Murdoch University's submission to the Education, Employment and Workplace Relations References Committee's inquiry on 'all aspects of higher education and skills training to support future demand in agriculture and agribusiness in Australia'

Murdoch University is a recognised leader in agricultural-related research as evidenced by the excellent results attained in the 2010 ERA ratings (e.g. an ERA rating 5 for Crops and Pastures).

Murdoch University's national and international research strengths include plant and animal virology, immunology, plant nematology and animal parasitology, phytoplasmas, fungi, microbiology, bacteria, etc., and a strong focus on crop pre-breeding research, molecular diagnostics, genomics, proteomics, metabolomics, and bioinformatics, transgenic plants and crop biosecurity, animal and veterinary science (among others). Within the Plant Biotechnology Research Group (PBRG) Murdoch hosts the largest team of plant nematologists in Australia, the only nematology group focussing at the molecular level. The PBRG also specialises in plant viruses and phytoplasmas (plant bacteria). Murdoch also has multi-million dollar internationally collaborative crop and pasture RD&E projects involving ACIAR and the Melinda and Bill Gates Foundation, among others, and hosts associated agricultural biotechnology companies such as Saturn Biotech, Xytogen and NemGenix. Murdoch's collaborative projects encompass R&D on crop pest and disease resistance, soil fertility improvement, crop diversification, abiotic stress, pre-breeding research for crop biosecurity, and biological nitrogen fixation (etc.), located predominantly in the Asia-Pacific, Africa, and Europe. Furthermore, Murdoch also has a strong focus on immune-mediated disorders, animal breeding, fish biology and diseases, pathogen therapeutics, autonomic and sensory neurobiology, veterinary bacteriology, viral immunology, ecology, and environmental management.

In terms of institutional capability, Murdoch University's world-class agricultural researchers have developed several unique Centres and Groups:

- The Centre for Rhizobium Studies (CRS) was established in 1997 at Murdoch University to increase the national capability in Rhizobiology and has released six commercial strains of root-nodule bacteria. These strains have been widely sown in the Western and

Southern Australia to fix nitrogen, an asset with an estimated value of $2 billion. The CRS has a strong molecular capability that focuses on rhizobium responses to stress, and also breeds new perennial legumes adapted to acidic and infertile soils and develop suitable rhizobia and inoculants carriers for them.

- The Centre for Production Animal Research (CPAR) has since become one of the largest centres for production animal research in Australia, comprising over 40 staff, postdoctoral scientists and research students. CPAR focuses on optimising animal production systems to ensure the final product (meat, wool, milk, eggs etc.) satisfies consumer needs, including animal health and welfare. The CPAR has strong collaborative research links nationally and internationally, including the DAFWA, CSIRO, MLA, AWI, Dairy Australia, Animal Welfare Science Centre, Cooperative Research Centres (Pork, Sheep, Beef), and with ACIAR. This expertise was recognised nationally in ERA 2010 with a score of 4 in Animal Production (Field of Research code 0702), equal to only three other institutions in Australia.

- The Centre for Comparative Genomics (CCG) is a collaborative biomedical and agricultural centre specialising in comparative genomics and bioinformatics at Murdoch University. A centrepiece of the CCG is comparative genomics for wheat and legumes. The CCG develops web-based software for breeding a range of crops, and undertakes larger-scale genomics analysis for molecular markers. The CCG also operate the Bioinformatics Research Laboratory (BRL). The BRL provides a range of commercial services including a range of bioinformatic tools and capability, genome sequencing, comparative genomic and molecular evolution, statistical analyses, repository mirrors, management systems, etc.

- The WA State Agricultural Biotechnology Centre (SABC) at Murdoch University has long provided platform technologies and world-class equipment and facilities for agricultural and veterinary biotechnology. Researchers in the SABC undertake grains RD&E, including marker-assisted selection, gene discovery, biosecurity, pest and disease research, transgenic crop research (including wheat), pests of stored grains, diagnostics, genomics, proteomics, metabolomics, and bioinformatics related to grains research. The SABC hosts several biotechnology research groups and companies and plays an important training role in hosting up to 100 honours and PhD researchers each year. Murdoch University provides the majority of FTE's working at the SABC, but significantly the DAFWA biotechnology laboratory is co-located at the SABC.

- The Separation Science and Metabolomics Laboratory at Murdoch University focuses on three core activities: analytical services, strategic partnerships and fundamental research. The laboratory, along with the Australian Centre for Necrotrophic Fungal Pathogens (ACNFP), forms a key Western capability that supports research through infrastructure investments in platform 'omics' technology.

- As indicated above, the Plant Biotechnology Research Group (PBRG) focuses on production of transgenic plants (eg wheat, sugarcane), nematode host-pathogen interactions and diagnostics, plant virology and exchange of pathogens at the interface between crop and native species, and on plant biosecurity.

- Murdoch is also a partner in the National Climate Change Adaptation Research Facility (NCCARF). Murdoch NCCARF projects include environmental support systems, crop soil carbon sequestration, and high resolution meteorological models and using remote sensing to detect surface changes in Agricultural regions.

The adequacy of funding and priority given by governments at the federal, state and territory level to agriculture and agribusiness higher education and vocational education and training;

The recent historical prominence of agriculture and agribusiness higher education and vocational education and training has not been encouraging. Biosciences and biotechnologies are fundamental enabling capabilities and technologies in agriculture[1-3]. Yet, Australia invests less in biotechnology as an absolute, and as a proportion of total expenditures than many OECD countries, and even less than many of its major agricultural competitors[4]. Furthermore, large multi-disciplinary teams are becoming increasingly necessary to tackle scientific questions regarding biological interactions within the environment and regional primary production systems[5]. While the cost of domestic production and distribution of final biotechnological goods and services is similar to other industrialised nations, our national primary industry market is small in terms of demand, value adding, and employment[4].

Within the Australian University system, there is now clear evidence demonstrating that both teaching of agriculture-related courses and research activities in agriculture are (a) expensive and (b) not fully covered by the funds received, e.g., through the CGS, through the DIISR block grant schemes (RTS, JRE, RIBG, SRE). In the case of teaching an agriculture-related tertiary degree program, the low student enrolments but (relatively) fixed direct (salaries) and indirect (infrastructure) costs necessitate the generation of a cross-subsidy from other parts of the University's operations to ensure the course's survival. Indeed, many Universities teaching an agriculture-related course have wound back their teaching programs (e.g., through staff reductions or divestment, diminution of practical (hands-on) teaching such as field trips) to compensate for the reduction in funds reaching the academic operational unit (School, Department) responsible for the teaching. This downward spiral has been in existence for the last 15-20 years and shows no sign of abatement, unless through direct intervention.

In the case of agricultural research activities, funds received to conduct research are generally insufficient (in the order of 25-50%) to over the true costs of conducting the research. As a specific example, numerous universities have moved to a budget model that charges a fixed amount for space for all facilities used in research. Simply by virtue of the nature and scope of agricultural research, e.g., glasshouses, animal housing, laboratories, research farm infrastructure, faculties/schools conducting research are therefore charged more for the space used to conduct the research. Unfortunately and through the budget models used in universities, which in part reflects the insufficiency of block grant income received through the DIISR schemes, agricultural research is viewed as "expensive" and often appears as a deficit in faculty/school budgets, unless the university in question can cross-subsidise; in my experience, this is uncommon.

The existing agricultural capability can be leveraged by policies which increase public and private investment, and encouraging public-private partnerships, creating markets for products, or collaborative networks[2,6,7]. Private agribusiness R&D expenditure can also indicate areas where education systems and governments may be able to leverage greater productivity down the production chain by facilitating greater R&D capabilities and collaborative projects in a form of RD&E vertical integration to increase both scale and scope. As Australia is not unique in the attempt to attract additional investment, a renewed focus for increased RD&E return on investment through collaborative efficiencies to make the most of available capability[1,3,8].

The quantum of investment is only one component of integrating knowledge and applications across sectoral chains to attain efficiencies and economies of scale and scope[2]. A greater expansion of skill-sets from fields outside of traditionally agriculture higher education and sectoral capability is required to internationalise Australian RD&E activity. In contrast to many areas of higher education, particularly in the agricultural sector, the recent increase in the number of skilled individuals in biosciences and related disciplines is good news[2]. However, smaller nations such as Australia may see this talented and highly mobile capability migrate towards larger labour markets if national agricultural innovation systems do not evolve beyond the historical paradigms of simply 'more funding, higher wages, more graduates, and higher productivity'.

Furthermore, the increasingly interdisciplinary nature of rural-related science will thus require a diverse scientific workforce, including chemists, physicists, computer scientists, mathematicians, engineers, etc.[2]. Offering interdisciplinary and cross-jurisdictional early career agricultural research fellowships and skills-development programmes will engage Australia internationally with the growing global technologically complex interdisciplinary focus[1,3,8].

The reasons and impacts of the decline in agricultural and related educational facilities;

Drivers of agricultural knowledge are fundamentally human economic issues related to productivity of a given area of land: i.e. increasing wealth, growth in productivity, population change, escalation of human concern about the environment, animal welfare, etc.[2]. Education institutions, governments, and private non-profit institutes continue to play an important role in fostering the fundamentally human and social elements of agricultural economies[9,10].

Regional innovation systems exhibit interdependence on applied and basic research infrastructure, and both small and large investments are necessary for the multidisciplinary perspective that facilitates new economies[2,3,7,11]. Agricultural RD&E economies of scope and scale are facilitated by investment in fundamental science, tools, techniques, and processes ("platform technologies"). Examples are bioinformatics, genome sequencing, RNA interference, metabolic pathway engineering, DNA synthesis, and synthetic biology[2,7]. These tools, techniques and processes enable multiple applications (which are often unplanned) and may result in positive development externalities, or spill-overs. Such platform technologies[2] have multi-layered subcategories of knowledge useful to multiply the value of investment to obtain increased scale and scope. For example, bioinformatic subcategories such as phenomics, metabolomics, proteomics, and genomics are platform technologies that may increase RD&E productivity by orders of magnitude higher than conventional agronomic methods[7,12].

However, the complexity of the human capacity constraints is daunting in terms of development, cross-communication, and analysis[12]. These new platform technologies require active cross-pollination between disparate research disciplines often outside of the traditional biological science sphere, (including health, minerals and energy, information and communication sectors) to derive greater scopes, scales, and the socio-economic benefits from the investment[2,8].

The relatively minimal national Australian R&D expenditures for even fundamental agricultural collaborative partnerships overseas may be indicative of the lack of a collaborative focus in R&D policy. For example, the 2008-09 expenditures from the Australian Government on agricultural research centres, predominantly located in transitional economies. The majority of the total R&D expenditure includes the Australian Centre for International Agricultural Research (ACIAR), which forms part of the Australian Government's international development and aid assistance programme. In 2008–09, ACIAR received $52.333 million from the Commonwealth Government directly, with an additional $16.006 million, primarily through AusAID and the Department of Agriculture, Fisheries, and Forestry (DAFF). Of the $68.416 million of ACIAR expenditures in 2008-09, only $9.362 million was spent through the Consultative Group on International Agricultural Research's (CGIAR) fundamental agricultural research centres, and only a further 1.2 million to non-CGIAR research centres[13]. Whilst this is projected to increase to approximately $14 million by 2012–13[13,14], the approximately $10.5 million expenditure on core agriculture, forestry, and aquaculture collaborations are only almost only 1% of the total 2008-09 agricultural, fisheries, and forestry rural subsector expenditure.

While noting that the above R&D expenditures and the stated mechanisms/institutions are by no means the only channel for R&D capability and knowledge development and transfer, the relatively small figures do not confer the primary importance of basic food production security in rural areas, especially in our neighbouring countries. Australia's current deficiency in international R&D collaboration was specifically targeted in recommendation 6.5 on p73 of the Cutler Report, stating "...build concentrations of excellence, encourage collaboration and achieve better dissemination of knowledge, introduce additional funding support for university and other research institutions to partner with each other and with other research organisations (national and international)"[1].

Solutions to address the widening gap between skilled agricultural labour supply and demand;

This submission attempts to collate some suggested solutions under headings below:

Providing incentives to students wishing to pursue a tertiary qualification in agriculture

Providing the appropriate incentives is one way that participation of students in an agriculture-related degree at university can occur. Specific examples include making agriculture a 'national priority' (just like mathematics and science; arguably agriculture is a 'science' anyway, so it is paradoxical that this isn't listed) thereby reducing HECS payments by students, increasing the cluster funding amount for Agriculture, providing entrance scholarships (e.g., through DAFF and State Government agencies working together), and (or) rolling out initiatives such as PICSE (the Primary Industry Centre for Science Education) nationally. I.e., it is funded nationally and receives long-term funding (15-25 years) to ensure the scheme, that aims to "to attract students into tertiary science and to increase the number of skilled professionals in agribusiness and research institutions", can truly be successful.

Renewed focus on regional secondary schooling

The present and future decline in Australia's overall rural and agricultural RD&E capability has been a concern for some time. Regional and remote high school students who could well be considered to have the highest level of interest in agricultural education are often relatively poorly served by the secondary schools that they attend. The key issues include a low number of WA regional high school students aim to go to university in the first place, the very low number that manage to be accepted into a university course, or an agricultural tertiary course. This is starkly illustrated by data from regional WA where the uptake rate into higher education from regional schools is vastly lower than that from metropolitan schools. The percentage of students seeking an Australian Tertiary Admission Rank (ATAR) in WA is around 60% within the past two years. At the same time, the percentages of Year 12 students achieving an ATAR in NSW, Victoria and SA are generally around 80-90%.

Equally, if a WA student attended certain regional agricultural colleges you could only attend Curtin University (Muresk for agribusiness and a few other courses) and Murdoch University (animal, life science, and environmental science etc.). This was essentially by agreement between the universities and the regional agricultural colleges. As such, to fill the university agricultural positions metropolitan students who may have no experience of agriculture and generally little interest in moving in regional areas would comprise the majority of enrolments.

Long-term policy deficit and/or lack of general support/awareness of commercial issues

Primary producers, industry, scientists, and governments will need to collectively identify technological and policy options that are most promising over the long-term[5,7]. Whilst private technical and financial requirements are often well known by the private proponents themselves, demonstrating the return on investment for public expenditures is often followed by demands for the creation of indicators by policymakers. This 'administrative burden' can stifle innovation at every stage of the process. Policymakers will need to efficiently measure resultant outputs, impacts, reduction of barriers and bottlenecks to production, or any other change resulting from investment through appropriate monitoring[3,15]. Furthermore, reporting requirements are supplemented with often protracted regulatory and licensing requirements. A focus on innovative RD&E will require a parallel and active focus on suitably reducing barriers to investment barriers to investment, particularly for gaining the 'early mover advantage'.

Undertaking agricultural biotech-related research is challenging in WA, particularly in the present economic climate with a focus on the mining sector, which also has a distortionary impact in agricultural regions. Universities generally have performed poorly in terms of commercialisation of R&D, and as a result there are few spin-out companies deriving from agricultural RD&E. There is very little support for commercialisation of agricultural research in Australia, and there is great difficulty in attracting commercialisation capital. There is also governmental inconsistency with R&D commercialisation support, particularly for commercialisation at the federal level. As R&D outcomes typically have medium-to-long time horizons, having strategic continuity is fundamental, and short-term politically-motivated tactical changes undermine the sectors they aim to support. The new tax rebate is a good start, and will hopefully introduce a modicum of stability into the RD&E commercialisation market.

Geographical clustering generating innovation

The traditional distance disadvantage (regionally, nationally, and internationally) experienced by Australia being has decreased over time improved transport and communication technologies[16]. New communication platforms may effectively substitute for some institutional co-location benefits of geographical clustering, and also create new research opportunities from networking with existing remote clusters to create new research capacity economies of scale. The use of new communication mediums may enable Australia to exploit nationally competitive advantages and advanced capabilities in crop molecular technologies, food genomics, animal molecular diagnostics, and tropical crop transgenics with greater international partnering[4,6]. These advantages, in addition to a high concentrated and well educated/connected workforce[17], large regional landscapes, good infrastructure, and a politically stable culture, are essential attributes to attract investment in long-term fundamental RD&E. Geographical clustering for cross-pollinating supporting agricultural technology will likely have unexpected positive externalities. For example, the cross-pollination of biotechnology and nanotechnology in the mineral oil and metal ore extraction sectors has resulted in increased recovery rates, lower input costs, and enhanced prospectivity of new smaller mines in more remote fields - all with a reduced environmental impact for rural and regional areas[2,18].

Cross-disciplinary research and new facilities that generate cross-pollination innovation

The challenge to rural Australia is formidable and requires ardent encouragement of cross-pollinating RD&E activity that focuses on the entire production and value chain[3]. This focuses on horizontal technological convergence (rather than the traditional approach of sectoral) to vertically integrate agricultural development towards a model that is more attune with what has historically worked[7,11]. Such convergence will require unprecedented innovation in research, engineering, monitoring, regulation, and cross-communication, with a particular focus on the social and ecological integrity of these newly complex production landscapes[3,7,19]. For example, as world energy demand continues to rise dramatically, the successful navigation of the various available bioenergy development paths already encompasses elements of energy supply diversity, national security, air pollution and health, rural and technical development, climate change, biodiversity and deforestation, improved strain selection, tax incentives and subsidies, fresh water quality and supply, distributed infrastructure, resource limitations, and so on[7,9,20]. These domains clearly do not fall squarely within current scientific disciplines, educational structures, or the agricultural sector. Nonetheless, agriculture is a key element.

International collaborative partnering and engaging the international labour market

International collaboration will be essential for small nations to develop RD&E efficiencies through sufficient scale, and Australia must maximise the inflow of new international technology, techniques, products, and services by public investment leverage in private science and innovation to foster technical capacity for domestic adaptation[4,6]. In terms of looking at productivity gains from the Australian R&D expenditure from simply a national utilitarian perspective, the lack of international agriculture-related RD&E collaboration foregoes the national benefits of being located in the Asia-Pacific region with a favourable currency exchange rate. In addition to relative purchasing power, Australia may choose to take advantage of the commonly lower labour costs, even for world-class scientists and engineers in many collaborating Asia-Pacific countries. Collaboration such as this can pass on lower R&D costs to Australia while generating greater R&D capability in collaborating nations without requiring researchers to relocate to Australia.

Compared to other OECD countries, Australian R&D costs are lower by approximately one-third, which includes wages of university graduates and experienced personnel. As labour costs are roughly half of total R&D expenses in OECD countries[4], Australia may have a competitive advantage in attracting investment capital from other industrialised nations, and also access the often lower R&D labour costs from Asia-Pacific regional collaboration. Nonetheless, retaining highly mobile R&D labour in Australia with a lower domestic remuneration levels than many major industrialised countries will be a challenge – this includes the lower waged Australian researchers[7,21]. As the vast majority of both public and private biotechnology R&D is undertaken in the USA[2], many nations may see their investment in human capacity simply leave to engage the USA R&D labour market. Thus, RD&E administrative bodies, including the higher education sector, will likely need to look for non-monetary incentives to compete with the global talent market. One option may be the reduction in administrative burden increasingly associated with research fields. Australian research time dedicated to short-term research grant applications and maintenance requirements are known to be high. A nation-wide move to longer-term and flexible contracts may be areas to improve Australia's ability to attract and retain researchers and their increasingly important personal collaborative networks[4].

The impacts of any shortage on agricultural research;

Consolidation of both capability and incentives for tackling national challenges of water, carbon, and environmental sustainability is necessary to develop a sufficient scope and scale of knowledge investment in Australia[1,20]. This will require reducing research duplication, efficiently delivering longer-term strategic government RD&E investment, increasing fundamental science research capability and collaborative partnering, in addition to improving the ability of private businesses to secure benefits to themselves and the regions they operate within[1,3,4]. This will be a major challenge, particularly for higher education researchers and policymakers, as this will require technology, capability, and knowledge sharing between conventionally disparate sectors.

The economic impacts of labour shortages on Australia's export oriented agricultural industries;

In states such as WA, salaries in the mining sector have significantly reduced the number of local students wishing to undertake advanced training in agriculture R&D. This has been partially offset by an influx of overseas PhD candidates, but these often start out with a poorer general grounding in basic sciences, and take up more staff time in terms of supervision, correction of English in written work etc. There is no doubt that Australia has fallen from the leader in agricultural biotechnology in the Asia Pacific Region in R&D 20 years ago to a follower in many fields, simply because those countries which foresee food shortages for their populations in the future have invested much more in agricultural R&D. As a result of easy information transfer, our competitors now have access to the same advanced information and germplasm as do Australian researchers. This will mean that their productivity and quality will improve, making it harder for Australia to compete in overseas markets.

The incorporation of animal welfare principles in agriculture education; and

Growing consumer and government concerns related to animal welfare, highlighted most recently of course by the *Four Corners* expose of Australian-exported cattle in Indonesian abattoirs, dictates the incorporation of the teaching of animal welfare principles into both secondary and tertiary agricultural-related curriculums. In the Bachelor of Animal Science degree taught at Murdoch University, teaching of animal welfare principles is front-and-centre in the unit ANS106 *Animal and Human Bioethics* (also to Veterinary Science students) and incorporated throughout the *Animal Production Systems* units. Furthermore, the School of Veterinary and Biomedical Sciences has had, and continues to have, numerous Honours and PhD students researching animal welfare-related topics (e.g., live export, sow housing).

Specific consideration is also required for animal husbandry as livestock accounts for between 40-50% of the value of agricultural production in OECD countries. Breeding programmes, health diagnostics, and therapeutics are the major focus of animal research, and enjoy a large international market[10]. The new and complex interplay between emerging international corporate interests and traditional livestock breeders requires much attention[21,22]. However, Australia will need to strategically approach this complex interface to maximise benefits, minimise opportunity costs, and efficiently foster existing areas of strength to develop a nationally specialised capability.

Finally and to reinforce the importance of animal welfare to education and learning, Murdoch University is fully engaged in the National Animal Welfare RD&E strategy as a member of the Steering Committee.

Other related matters.

Whilst the supply of 'traditional' research/science skills and 'human inputs' into agriculture has gained much attention in recent decades, there are less prominent, but just as essential collaborations between people 'downstream' from the primary research knowledge generators. Such people (including farmers) more often extend such knowledge to produce, process, and also consume the products/services, and thus hold essential knowledge required to be 'fed back' into the research innovation system. Rural people have a unique and detailed knowledge of their lands and environment, and must be enabled to play a central role in their management. Unfortunately, at present the complex multi-functional lives, skills, and knowledge (often informal) of people in rural regions do not generally feature in R&D policy documentation, implementation, and capacity building[3,23]. Furthermore, declining rural populations in many Australian regions (and the associated social disconnection, service rationalisation, declining knowledge-base, seasonal skill shortages, and increasing proportion of absentee landowners), creates difficulties in 'feeding back' solutions.

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