Annex 6

I. Funding or research and research training in the higher education sector

A. Current funding schemes

The Australian Government operates a dual support system for funding of research and research training. The system consists of competitive grant programs, where funding is distributed to research teams through merit-based, peer-determined processes, and performance-related block grants, which are allocated to institutions.

The principal competitive grant awarding bodies, the Australian Research Council and the National Health and Medical Research Council, collectively distributed approximately $1.1 billion in 2008. Approximately $1.21 billion was provided in 2008 to eligible higher education institutions as block grants for research and research training, through a number of performance-based schemes. Institutions have considerable autonomy in deciding what research projects, personnel, equipment and infrastructure this funding should support.

The principal research block grants administered by the Department of Innovation, Industry, Science and Research are:

- Institutional Grants Scheme (IGS) - $308 million in 2008.
- Research Infrastructure Block Grants (RIBG) – $208 million in 2008.
- Research Training Scheme (RTS) - $585 million in 2008.
- Australian Postgraduate Awards (APAs) - $98 million in 2008.
- International Postgraduate Research Scholarships (IPRS) - $19 million in 2008.

Block grants are principally allocated to institutions using program-specific formulae that reward the performance of institutions in attracting research income, disseminating research results in mainly peer-reviewed publications, through the successful completion of research degrees by students, and by higher degree by research student load.

Institutional Grants Scheme (IGS)

The stated aim of the IGS is to maintain and strengthen Australia's knowledge base and research capabilities by developing an effective research and research training system in the higher education sector. Under this scheme, block grants are provided ($308 million in 2008) to support research and research training activities. Institutions have discretion in the way they spend their IGS grant provided it is used to fund any activity related to research.

The IGS allocation is based on an index of institutional performance comprising research income (60 percent), HDR student load (30 percent) and publications (10 percent). There is a safety net which prevents poorly performing institutions from losing more than 5 percent from year to year.

Research Infrastructure Block Grant Scheme (RIDG)

The RIBG scheme provides block grants to enhance the development and maintenance of research infrastructure and to meet project-related infrastructure costs associated with competitive grants awarded by bodies including the Australian Research Council and the National Health and Medical Research Council. Indirect research costs supported through RIBG include the non-capital aspects of facilities such as libraries, laboratories, computing centres and the salaries of support staff. The allocation is formula-driven with grant amounts reflecting the relative success of each institution in attracting Category 1 competitive research funds, as calculated from the Australian Competitive Grants Register (ACGR). The current level of funding provides a 'top-up' of approximately 20 percent to competitive grants.

Research Training Scheme (RTS)

The RTS is the largest of the block grants in support of research and research training. The RTS mechanism returns 75 percent of higher education providers' previous year's allocations and allocates the remaining 25 percent according to providers' relative success in a performance index comprising:

- higher degree by research completions (50 percent),
- research income (40 percent), and
- research publications (10 percent).

A 'safety net' provision reduces the potential loss to a poorly performing institution to a maximum of 5 percent from year to year.

Australian Postgraduate Awards

The APA scheme provides block grants to higher education institutions in support of training for a higher degree by research students. Awards are available for a period of two years for a Masters by research degree or three years, with a possible extension of six months, for a Doctorate by research degree. Award holders receive an annual stipend ($20,007 as of 2008) and may be eligible for other allowances. New scholarships are allocated to institutions on the basis of the RTS performance index described above.

International Postgraduate Research Scholarships

The IPRS scheme provides block grants to higher education institutions to maintain and develop international research linkages and specifically aims to attract top quality international postgraduate students to areas of research strength in the Australian higher education sector and support Australia's research effort. The program provides 330 new scholarships each year. New scholarships are allocated to institutions on the basis of the RTS performance index described above.

B. Analysis of the allocation criteria for the current funding schemes

The schemes allocate together over $500 million annually, predominantly on the basis of research income earned from national competitive grants and other sources. In part this is in recognition of the fact that competitive grants are not designed to meet the full costs of

research, an issue to which we will return.

An important implication of the allocation criteria is that universities are faced with only weak incentives to recruit high quality researchers who work outside of grant-winning areas, such as researchers working in theoretical areas where the need for expensive equipment and support staff are low. The primary output of such researchers is in internationally recognised publications, but publication output is given only a ten percent weight in the IGS allocation formula and zero weight in the RIBG scheme. Moreover, the current method of assessing publications gives the same weight to an in-house journal or book publisher (as long as it passes a minimum standard for refereeing) as it does to one of the world's leading international journals or academic publishing houses.

The high weight afforded to research income, rather than research output, under the IGS and RIBG formulae also imply a long lag in rewarding high quality performance. For example, if a university appointed a new researcher in 2000, that researcher would not be likely to submit a major ARC application until the beginning of 2001. If awarded, the grant would not commence until 2002. The financial return to the university on their initial investment in 2000 would not come through IGS and RIBG funding until 2004 – a four year lag. Moreover, the success of the grant application is likely to have reflected the researcher's publication performance in the mid to late 1990s, so the return to performance is likely to be between lagged between five and ten years.

The Excellence in Research for Australia (ERA) initiative was announced in February 2006. This initiative, to be developed by the Australian Research Council (ARC), will assess research quality using a combination of metrics and expert review. It will provide a sound basis for ranking the quality of research output across Australia.

FINDING 1. The allocation criteria for performance based block funding under the IGS and RIBG schemes give inadequate weight to the quality of research. In future, more substantial weight should be given to research quality using rankings derived from the ERA assessments.

The Research Training Scheme (RTS) and the domestic and international scholarship schemes (APA and IPRS) currently distribute over $700 million annually. The allocation criteria for these funds are dominated by historical funding rather than by any measure of the quality of training. Three quarters of the RTS funding, i.e. over $400 million of the total, is based on the previous year's allocation, and the safety net provision prevents any substantial re-allocations from taking place year to year. The rest of the funding is allocated according to a 'performance' index. Half of the weight in the performance index is allocated to research degree completions, and these completions are heavily influenced by past awards of scholarship funding.

Placing so much of the weight on historical funding implies that current funding of research training does not reflect the quality of the training. Rather than providing the best research teams in the country with funds and scholarships to attract the best research students, the current funding schemes consign a substantial proportion of research students to sub-optimal research environments.

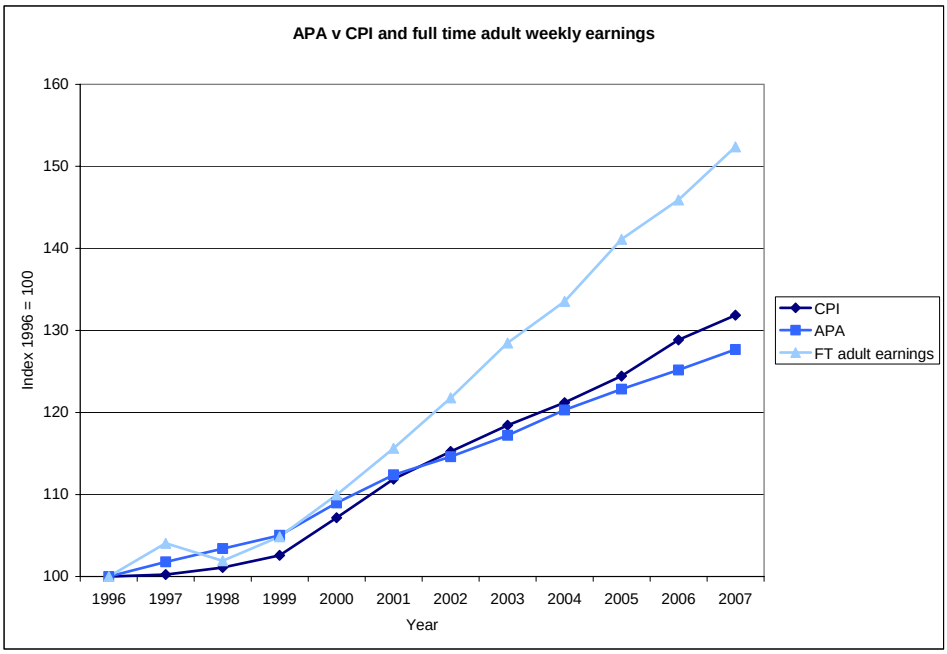
FINDING 2. The allocation criteria for the funding of research training and scholarships give inadequate weight to the quality of the research teams who supervise and train the students. In future, less weight should be given to the historical funding patterns and more weight should be given to the quality of the supervising research teams based on rankings derived from the ERA assessments.

C. Analysis of the level of funding

Research Student Stipends

An array of evidence suggests that the level of stipends awarded to research students is inadequate. Research students are currently awarded an annual stipend under the APA of $20,007 for three years, extendable for 6 months under special circumstances. The real value of this stipend has been eroded over recent years. Figure 1 plots an index of the APA stipend rate from 1996 to 2007 compared with the Consumer Price Index (CPI) and an index of full time adult weekly earnings.

Figure 1: APA versus CPI and full time adult weekly earnings



Source: Department of Innovation, Industry, Science and Research submission to the House of Representatives Committee on Industry, Science and Innovation Inquiry into Research Training and Research Workforce Issues in Australian Universities

The figure indicates that growth in the stipend rate in recent years has failed to keep pace with that of either prices or wages. The comparison with wage levels is the most appropriate since this represents the opportunity cost of research training for a graduate. On this comparison, the value of the stipend has fallen by 17 percent sine 1996.

The Review Panel has noted that under the Australian Postgraduate Award (Industry) scheme research students are currently paid an annual stipend of $26,140. This level of stipend is judged to be sufficient to recruit and adequately support students undertaking

full-time research training.

At its current rate in 2008 (approximately $385 per week), the full-time APA stipend is only marginally above the Henderson poverty line[1] for the March quarter of 2008, which for a single person working is $378.08 per week (equivalent to $19,660.16 per annum).[2] The Council for Australian Postgraduate Associations (CAPA) has reported that the stipend rate will slip below the poverty line by the end of 2008.[3]

Further evidence of the inadequacy of the student stipend comes from a recent study by Universities Australia.[4] This study reports that, amongst full-time higher degree research students in 2006, 38 percent used up savings in order to study in 2006, 46 percent believed that supporting their studies put a great deal of financial pressure on their parents or partner. Three-quarters of part-time research higher degree students indicated they would prefer to study full-time if their financial circumstances permitted.

A further issue with the APA scheme warranting urgent attention is that support provided (up to 3.5 years) is not consistent with research training place allocations under the Research Training Scheme (4 years) and does not reflect the mean completion time for a full-time PhD of 5.4 years.[5] A key implication of this anomaly is that there is a gap of up to 12 months where students are unable to access income support under the APA scheme, at one of the most critical points in their research training – the write-up of the PhD thesis. Coupled with the low value of the APA stipend, this gap negatively impacts on the quality of the research training experience.

FINDING 3: Both the level and the length of support currently provided under the APA scheme are inadequate to encourage and support the participation of the best students in research training.

The full cost of university research

Funding of research and research training under the performance related block grants and the competitive grants program covers only a fraction of the full costs of research. Lacking full funding, research and research training are typically subsidised from other revenue streams – notably full fee income from overseas students. This cross-subsidisation is not sustainable in the longer term. If the fees paid by foreign students are

[1] The Henderson Poverty Line as defined in the 1973 Commonwealth Commission of Inquiry into Poverty—Commission of Inquiry into Poverty, 1975, First Main Report, Poverty in Australia, AGPS, Canberra.
[2] Published by Melbourne Institute of Applied Economic and Social Research, University of Melbourne. http://www.melbourneinstitute.com/labour/inequality/poverty/default.html
[3] CAPA Media Release: APAs to Break Poverty Line. April 30 2008 http://www.capa.edu.au/files/APAs-to-break-poverty-line.pdf
[4] Universities Australia, Australian University Student Finances 2006: A summary of findings from a national survey of students in public universities, cited in the Department of Innovation, Industry, Science and Research submission to the House of Representatives Committee on Industry, Science and Innovation Inquiry into Research Training and Research Workforce Issues in Australian Universities, 2008
[5] Graduate Careers Australia *Post Graduate Destinations 2006: The Report of the Graduate Destination Survey*. 2007.

not reinvested by universities in providing high quality teaching and specialised support for students with linguistic and cultural challenges, then Australian universities will become uncompetitive in the global markets for undergraduate and postgraduate studies. Competitive pressure is likely to be particularly intense for the foreseeable future given the high exchange rate for the Australian dollar which results from the global commodity boom. A decline in overseas student income would, under the current funding system, play havoc with universities' research activities.

Innovative Research Universities Australia (IRUA), for example, have expressed concern in their submission to the Review at the over-reliance of Australian universities on international student revenues as a source for cross-subsidisation of research. They state that:

> *In our view, a continuation of this over-reliance to the extent currently demanded by higher education and research funding policy will significantly weaken Australia's innovation system*.[6]

IRUA furthermore pointed to the adverse effects of such cross-subsidisation on the quality of course delivery and related services, noting that:

> *A continued transfer of student fee income from learning and teaching budgets to research budgets could over time erode the quality of course delivery and student services. It is far preferable for surpluses generated from international student revenue to be re-invested in enhancing the quality of the student experience*.[7]

Other universities pointed to the distorting effect of partial funding. The University of Western Australia, for example, commented that:

> *While the initial intention of partial funding may have been to encourage universities to seek additional funds from industry and other sources, the result has been sub-optimal performance across the board and a distortion of priorities and effort. Commonwealth research agencies need to be funded in ways that allow them to fund the full cost of research and reward universities in an appropriate way for success*.[8]

Similarly, the NSW Department of State and Regional Development noted:

> *the current model leads to inefficiencies and sub-optimal allocation in universities and State governments, and increases the administrative burden associated with research programs*.[9]

Research Agencies have also expressed concern. CSIRO, for example, commented in its submission that:

> *the Australian NIS would be greatly simplified if funding bodies invested in the full cost of the research they are supporting…it is not uncommon for*

[6] Innovation Research Universities Australia – Submission no. 332, p25
[7] Ibid, p26
[8] University of Western Australia - Submission no. 313
[9] NSW Department of State and Regional Development - Submission no. 632

> *research funders or agencies to leverage their funds two or three times (and occasionally higher) with the result that there is really very little new money to sustain the system. It is concerning that this has become the dominant mode of investment because it is producing serious distortions in the strategic roles of R&D providers and undermining their sustainability. This model of research funding results in marginal costing by the research providers and the subsidisation of research through other means; and it distorts the core purpose and roles of research organisations as they jettison their strategic research strategies in favour of shorter-term, near market research.*[10]

Available evidence suggests that the ARC and other key research funding agencies do not fully fund the cost of the research they sponsor. In particular, ARC competitive grants are designed to cover only incremental costs of research programs – typically covering the extra costs of new research and laboratory assistants and additional materials but contributing nothing to chief investigator salaries and overhead costs. Unless the application is specifically for a fellowship, the salaries of the researchers are met by the university, which also bears all of the overhead costs. Overhead costs can be very substantial covering administrative support, recruitment costs, IT facilities, internet access, libraries, etc. Infrastructure costs are supposed to be met by the retrospective allocation of block grant funding (for example, IGS and RIBG), but the relatively small pool of funding is clearly not sufficient to cover the shortfall on full costs.

The ARC currently estimates that it funds approximately 60 percent of the total direct cost for the research it sponsors through its Discovery Project scheme and reports a lack of capacity to support the indirect costs within its current budget.[11] The Australian Technology Network of Universities (ATN) suggests in material provided to the review that the contribution of universities to full cost recovery range from 30 percent to 50 percent. It is not clear whether these estimates include capital costs.

While precise estimates of the full costs of university research and research training are not currently available, the Review Panel understands that government is currently investigating the full costs of both teaching and research in Australian universities. The Review Panel considers that this work, along with an examination of the relative merits of approaches developed in other countries, could form an initial basis for determining the details of a suitable full costing and funding framework for Australia.

Lessons from other countries

For some time now, in recognition of these issues, countries have been progressively moving to towards systems which accurately account for the full economic costs of research activities and introducing funding mechanisms that recognise those costs.

For example, the Transparent Approach to Costing (TRAC)[12] is the standard, activity-based method used for costing in higher education in the United Kingdom (UK).

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[10] CSIRO - Submission no. 217
[11] Australian Research Council - Submission no. 576
[12] See http://www.jcpsg.ac.uk/downloads/guidance/Overview.pdf

Developed in 1999 as part of the UK Government's Transparency Review, since 2000, TRAC has been the methodology used by the 165 Higher Education Institutions in the UK for costing their main activities (Teaching, Research, and Other core activity).

The principle objectives of TRAC are:

- to provide consistent and robust information about the cost of activities to assist institutional planning and management;
- to provide a basis for the pricing of activities, particularly those that are publicly funded;
- to meet the requirement for accountability, particularly for the use of public funds, when the institutional portfolio includes a complex mix of activities; and
- to provide at both institutional and national level an appropriate and comprehensive cost model to guide investment for the future.

From 2005, the United Kingdom Government provided significant additional funding (120 million pounds a year from 2005-06 and additional 80 million pounds per year from 2007-08) to enable the UK Research Councils to fund projects at 80 percent of the TRAC full economic costs while maintaining the current volume of Research Council supported research in higher education institutions.[13]

FINDING 4. The current failure to identify the full costs of research and to fund university research accordingly is contributing to a lack of sustainability in both research activities and in the teaching export activities that provide the financial cross-subsidies. Current investigations by the Australian Government and information from the experience of other countries, in particular the UK, offer a relatively low-cost solution to the information problem.

Implications for funding levels and mechanisms

Once the full costs of research have been established, a transition to full-funding will become feasible. If the recommendations of the Review for increases in the level of research funding are accepted, it will be possible to move towards full-funding without jeopardizing the number of research projects which receive competitive grants and the amount of research funded by universities from performance based block grants. It is beyond the remit and resources of this Review to provide a full assessment of the optimal balance between competitive grant, performance related block funding and infrastructure funding from the new Education Investment Fund. These important assessments should be dealt with in the forthcoming process of negotiating mission-based compacts between government and universities.

To the extent that funding is increased and the allocative criteria for the block grants and funding for research training are aligned to the ERA rankings of research quality, we can expect more high quality research to emerge. Competition amongst universities for research-quality based funding can be expected, following the UK example, to encourage academic entrepreneurship which will improve the quality of research through

[13] Research Councils UK, http://www.rcuk.ac.uk/aboutrcs/funding/dual/fec.htm

specialisation and concentration of resources.[14]

Rather than debating whether Australia can support two or three 'world-class' universities, the focus should switch to establishing a hundred or more world-class research facilities and research groups across the whole university system. Domestic and international networking should be promoted to ensure that the benefits of specialisation and concentration of research activity spread across the whole of the system.

[14]A 2003 UK Department for Education and Skills report, *The Future of Higher Education*, pointed out that: "*Concentration brings real benefits, including better infrastructure (funding excellent equipment and good libraries), better opportunities for interdisciplinary research, and the benefits for both staff and students which flow from discussing their research and collaborating in projects."* The OECD has also picked up on this trend in a number of member and non-member countries. The Organisation's 2005 report, *Innovation Policy and Performance: A Cross-Country Comparison*, offers several examples of both the benefits arising from concentration of research and the problems arising from lack of concentration, noting particularly that fragmentation can lead to limited resources being spread to thinly, leading to an overall decline in research performance.

2. National Priority Research Centres

The Review recommends further consideration of the proposal that National Priority Research Centres be established in areas of key importance to Australia's innovative future. The Centres will build research collaboration among our best researchers, provide careers for our top young scientists and attract the best mid career researchers from across the world. The Centres would build research capacity at the highest level, providing knowledge and discoveries essential for a future competitive Australia.

These Centres will not duplicate the ARC Centres of Excellence. They will be set up in research areas which the Government regards as of high priority for innovation. They will support the best researchers in the country in the priority areas, irrespective of whether those researchers are in Universities, CSIRO or other Government funded research agencies, or medical research institutes. All categories of these researchers receive direct support and they will not be differentiated as to their Institution. The proposed duration of the Centres is ten years, not the shorter period which applies to the ARC Centres of Excellence and this is important because it not only provides the best young researchers of Australia new avenues for a career, but it is critical as a feature in attracting the best early to mid career scientists from around the world to make the decision to locate their research career in Australia.

These Centres will also be multidisciplinary and although focusing on fundamental research, they will need to present detailed plans as to how their discoveries will be delivered to end users. It is anticipated that highly regarded industry representatives will be on the Steering and Advisory Committees from the very beginning of these Centres.

The recommendation is to strengthen basic research and build capacity in areas of critical national importance by:

- Supporting the best scientists in Australia in chosen research areas
- Providing the means for these top scientists from different research institutions to collaborate closely towards agreed objectives
- Attracting high performing early to mid-career scientists from around the world to work in Australia, building our R&D capacity
- Linking each basic research centre with a series of satellite application research laboratories in both the public and private sectors

Australia is slipping behind its international colleagues and competitors in key areas of fundamental research in virtually every scientific discipline. We have developed an imbalance in the past few years between investment in basic and applications research. In the last decade, gross expenditure on all forms of R&D has grown, but the proportion spent on basic research has declined. Between 1994/95 and 2004/05, the share of expenditure on basic research declined from 27 percent to 23 percent, whereas applied research and experimental development grew from 73 percent to 77 percent. Increased investment in applications research has been justified but must be matched with increased

investment in the acquisition of new knowledge and intellectual property from basic research.

We have an ageing population of top researchers and these elite scientists are concerned with the deficiency of high performing, mid career researchers progressing through the ranks.

Australian academics (and researchers) aged in their 40s and 50s outnumber those in their 20s and 30s by 31 percent; a whole generation of potential academics appears to have been lost to other occupations, industries and countries.

In our country of only 21 million people, we lack critical mass and skills across many of the disciplines needed to generate new discoveries in topics of national importance. These issues are of particular concern to Australia's future growth – they include climate change, reduced fresh water supplies, degraded environments. Emerging paradigms of science, nanotechnology, biotechnology and epigenetics must be vigorously pursued if we are to be respected at the highest international forums of exchange of new scientific information.

The productivity commission's 2007 report on public support for science and innovation noted that positive spill-over from basic research would only be realised if support were provided for mechanisms for efficient knowledge diffusion. The Centres and their road maps to applications provide for this need.

- We need to establish virtual National Priority Research Centres primarily focussed on basic research but with roadmaps for development and uptake of new knowledge and Intellectual Property into innovative industries.
- We must support our most distinguished researchers in a collaborative program approved by international peer review. Elite teams will be drawn from Universities, CSIRO, other PFRAs and Medical Research Institutes and would involve International Collaborations.
- The critical investments are for human resources and elite capability building, not for capital expenditure or additional administration load.
- The Centres if supported for a period of at least ten years would provide careers for our best young scientists as well as attracting high performing young scientists from around the world.

The proposed National Priority Research Centres will build on the current strengths of Australian science while addressing its shortcomings. The National Priority Research Centres will be based on collaboration. In a sense they will be similar to the Cooperative Research Centres, but will focus on strategic basic research.

The Centres will address the key problems and opportunities of our country. Global science systems are struggling to keep pace with the evolution of scientific endeavour. Many of the most urgent problems we face require novel approaches which facilitate collaboration across the traditional boundaries of disciplines, including those between the

"hard sciences" and the humanities and social sciences. The Centres will be interdisciplinary.

Human Resource Capability Building

The National Priority Research Centres will strengthen our human capital. They will build for the future by ensuring attractive arrangements and environments for world class researchers. In many cases these researchers will introduce new capabilities to Australian research, capabilities we need to enable us to be competitive in the first rank.

The centres will not uproot our best researchers from their present Institutions but instead, engage them for an agreed percentage of their time, 50 percent or more, in involvement in the Centres' collaborative programs.

The Centres will provide career opportunities for our best young scientists and will attract and develop leading, early to mid-career researchers from around the world. This approach has been successfully employed in CSIRO's Science Leader program which has attracted leading researchers from the United States, Europe, United Kingdom and China. These Science Leaders with the additional support provided to them have already proven to be catalytic centres of excellence in their respective fields. They are building powerful research groups.

The Centres will complement, not compete with the existing research funding fabric providing for Universities, publicly funded research agencies such as CSIRO, and medical research institutes. With their additional resources the Centres will strengthen the research fabric in Australia. The focus on applied research in the CRC Program, ARC linkage programs and CSIRO's Flagship programs has been warranted, but they have generated an unintended outcome - a reduction in the capacity for major research agencies to support the basic and strategic research necessary for the discovery of new knowledge so critical for future, powerful innovation.

Competitor Countries

Many of our major competitors have made substantial commitments to basic research capability recently and see this as being fundamental to their prosperity in the 21st Century. At the same time, they are developing novel ways to adapt to the changing circumstances of scientific endeavour including engaging in an unprecedented level of global competition for talent. The United States has employed a strategy of virtual multi-hub, multi-institution collaborations to support mega research projects through the National Science Foundation, National Institutes of Health and the Department of Energy. Japan has invested in 10 year support to a number of high priority research areas based around leading scientists. India and China have also made large investments to achieve rapid advances in the quality of their fundamental research capacity. China has moved within the last decade to transform many areas of science from a third world state to leading edge Institutes based around major investments in training and by attracting a cadre of top Chinese researchers from western countries. They have supplemented their efforts with the involvement of the Chinese scientific diaspora around the world.

If Australia does not maintain strength in basic research in key areas we will lose our international standing, we will not be a player in the emerging areas of science that are so important for innovation, and we will not be able to attract and train the top level of young scientists from around the world so adept at working across disciplines and in developing new technologies.

Our capacity to innovate depends upon a solid platform of enabling knowledge and technologies. A weakening of that platform over time will have serious consequences for our international standing and our national prosperity.

Governance

The government will nominate research areas of key importance to Australia. The Virtual Centres would be administered by the Department of Innovation, Industry, Science and Research (DIISR) along with other departments where appropriate. In the initial phase of the program it is envisaged that we should develop ten centres, each resourced at ten million dollars per annum for ten years (10 x 10 x 10). The $10 million figure is based on a structure comprising six groups of ten scientists. In addition there would be provision for specialised equipment.

International collaborations are likely to be an important part of the research in these Centres. A collaborative co-investment regime could be expected to provide an additional $5 million per year for each of the Centres.

The focus on quality, high profile issues of national significance is essential. The suggested level of funding and the timeframe are sufficient to ensure a continuity of commitment and thereby generate effective outcomes. These funds are not intended for capital investment – they are to support the involvement of lead scientists, to support postdoctoral fellows and early career scientists in the program, and importantly to provide for the attraction and employment of high performing mid-career science leaders from around the world.

The putative science leader and a number of other high achieving scientists from various Institutes, Universities, PFRAs or medical research initiatives in the designated area will be invited to produce a research proposal which would be peer reviewed by national and international experts. One research organisation (University or Government funded laboratory) will be invited to be responsible for the administration and financial management of each Centre. Reports to DIISR would include annual statements from external auditors and progress reports against agreed milestones and timelines. Scientific reviews by external experts would be conducted every two years. The science leader would be supported by an Advisory Committee with international experts and industry representation. As discoveries are made and intellectual property protection is put in place, the Advisory Committee will be responsible for initiating contact and arrangements ensuring delivery and use in applications to the advantage of Australia.

The National Priority Research Centres introduce a new and powerful investment for support of Australian R&D. The Panel has argued in this report for the increase of

Government investment for funding of research in Universities and Publicly Funded Research Agencies such as CSIRO. The Panel strongly believes that long-term basic research provides the new ideas and Intellectual Property that is needed to fuel the future Australian economy, providing the basis for successful participation in global enterprise, providing new opportunities in the evolving job markets, and supporting a quality of life desired by all Australians. The proposed National Priority Research Centres will enable direct research partnership between the most outstanding researchers in the University and Research Agency systems. The Panel recognises that in most scientific disciplines Australia has some elite, world ranking researchers but they are few by world standards. A strategy to bring these elite scientists into collaborative programs is sure to lead to synergies of discovery of new knowledge.

Many of the most urgent problems we have as a nation require novel approaches that facilitate collaboration across boundaries, including those between the 'hard sciences' and the humanities and social sciences. The proposed NPRCs will also strengthen our human capital by putting in place attractive arrangements for world-class researchers. These researchers will introduce new capabilities to Australian research, capabilities we will need to enable us to be competitive in the first rank. The NPRCs, with ten year contracts, will provide much needed additional career opportunities for our best young scientists, helping Australia to retain its high performing scientists.

The Centres will form a complementary parallel development to existing Government initiatives such as the National Collaborative Research Infrastructure Strategy.

NPRCs could be established in some of the recent breakthroughs in biotechnology (Box 1 – Epigenetics) and Nanotechnology (Box 2). These are areas where we do have some leading edge scientists in different but pertinent interactive disciplines – the Centres would optimise the probability of Australia maintaining a front line position in each of these areas, so crucial to future innovations in medicine and agriculture. We are uniquely placed to mount successful programs.

Other areas where a focus on strategic basic research is needed include Fossil Fuel Chemistry. The provision of clean, sustainable and cost competitive energy and chemical feedstocks is a key economic imperative for Australia. Australia is fortunate in having large reserves of coal and natural gas, which can provide both energy and an alternative feedstock source for chemicals. Environmental necessities require that new, more efficient and cleaner processes for the exploitation of these reserves be developed. There is limited research being conducted in Australia into the novel exploitation of the nation's fossil fuel endowment. There are isolated centres of research excellence, but there has been little incentive to focus, cooperate and integrate efforts needed to develop the basic science underlying future security and commercial exploitation. There is a world market for the new approaches successful research would provide.

It should be emphasised that the basis of the initiative is to study the fundamentals that can be expected to lead to future exploitation of novel intellectual property on a world

Box 1 - Epigenetics – the new frontier in biological research

Recently knowledge of the control of gene action has increased dramatically. With this has come a greater capacity to modify the genetics of plants and animals to increase food production and the nutritional quality of foods and animal feeds, and for the diagnosis and treatment of human disease. Epigenetic factors control the way that a cell uses encoded genetic information. Our understanding of epigenetics is in its infancy but recent technical developments now provide us with the tools required to further our understanding.

Epigenetic mechanisms are similar in all higher organisms. In Australia we have scientific leaders in plant, animal and human epigenetics. In a number of countries large investments are being made in projects aimed at understanding Epigenetic gene control (US NIH human epigenetics ($119m). If Australia is to maintain a frontline position, we need to invest to develop an interactive group of our best researchers in this area.

Basic knowledge of epigenetic gene regulation will be used to improve both medicine and agriculture. Epigenetics will help provide food security and food quality to protect animals and plants against disease and to better equip them to respond in a robust manner to environmental stress challenges.

Already epigenetic mechanisms are the target of drugs to control specific types of cancer. It is clear that epigenetic controls are involved in the interaction in the womb between the maternal and foetal genomes.

The proposed Priority Research Centre would develop capabilities in the genome wide analysis of changes in DNA methylation, chromatin proteins and small RNAs. Bioinformatic analyses of epigenetic regulation mechanisms will enable advances in plant and animal gene control which will also apply to the control the of human genes.

scale. This is the opportunity to invest in some of the best brains in Australia in the context of clean routes to energy, fuels and chemicals. Preliminary economic assessments will be made at an early stage in order to define achievable objectives, but the emphasis will be on building Australian capability and opportunity in the critical area of development. The immediate objective will be to develop fundamental understanding of the basic science and, where necessary, engineering of the creation of clean fuels and chemicals. In the longer term commercial exploitation of this understanding will be made.

The Antarctic and Southern Ocean Region plays a major role in the response of the whole Earth System to global warming. Changes in the Southern Ocean and Antarctic sea ice affect global ocean circulation, with impacts on Antarctic and Southern Ocean ecosystems, coastal ecosystems in the Pacific and Indian Oceans, and in the global climate. Australia needs the very best prognostic Antarctic and Southern Ocean science capabilities to support our climate change vulnerability and risk assessments. Without these capabilities, new management and adaptation policies for our nation will be hamstrung and the planning of our responses to the changes in the Antarctic and Southern Ocean region will be impossible.

Annex 6

Box 2 - Nanotechnology – potential for sustainable energy and healthcare
Nanoscience has emerged, in the past decade, as a critically important cross-disciplinary science, which constitutes a new and powerful toolbox for engineering materials and products at the molecular level. Nanoscale science deals with the theoretical and practical aspects of the synthesis, characterisation and application of nanoscale material building blocks. It has the potential to transform many Australian industries in areas such as clean energy, climate change mitigation and water management, treating disease and personalized medical care, and national security. Nanomaterials constructed by self-assembly or biomimetic processes frequently possess different, improved and sometimes revolutionary properties compared to their bulk counterparts. Nanostructured semiconductors and other electronic and photonic materials have exhibited extraordinary properties and performance promising for applications in solar cells, fuel cells and energy storage devices, energy-saving solid state lighting and water purification processes. Exciting new developments in creating novel electro- and photoactive materials by using self-assembly and bottom-up nanoprocessing offer the potential for groundbreaking innovations urgently needed in clean energy fuelling our carbon constrained world.

Applying the new found techniques of manipulating molecules affords the possibility for gene and drug delivery by directly moving molecules into cells, or devising new and powerful imaging and diagnostics all of which are essential in effective personalised medical care and treatment. With the extraordinary promises nanotechnology has shown, we propose this research centre of excellence to bring the best and brightest among nanotechnology researchers in Australia, to focus on transformative innovations in technologies for sustainable energy and health care.

The Centre will foster expanded opportunities for training Australia's Antarctic and Southern Ocean research 'stars' of the future. Major international partnerships with the world's best and brightest scientists will enable research at scales we could not tackle alone, as well as recruiting new talent from around the globe in areas where our local capability needs enhancement. While the focus of the Centre would be strategic and of the highest calibre, it also will build relationships with key Government agencies to ensure the research outputs have easy passage into policy.

Another Centre in the Humanities and Social Sciences would focus on 'Behavioural Changes associated with adaptation to Climate Change and Energy Efficiency'. Recent global conditions emphasise the need for Australia to increase our research capacity in 'Food Security, Nutrition and Human Health'.

The Panel foresees that the recommended Governance arrangements we have put forward, would be of seminal importance to the Government in advice as to the most critical R&D areas to be included in the portfolio of National Priority Research Centres.