenge of equipping students with the skills needed to meet this demand and to enhance the skill base. In my opinion, science and mathematics should be compulsory in years 11-12 and Universities should revert to having prerequisites for courses that require STEM. It will also require a strategy that enables prospective students in STEM disciplines to see clear pathways from the classroom to a rewarding career.

- ***There is a need to improve the translation of research into commercial outcomes to help drive innovation in Australia, grow successful Australian businesses and boost productivity.***

For the sake of this discussion, I propose there is a continuum of 1-10 from new idea or invention (defined as 1) to final practical or commercial product (defined as 10). Fundamental research falls into categories 1-3, while industry often is active between categories 6-10. Applied or translational research, sometimes known as the "valley of death" occupies categories 4-5. Many nations have identified this as a crucial gap, and are playing an active role in "de-risking" projects to encourage greater uptake of new ideas and innovation by industry.

Examples where infrastructure and funding have been enhanced to support the gap between academia and industry includes the UK Catapult system initiated by InnovateUK. Similarly, the Netherlands has Top sector support, while Canada has developed the Centres of Excellence program. Funds are provided to promote projects through categories 4-5, with rigorous evaluation of progress, and mentoring in commercialisation. These countries have also placed a large emphasis on facilitators, whose role is to link academia and industry. The new Australian Industry Growth Centres Initiative and a reinvigorated CRC Programme could potentially play similar roles.

4. **Stakeholders want leadership and facilitation from Government.** ***(The Opportunity)***

Australia, as a nation, has a wonderful opportunity to build on the strengths that it has developed, and utilise the assets it has naturally been endowed with. Australia has a major geographical advantage and in Western Australia's case is located in the same time zone as 60% of the world's population, which is the fastest growing area globally. Externally, the nation is seen as secure, stable and "green and clean".

One of the first pre-requisites for long-term planning is definition of what the nation is good at, where it has comparative advantages and what to focus on. To deliver a comprehensive science plan across a large nation like Australia requires considerable coordination. The Commonwealth Government must play a critical role in this process by providing clear direction and co-ordination, clearly defined, long-term funding schemes, physical and emotional environments that encourage innovation, creativity, entrepreneurship, risk-taking and fewer impediments to business development. It has, therefore, been pleasing to see the development of National Science and Research Priorities, and the clearly articulated alignment with the *Industry Growth Centres Initiative*. Reassuringly, these areas also overlap significantly with areas identified by the independent 2014 McKinsey and Deloitte reports, mentioned above.

In April 2015, the Western Australian Government released *A Science Statement for Western Australia*, The Statement outlines Western Australia's priorities for scientific research, based on areas where Western Australia has a comparative advantage and a strong base of research and industrial capability. This clear direction for science is essential and the very first step to align research efforts across the State and enabling better use of available resources.

The priorities are:

- mining and energy;
- medicine and health;
- agriculture and food;
- biodiversity and marine science; and
- radio astronomy.

This State has done extremely well in the sectors described above, but there are other areas where there are massive opportunities for Western Australia. While the mining, oil and gas, and agricultural sectors are likely to remain the basis of Australia's exports, it is imperative that Australia diversifies beyond its current commodity-based economy. Huge opportunities exist in other areas like the life sciences, especially given the national strengths in biomedical research. To date Australia has not developed significant biotechnology or pharmaceutical industries. As almost half of all pharmaceuticals used worldwide originated from natural products. Excellent opportunities exist to extract value from the nation's unique biota, which may produce new antibiotics, anticancer agents, herbicides etc. It is time for Australia to value biological resources as a major asset in the same way that it appreciates geological resources.

Another wonderful opportunity exists with radio-astronomy via the Square Kilometre Array (SKA) project the world's biggest radio astronomy project being built in rural remote Western Australia. The SKA project represents a paradigm shift for grasping new opportunities. Ten years ago, Perth had virtually no radio astronomy, but thanks to the initiative of the Commonwealth, CSIRO, the State Government, Curtin University and The University of Western Australia, Perth is now an internationally recognised centre for radio astronomy with more than 125 radio astronomers in the State.

In addition to the exciting scientific benefits, the data generated from the world's largest radio-astronomy project will be phenomenal. In the coming years Perth is expected to become a major "big data" hub with strong capabilities in data-intensive science. This State could become an international leader in "big data" analytics, developing new mechanisms to evaluate massive data sets. This rapidly burgeoning field could become an entirely new industry for Western Australia. This example shows, what is possible if you have the right environment, the right people and a vision is shared across institutions.

Australia has a unique opportunity right now to reposition itself. By taking this VIP (Vision, Investment and Planning) approach, Australia can develop a long-term plan for science and demonstrate how it supports the nation. It also needs to be complemented with what I term an I2I (ideas to implementation) approach, which effectively translates academic discoveries into practical outcomes.