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Dear Committee Secretary,

Please find attached our submission to the House of Representatives Standing Committee on Agriculture and Industry.

This submission addresses the role of technology in increasing agricultural productivity in Australia and focuses on the following term of reference:

- emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals.

This submission has been prepared jointly by the Australian Genome Research Facility (AGRF) and the University of Adelaide. AGRF is a not-for-profit organisation that provides scientific support services to Australian researchers in the field of genomics. The University of Adelaide is globally recognised for its research and development, teaching and commercialisation related to crop and animal breeding and associated genetic technologies.

Yours sincerely

Dr Susan Forrest
Chief Executive Officer
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Acting Deputy Vice-Chancellor (Research)
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SUBMISSION TO THE HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON AGRICULTURE AND INDUSTRY.
September 2015

This submission addresses the role of technology in increasing agricultural productivity in Australia and focuses on the following term of reference:

- **emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals.**

Break-throughs in our understanding of the basis of genetics in the 20th Century have led to a major improvement in food production globally. The result has been to delay for decades the point at which human populations exceed the carrying capacity of the globe. However, it is clear that we are once again reaching this point and new technological breakthroughs will be required to further delay global food shortages. The implications of failing to achieve food security for the world in the coming decades has been demonstrated dramatically in northern Africa, where food shortages in the 2000's led to rising food prices which in turned fuelled internal conflict and war. Lack of food security is widely regarded as being a stimulant for the current conflict in Syria which is now causing a flood of human refugees into Europe.

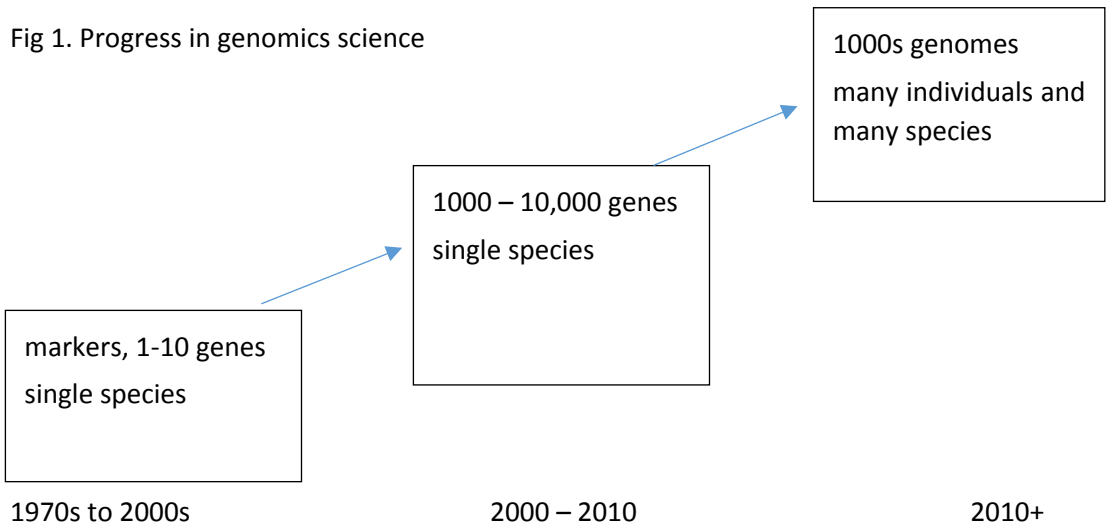
The ability to identify markers and genes for improved crop productivity was a critically important break-through in the 1970s and has enabled plant breeders to fast-track the breeding of new varieties that have enabled farmers to achieve more consistent, higher yields thereby overcoming many physical and environmental constraints to production. More recent advances in technology have enabled the mapping of 1000s and 10,000s of genes for individual crop species, increasing the speed at which target genes can be identified for breeding programs. However, the next revolution in genomic technology will be to massively increase the speed and decrease the cost of reading genomic sequences, giving us for the first time an ability to map the genome of entire agricultural production systems, including micro-organisms in the rumen and milk, the functional diversity of soil organisms, the provenance of food and fibre products and the presence of disease, weeds and pests. Such genomic infrastructure will transform the way we manage and improve agricultural performance and impact (Figure 1).

For Australia, the potential benefits of a major investment to fast-track our understanding of genomics and its application to agriculture are:

- Development of sustainable and productive farming systems for the dry tropics in northern Australia, including cattle and crops;
- An ability to shift existing crop and animal production systems into new climatic zones where they have previously been unproductive;
- Improved resource-use efficiency across all agricultural systems;
- Improving market access and ability to extract price premiums in global food chains through measurably improved animal welfare, reduced use of antibiotics in animal production, and more sustainable production with a reduced environmental footprint;
- Fast-tracking of the transformation of Australian native plants into high value, productive and disease resistant crops and pastures that are suited to our harsh environment;
- Development of rapid DNA screening to assure the provenance and origin of food and fibre products, and support market access of premium Australian products globally;

- Improvement of the efficiency of agricultural production by manipulating microorganism communities in the rumen of cattle and sheep, the soil under crops and pastures and in biocontrol agents for pests, weeds and diseases;
- Development of rapid, cheap bio-surveillance tools based on genomics to track incursions of pests, weeds and diseases faster and more effectively;
- Reduction in the cost and time required for scientific field trials, leading to improved efficiency of investment in research and development.

Fig 1. Progress in genomics science



To achieve these outcomes for Australia, the scale and coordination of genomics science will need to be increased significantly. Only by establishing a coordinated, national program can an investment in genomics science achieve the outcomes identified within the timeframe required to sustain Australia's competitive advantage in global food value chains. Since genomics has a common framework across all sectors, we suggest that a dedicated entity, *Genome Australia*, be established to provide the capability to prosecute a national strategic agenda in genomics, as a major enabler of a modern, robust and diversified 21st century economy. Key outcomes will include major leverage from national and international research investment, acting as a magnet attracting a talented workforce, and building private sector investment from the health, biopharmaceutical, agri-food, environmental management and related industries.

We propose a structure for *Genome Australia* where the federal government provides up to 50% of the funding for infrastructure platforms and strategic research and development programs, including international partnerships, with the other 50% being supplied by co-investing institutional partners, state government grants, philanthropy and industry. *Genome Australia* would coordinate genome science and technology in Australia and would work collaboratively with the genomic capability in the region and globally. An important aspect of the Australian genomics initiative is the highly refined capacity to link genomic science with biological processes and the agricultural and food industries.

Although similar to programs in Europe and North America, such as Genome Canada[1], Genome Australia builds on Australia's unique attributes of highly diverse environments, sophisticated

environmental monitoring systems and a focus on low input production systems. By combining our strong knowledge of the biological issues facing sustainable production in these environments with the latest genomics technologies we can ensure the long term viability of out agricultural industries and take the lead in setting the global innovation agenda for low input farming and food security.

Genome Australia would have four areas of focus and would prioritise projects involving significant collaboration:

1. National Genome Centres
2. Capacity Building and Education in bioinformatics, biostatistics and computational biology
3. Ground-breaking Projects in priority agricultural genomic research areas
4. Consideration of the economic, ethical, environmental, legal and societal (GE3LS) issues related to the development and delivery of genomics technologies.

A more detailed description of the proposed Genome Australia is attached (Attachment 1).

Global food security depends on the development and delivery of new technologies to increase food production on limited arable land, without relying on increased water and fertiliser use, and in a world where the frequency and severity of climate 'shocks' are expected to increase due to the ongoing impact of climate change. Several factors place Australia at the forefront of capability to address this challenge:

- Australian agriculture has maintained its leading position by producing food on the driest inhabited continent, on low quality soils and in the face of continual climate variability.
- We have built strong links and capabilities in delivering technological development to developing countries in our region.
- We have a strong research and development (R&D) base and our agricultural R&D capability ranks among the best in the world.
- We have developed a strong capability in climate change research including studies on impacts, adaptation and mitigation.
- We have expertise in human health and nutrition research.

These strengths provide a solid foundation to catalyse transformation in the food value chain. We now need to position Australia as a global leader to harness the rapidly advancing technologies of genomics for our agricultural industries.

This submission has been prepared jointly by the Australian Genome Research Facility (AGRF) and the University of Adelaide. AGRF is a not-for-profit organisations that provides scientific support services to Australian researchers in the field of genomics. It is our mission to empower Australia to be recognised for world-class innovation and leading edge genomics research. The University of

[1] http://www.genomecanada.ca/en/

Adelaide is a globally recognised for its research, development, teaching and commercialisation related to crop and animal breeding and associated genetic technologies.

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Attachment 1. Forrest and Lowe submission to Standing Committee on Agriculture and Innovation

Genome Australia

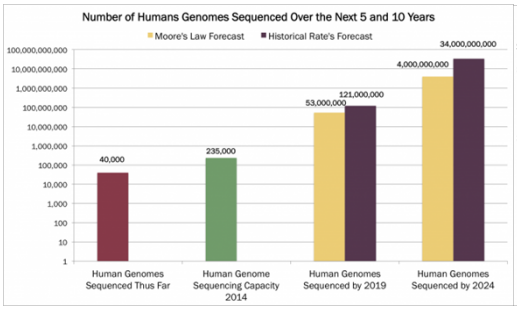
"Genomics is the information superhighway of biology and medicine."

Introduction

Genomics will not only transform all of the biologically-based industries - medicine, healthcare, agriculture, natural products and the environment, which are the largest and most important facets of the national and global economy - but also create entirely new industries that we have barely yet dreamt of, as did electronics.

The global pace of advances in genomics capability has been little short of breathtaking. Already, "small scale" genetic testing has proven economically and socially beneficial, for example BRCA gene testing in cancer. Reductions in the cost of DNA sequencing have comfortably outstripped that seen in the computer industry as described by "Moore's Law". This level of improvement is only now reaching the point where it can credibly lead to transformational scientific advancement and to the development of new commercial sectors. For instance, the astonishing growth in the number of people whose genomes have been sequenced means that the allure of personalized genomic-led medicine is becoming a realistic prospect in the foreseeable future (Fig 1a). Likewise, the exponential growth in genome sequences generated for new species (Fig 1b) is set to transform most of the life sciences and will inevitably lead to the creation of new economic activity. Exploitation of these opportunities for the benefit of the Australian economy and for the country's global scientific standing requires national coordination, speed and a common purpose**.**

Moreover, it needs a dedicated **national initiative (Genome Australia)** seeking to realise the enormous potential of genomics and its translational spinoffs that will generate intellectual property, healthcare advances and economic, environmental and social development – in short, health and prosperity for Australians.



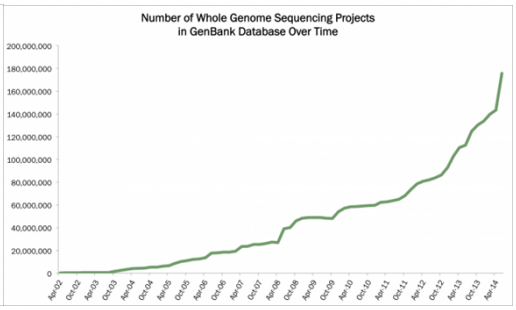


Figure 1a Figure 1b

Source: http://ark-invest.com/genomic-revolution/declining-costs-of-genome-sequencing

Genome Australia

The genomics revolution enables advances across all of the life and biological sciences and impacts on seemingly unrelated disciplines and industries such as IT, engineering, petrochemicals and mining (and therefore is far broader than the remit of NHMRC, ARC, and rural research agencies, to name some). By genomics we mean, primarily, the use of advanced DNA sequencing and analytical technologies and programs to interrogate genomic, epigenomic and gene expression profiles in relation to research questions and applied objectives, recognizing that these technologies have developed faster than any other in history. There is also a place for

related technologies in proteomics and metabolomics, which have context-specific applications, but which do not offer the power of the DNA technologies.

Since genomics has a common framework across all sectors, we suggest that a dedicated entity, *Genome Australia*, be established to provide the capability to prosecute a national strategic agenda in genomics, as a major enabler of a modern, robust and diversified 21st century economy. Key outcomes will include major leverage from national and international research investment, acting as a magnet attracting a talented workforce, and building private sector investment from the health, biopharmaceutical, agri-food, environmental management and related industries.

We propose that *Genome Australia* be modeled on Genome Canada[1], in which the federal government provides 50% of the funding for infrastructure platforms and strategic research and development programs, including international partnerships, with the other 50% being supplied by co-investing institutional partners, state government grants, philanthropy and industry. In emulating the Canadian model (which has included dedicated programs in medicine, agriculture, biodiversity etc.), *Genome Australia* would seek to coordinate genome science and technology in Australia and would work collaboratively with the genomic capability in the region and globally. An important aspect of the Australian genomics initiative is the highly refined capacity to link genomic science with biological processes, medical advances and the agricultural and food industries.

Genome Australia would have four areas of focus and would prioritise projects involving significant collaboration:

1. National Genome Centres ('platforms' in Genome Canada parlance) – to provide advanced equipment and bioinformatic capability, perhaps with specialist foci, that would not only provide cost-effective state-of-the-art services in genomic analysis to Australian researchers and industry but would also explore the latest technologies and ensure these innovative capabilities become rapidly available to Australian researchers. These centres would be highly networked to ensure resources, experience and expertise are shared, both with local groups at varying scale and linked into similar networks internationally. With an integrated national focus, expensive duplication would be avoided.

2. Capacity Building and Education in bioinformatics, biostatistics and computational biology – allowing appropriate experimental design, the development of new tools and promoting availability of existing tools for analysis of genome data sets, allowing Australian researchers and industry to mine their own data sets and exploit data generated elsewhere. Universities would be supported to develop training in computational methods to enlarge the pool of analytical capacity supported by *Genome Australia* and available to the research community, and simultaneously be fundamental to training a new generation graduates skilled in this area and boosting capacity and innovation for the business community more generally.

3. Ground-breaking Projects in genomics – to ensure that Australian genomics science would be at the forefront in the following key strategic areas:

- *Heath & Medicine* — to improve disease prevention, diagnosis and treatment with a view towards the improvement, efficiency and sustainability of the health care system by targeting expensive therapies to gain maximum benefit and contributing Australian IP to the development of new therapies.
- *Agri-food, Fisheries & Aquaculture, and Forestry* — to improve competitiveness by enhancing food production, profitability and quality, increase crop and livestock

[1] http://www.genomecanada.ca/en/

hardiness, enhance farm practices through genome/ epigenome-directed agronomy and minimise food waste during harvest, storage and transport. Genomic advances will also improve the balance between profitability and the impacts on the wider environment, help manage pests and diseases, drive the development of functional foods and promote the sustainable sourcing from our very diverse land, forest and marine ecosystems.

- *Environment and biodiversity*— to complete the genetic catalogue and tree of life of Australasian biota, one of the most unique on earth; to document the distribution of genetic resources in key pre-domesticated and wild relatives to support the next wave of bio-prospecting and sustainable natural resource product development; to identify adaptive variation to support climate change adaptation strategies and to enable rapid identification and monitoring of biodiversity for enhanced environmental impact assessment, environmental remediation and waste management.
- *Biosecurity – pests, weeds and diseases* — to protect our unique and valuable natural and agricultural environments from exotic pests and accurately identify pests in our own export products to minimise damage to trade. Additionally, to ensure preparedness and responsiveness to disease incursions (e.g. by quickly identifying pest genetic sources) and to support the advantages of Australia as a source of "clean, safe, ethical and sustainable" food and biodiversity resource products.
- *Other Industries* — to explore the use of genomics in industries not traditionally linked with life sciences, such as mining and to exploit the link between genomics and synthetic biology which will add tools to industry, the likes of which we have not yet experienced.

4. Consideration of the genomics-related economic, ethical, environmental, legal and societal (GE3LS) issues — when technology is introduced in a manner in which the implications and benefits are explained and discussed, the Australian community are early and enthusiastic adopters. *Genome Australia* will play a leadership role in working with the community and with industry to explore the ethical, legal and social challenges and opportunities of genomics research and the application of genomic-based technologies**.**

Current status

Nationally accessible infrastructure for genomics and bioinformatics is supported through NCRIS, EIF Super Science, CRIS and NCRIS 2 and is administered through Bioplatforms Australia. The entities currently supported in this manner include the Australian Genome Research Facility, the Ramaciotti Centre at UNSW, the Biomolecular Resource Facility at ANU and most recently, the Kinghorn Centre for Clinical Research at the Garvan Institute for Medical Research. There is also substantial additional genomics and bioinformatics capacity that is generally university-based and operated, elements of which are accessible to the Australian research community.

This existing funding represents a baseline investment in genomics for the future and has already built a national infrastructure network, enabled the delivery of data for large scale research projects including those in the biology of melanoma and of wheat and initiated the process of delivering bioinformatics capacity through new training programs. The potential of this capability has been proven and with time will realise significant value in sectors of importance to Australia.

The following areas need further enhancement:

- The ability to develop and implement innovative genomic approaches to clinical and biological questions through investment in people and tools to undertake and apply this knowledge.
- A significant increase in bioinformaticians and data scientists to enable improved experimental design and analysis, thereby to advance a wide range of national applications.

- Major funding for genomics projects not readily available in the present funding system. Bioplatforms Australia fund a selection of genomics data resources and NHMRC and ARC have their standard project and program grant programs where genomics may form part of the application but this does not sufficiently address the growing demand for genomics use.
- Further investment in capital and operational support to deliver services as well as build knowledge networks to enhance the uptake of genomics technology.

Governance

Australian research investment is sectorially fragmented but open to increased coordination and optimisation. We suggest that Genome Australia be established with the appropriate structure to enable strong linkages to Federal departments and state governments – key departments being Department of the Environment, Department of Agriculture, Department of Employment, Department of Health, Department of Human Services (DHS), Department of Immigration and Border Protection and Department of Industry. Input from the Attorney-General's Department (AG), Treasury, Department of the Prime Minister and Cabinet (PMC), Department of Education, Department of Finance, Department of Foreign Affairs and Trade (DFAT) may also be of value. Strong links to major government funding agencies such as ARC and NHMRC to develop synergistic approaches to funding genome science would be important.

Other important considerations include the creation of a board of management with strong governance, audit and risk skills and with appropriate scientific, industry and consumer representation and a major focus on international engagement. Key committees would include a Programs committee that designs, reviews and recommends programs for funding and a Science and Industry Advisory Committee responsible for evaluating emerging scientific research challenges and to define areas for future investment as well as opportunities for international collaboration. With the inclusion of these high level governance committees, the management of the existing Bioplatforms Australia could be the appropriate resource to supply the core.

Funding

We propose that *Genome Australia* be empowered with a federal government contribution of approximately $100M per annum (i.e. overseeing a total budget of $200M per annum with matching funds from co-investors in platforms and projects), which is commensurate with the level of funding of Genome Canada. Initially we propose a rolling 3+3 year commitment, with a thorough review in year 3 to determine whether ongoing funding for years 7-9 (etc.) is merited, based on continued relevance and performance. This model allows a balance between stability and dynamic control, with *Genome Australia* and its partners given three years notice, if required, to improve performance or shut down. During the establishment phase, we suggest ramped funding, with the federal government providing an initial $1M in 2015 to develop a strategic and operational plan, put in place an appropriate governance structure and solicit competitive funding bids/contracted research, $40M in financial year 2016-17, $70M in 2017-18, and $100M per annum thereafter. With matched funding from partners, this would equate to a $200M pool for genomic sciences and genomically-driven industry development.