Walter and Eliza Hall Institute of Medical Research

Background and context

Public support for science and innovation is critical to Australia's economic and social development. This submission is from the perspective of the medical science sector with a clear emphasis on science and innovation in medical research institutes since we strongly believe that this sector has specific characteristics that must be addressed. These include long lead times to public benefit through clinical translation, high cost of this translation and the relatively weak commercial sector in Australia. Furthermore, investment in science and innovation as it relates to health has a profound impact on the well-being and quality of life of Australians and there is a clear need to balance innovation related to intervention and prevention. We believe that current econometric analyses of benefit or return from an investment in science do not adequately address the characteristics of the medical sector and focus only on a high level view of innovation at the macroeconomic level.

Australia must not elect the strategy of becoming reliant on other nation's science capacity. Without a competitive science capacity Australia would not be included in discussions with leading economies, would not have the capability for fast adoption of technologies and response to threats and would not be able develop value-added exports. Leading Australian scientists are required to not only conduct research in Australia but also discuss developments at the "international R&D table" and assess their relevance and impact for Australia. Australian expertise is required to ensure that our technological infrastructure is maintained at the "state of the art" level, anything less would jeopardize our economic competitiveness and ability to respond. For example, Australia' leading role in the international challenge from influenza would not have been possible without the accumulated public investment in maintaining a strong science base in virology and vaccines.

Our challenge is to transform our science capacity into social and economic outcomes. The medical science innovation sector in Australia is relatively immature and unlike other sectors with respect to level of industry and finance sector investments. There is strong public funding of basic medical research but inadequate funding for translation, development and commercialisation. As a consequence Australia fails to capitalise on this public investment. With respect to commercialisation Australia is relatively strong in devices but weak in diagnostics and pharmaceutical development, in spite of the strong investment in basic biology and clinical science. Australia's track record of development is highlighted by Gardesil (CSL/Merck), Relenza (Biota/GSK), and Kapanol (Mayne) with no other pharmaceuticals fully developed in this country.

The Walter and Eliza Hall Institute is one of Australia's leading medical research institutes with research expenditure of approximately $60 million per annum and 550 FTE including staff and students. Activities span basic science, clinical translation and commercialisation across all areas of strategic focus including cancer, haematology, infection, immunology, autoimmunity, genetics, bioinformatics and structural biology.

Definitions

BERD Business Expenditure on Research and Development
FTE Full Time Equivalent
GERD Gross Expenditure on Research and Development
SME Small to Medium sized Enterprise

1. The economic, social and environmental impacts of public support	
The Commission is interested in exploring both the positive and negative impacts of the current system of public support. Evaluation of the economic, social and environmental impacts of science and innovation is difficult for many reasons. The Commission invites quantitative and qualitative information from participants about the impacts of publicly supported science and innovation on Australia's productivity performance, and in the achievement of specific social and environmental goals.	
For which aspects of science and innovation (e.g. R&D, diffusion/adoption of new ideas and technology, commercialisation) are benefits most apparent?	*Investing in a continuum* - Benefits accrue from a continuum of activities. Fundamentally, the total benefits from investment in science are most apparent from upstream investment in world-class research. It is from these areas that diffusion can be maximised, particularly in medical research as the underlying biology is better understood and required multidisciplinary linkages are made. However, these potential benefits are not realized if the "downstream" components responsible for value adding through translation are not adequately resourced. Furthermore, a culture stimulating translation and adoption is essential. Therefore, we believe that the greatest return from investment comes from both a sound and balanced level of investment (i.e. critical mass) and effective routes to translation. *Plurality* - The greatest benefit will come from a science investment strategy that accepts plurality – public funded research driving an ever-increasing body of knowledge and capability that can complement and effectively link to product-oriented research and development in the commercial sector. The greatest erosion to the benefit of a public investment in science will come if we try and conduct public science on a general quasi-commercial basis without adequate reference to the commercial sector. *Focus on invention* - Previous distinctions between basic, strategic and applied research have become blurred as innovation becomes less linear and more iterative with frequent cycling between all types of research as the knowledge base increases. The distinction between discovery and invention is often not well understood. The greatest benefits accrue once a discovery has shown to lead to an invention with clear utility.

To what extent, if any, does public funding of science and innovation 'crowd out' expenditure that would otherwise be made by the private sector?	*Consider market dynamics* - Being faced daily with clear examples of market failure in medical science innovation investment we see no evidence of the private sector being "crowded out". We also refer to a detailed submission from the Australian Association of Medical Research Institutes (*Public versus private funding for health and medical research*) that specifically addresses this question. The emerging role of academia in commercialising medical science innovation[1] is precisely because of market failure and the need to source funds in the absence of industry or venture capital investment prior to reduction to practice. Transnational pharmaceutical companies are increasingly looking towards academia and SMEs as a source of IP but at a later stage of development (after reduction to practice)[2]. Therefore, while the P-3 Scheme may stimulate investment by transnational companies in Australia the real IP value to be captured from public investment resides in focusing on the funds required between proof of principle and reduction to practice with animal data. *Competitive advantage* - The private sector will fund R&D that it believes it will directly benefit from and gain a competitive advantage. It will generally not fund research that cannot be captured as a patent or as a commercial secret. The private sector in turn relies on the publicly disclosed body of knowledge on which to build its own specialised R&D portfolio. It should also be noted that due to high costs and lead times there is relatively little "pre-competitive" collaboration in commercialisation of medical research. This is in contrast to the intensive pre-competitive periods often experienced in, for example, automotive, ICT, defense and electronics sectors. *Public investment essential* - Governments generally take the view that it is their role to support an environment that is conducive to business in general rather than an environment that gives a competitive advantage to one business over another. In this context the roles of public versus private funding of science and innovation ought to be almost mutually exclusive but mutually reinforce the innovation cycle. A major decrease in public funding might see a transient increase in private funding as researchers redirect their activities to be attractive to the short-term aims of business. However, in the long term the major new discoveries that actually create completely new business opportunities and sectors would be lost and the economy would stagnate. *Sector specific analysis* - The debate over public funding crowding out private funding must be based on focused analyses related to the specific characteristics of knowledge and industry sectors. In the context of

[1] Mehta S (2004) Nature Biotech 22:21-24
[2] Kalorama Inf (2004) Outsourcing drug discovery (KLI-827058)

	medical research in Australia two important aspects must be considered – a) there is only a small domestic industry with inadequate strategies and resources to capture the opportunities and b) the risk averse nature of available private capital greats a funding gap. It is this early stage funding gap that must be addressed in order to achieve reduction to practice. *Public funder threat* - We maintain that a major threat to private investment would come from public funds if the providers of those funds had claims over commercialisation rights. Since industry finds it generally unattractive to deal with governments or public bodies with respect to commercialisation they would tend to seek other opportunities in such cases. Furthermore, the temptation for public research funds managers to create commercialisation entities is a concern and increases the complexity of commercialisation particularly when the research fund users also have commercialisation responsibilities.
To what extent can 'simple' measurement of inputs (e.g. expenditure, number of scientists, etc.), provide reliable indicators of the impacts of public support?	*Lack of causal links* - With respect to investment in research there is no immediate link between inputs, outputs, outcomes, and impacts. Any link between inputs and impacts is clearly one of "quality investment" and simple measurement of inputs would not have any direct relationship with outcomes. Research outcomes are largely unplannable and assuming adequate quality assurance and performance evaluation criteria inputs reflect a cumulative investment in the body of knowledge. *Incentives* - The level of expenditure, the number of institutions and number of scientists is a reliable measure of the level of activity but this does not necessarily relate to impacts. The incentives created by the principles of distribution of research expenditure, the types of institutions and scientists that are supported, and the ultimate performance measures will determine whether the supported research has a real impact on the body of knowledge or on society in general.

To what extent do measurement parameters (e.g. papers, spin-outs, patents etc) guide behaviours? What is desirable/undesirable?	*Profound impact* - Measurement parameters have a profound impact on behaviour when they are used as performance indicators and it is clear that careful balance is required. Therefore, it is absolutely clear that, to the extent that future funding is determined by past performance, the value assigned to different performance indicators will drive behaviours accordingly. Given this, it is essential that the altered behaviours are ones that will lead to the desired outcomes such as greater positive impacts on knowledge, more competitive businesses, greater quality employment and national wealth, a healthier society in body and mind, etc. The following examples illustrate the issues: a) Measurement of impact on knowledge by publication counts will encourage more publications but provide no incentive to publish high impact, long-term studies since the increased time and expense of these studies will only reduce the total publication count for an applicant. A better measure would determine the impact of published work on the overall body of knowledge by delineating the recognition and influence that the work has had. b) Research-oriented clinicians are critical to translation of basic research into the clinic. However, these dedicated individuals must balance their clinical duties with research and education commitments. As a consequence measurement of publications alone does not take into account their actual contribution to science and innovation. c) Emphasis on interventions and therapeutic products could mean that measures based on prevention, education, promotion and policy have lower priority, even though the total overall benefit to society could be greater. d) As for measuring papers published, simple counts of patents lodged bears no relationship to actual commercial value. Most patent applications have little eventual value and identifying those patent applications that will be granted and have significant commercial value remains extremely difficult. Will a continued emphasis on measuring US patents be a sufficient measure of future value in the face of the rise of the Chinese and Indian economies? All patents are not equal. For example, in the realm of pharmaceutical development, composition of matter patents

	are highly valued but we continue to regard method and process patent applications as being equally important. Therefore a medicinal chemist delivering a composition of matter patent is likely to make a more significant contribution that a scientist contributing to a method or process patent with questionable enforceability. In the world of software engineering proprietary know-how often has greater value than patents. e) Focus on spinout companies can often be at the expense of other more attractive commercialisation options such as collaboration and licensing. Spinout companies may present additional economic spillovers, however the opportunity costs are rarely considered. These costs can include distraction from public research commitments, diversion of management skills, conflicts of interest, loss of IP through assignment and failure, and a more risky route to market. f) Diffusion is critical to achieving greater benefits from research investment. Therefore lack of emphasis on mobility within and between disciplines, and between organisations and sectors must be addressed. Our current discussion about science "diffusion" reflects a view that the process is akin to osmosis when in fact a more catalytic approach is required. *Understanding value creation* - The entire value creation chain must be recognised rather than attributing too much value to "snapshots" at any one point in the chain. For example, real commercial value is created when science results in a patent which is licensed and commercially developed or when a spinout company attracts significant capital investment and creates employment and a revenue stream. These latter activities represent a very small proportion of the starting pool, but the greater investment of time and money required to achieve them and the much greater benefit that accrues to society must be recognised in the measures of performance. The same generic thinking can obviously be extended to measuring impacts of research on health gains, cost savings and community well being. Therefore, we strongly recommend consideration of contribution to these "downstream" activities as being critical to measuring performance and delivering value to society.

What partial quantitative measures or indicators — such as numbers of patents, citations in journals, or the establishment of new firms and new agglomerations of 'high tech' firms — are most useful as indicators of the outcomes from public support?	*Consider MORIA* - The thinking in the previous answer has been partially formalised in the NHMRC's "work-in-progress" - Measurement of Research Impact and Achievement (MORIA). This tool aims to provide a (mostly) quantitative measure of the impact of research in the knowledge, economic benefit and health gain domains. In each domain significantly higher scores are achieved by research that can demonstrate real impacts. In the knowledge domain impact is primarily measured by citation ranking that is international and field specific. In the economic domain the primary measures are levels of investment, commercial income and employment creation. In the health domain the primary measures are improvements in health practice and/or cost savings. *Integrated approach* - We recommend a carefully integrated approach to indicators and suggest a stronger emphasis on linkages, collaboration and participation in the total value chain. We know that many papers are infrequently cited, most patent applications are never commercialised, and most spinout companies fail. Therefore, is seems profoundly unsound to use these as sole indicators and clearly wise to focus on the scientists' ability to engage directly or indirectly in diffusion, translation and community outcomes.
To what extent are overseas performance measurements, or targets, relevant to Australia, allowing for such aspects as differences in industrial structures and in the institutional and regulatory environments?	*Benchmarking vital* - International benchmarking is vital to enhancing competitiveness in research outcomes since knowledge generation and associated translation and commercialisation are international activities. Comparison with other nations is essential to understanding drivers of innovation and community outcomes and the different dynamics for industry sectors. In particular, the medical research and translation community is global and therefore international comparisons will reflect expectations, assist in establishing important international linkages and drive increased relative performance. While there are nation-specific factors we believe that international comparisons are important for Australia due to the relatively small size of our research investment, economy and position in global medical research IP translation. Understanding the differences between Australia's and other economies is important. Therefore, when assessing performance and devising improvement plans for innovation from medical research investment we must recognise that Australia has a relatively:- a) Small and immature business investment in medical R&D b) Strong public investment in medical research c) Weak medical product development and

	commercialisation capability (with the possible exception of devices) d) Weak capital market for high risk investments in medical research e) Strong and respected regulatory environment for commercialisation of medical research Our benchmarking must span all relevant markets and include the US because of its current economic domination and also the Scandinavians because of their ability to link academic and industry sectors[3].

[3] The approach to innovation ranking proposed by Gans and Stern should be considered (Gans J, Stern S, *Assessing Australia's innovative capacity in the 21st century*. IPRIA, 2003)

2. Impediments to the effective functioning of Australia's innovation	
The Commission is asked to identify impediments to the effective functioning of Australia's innovation system and to identify scope for improvements, including in the following elements of the innovation system: *• knowledge transfer;* *• technology acquisition and transfer;* *• skills development;* *• commercialisation;* *• collaboration between research organisations and industry; and* *• the creation and use of intellectual property*.	
What problems currently exist (please be as detailed as possible)? What causes them? How significant are they? What are their effects?	*Early stage funding gap* - The biggest impediment to most of these activities is the funding gap between the completion of an academic research project and the development of a commercially attractive proposal. This is a worldwide problem but is especially acute in Australia. The problem begins at the patenting stage where the funds required for entering the national phase (international patent) are prohibitive for most academic organisations and cannot be legitimately sourced from research funds. This results in most academic groups seeking commercial licensing far too early (to pay for patents) and at a time where it is either too hard to gain commercial interest or the value of the intellectual property is heavily discounted because it is so early. Even worse, patent applications are discontinued at an early stage if funding partners cannot be found. This results in heavy foregone commercial losses to Australia. Appropriately managed funds to address this gap would be a major advance in securing patents and returns to the community from public investment in medical research. *Accounting for medical BERD* - A telling statistic is that while Australia has a 2.5% share of world scientific literature it has only a 0.7% share of world patents. Australia's gap in innovation performance between scientific articles and graduates in science and translation into patents per capita and business R&D investment is marked[4]. This translation failure is further exacerbated by a low BERD. The impact of this gap is particularly marked for medical research where a large public investment is not matched by a large industry sector with a strategic emphasis on early stage innovative R&D (note; CSL, Cochlear and ResMed account for a major proportion of BERD in this sector which is dominated by undercapitalized SMEs). *Caution with spinouts* - In some cases it is attempted to build value by creating a spinout company with minimal seed capital investment. However, the time needed to create value in the company usually sees the company run out of cash before it becomes attractive even to

[4] Davis G, Tunny G (2005) International comparisons of research and development. Macroeconomic Policy division, Australian Treasury

	venture capitalists and even to the venture capitalists that have received leveraged Government funding to provide pre-seed or seed capital. *Policy inconsistencies* - Inconsistent commercialisation policies and incentives adopted by CSIRO, universities and institutions further reduce the efficiency of Australia's innovation system. *Lack of foundations* - Australia is at a relative disadvantage having no equivalents of the major grant foundations in the US, UK and elsewhere[5] and a relatively low level of philanthropic investment in science programs. While it is clear that these large overseas foundations and contributions must serve a very large pool of applicants, the fact that they exist and contribute drives a strong culture of investment in science.
How successful are the approaches and institutional arrangements currently taken to overcoming such problems? What are the costs, as well as the benefits, of these approaches?	Two examples from the Walter and Eliza Hall Institute illustrate successful approaches. *CRC model* - Participation in the CRC for Cellular Growth Factors resulted in the discovery of the IL-13 receptor and its role in asthma. Through its commercialisation partner Zenyth Therapeutics (previously Amrad), the CRC captured the IP and incubated it to the stage of pre-clinical licensing. The CRC scheme and industry partner funds provided sufficient capital to bridge the funding gap noted above. Zenyth were subsequently successful in licensing the IP to Merck and have already received more than $15 million in pre-clinical development payments. Our experience shows the importance of these "priming funds" that are so critical in therapeutic development. The shortage of such funds is clearly part of the explanation for Australia's relatively poor performance in drug discovery[6]. *Commercialisation policy* - WEHI has implemented a commercialisation policy that provides for a 20% return to all staff and students, and a 30% return to inventors. This distribution of returns facilitates a culture of innovation and acceptance of translation and business development. As a consequence the Institute has more than 50 patent families already partnered, a further 50 under development, and a new provisional patent being submitted every month on average.
Can these problems be more effectively addressed? If so, specifically how?	*IP and development funding* - The Government could fund commercialisation of research from academic organisations more effectively by providing pro-rata commercialisation infrastructure funding. This eligibility should include medical research institutes to capture biotechnology and health science investments. The commercialisation infrastructure funds should be

[5] e.g. Wellcome, Howard Hughes, Gates, etc

[6] The value of deals negotiated by G2 Therapies, Biota and Zenyth Therapeutics is recognised but considered to represent only a part of Australia's potential that is limited by early stage funding

	auditable and dedicated to patent protection, maintenance of a business development office and pre-seed funding for start-ups. The funded organisation is best placed to make its own choices from its research portfolio of commercialisation opportunities and recurrent funding could be based on the effectiveness of its commercialisation choices (using the outcome measures described above). The current approach of funding venture capital consortia (seed and pre-seed funds) to identify commercial opportunities in academia has not worked well because; a) Such consortia necessarily take a very short term approach to liquidity and therefore identify only late stage projects (hence the funding gap) b) There is no incentive in this funding model for academic organisations to improve their commercialisation performance c) It does not provide for professionalisation and capacity building of academic business development offices in the way that this recurrent funding would d) Medical research institutes are not eligible for the current pre-seed funds *Encourage collaboration* - Mechanisms that encourage greater sharing of patent information and "pooling" between publicly funded organisations should be encouraged. Such greater collaboration could realise synergies and potentially present a more attractive investment opportunity. The Walter and Eliza Hall Institute notes the current success of the intermediaries from the InnovationXchange in facilitating IP collaboration discussions between organisations.

Are there significant barriers in Australia to the diffusion and transfer of knowledge?	*Diffusion is limited* - Six key areas must be addressed in order to enhance diffusion of knowledge in Australia. In each of the following areas we believe that Australia is relatively weak: a) Increase general understanding of the differences between knowledge diffusion, transfer, and catalysis and their dynamics and drivers b) Encourage mobility of scientists between organisations and sectors by identifying and removing barriers c) Secure early stage investment funds to address the gap noted above d) Establish commercialisation policies that provide an incentive to participate in translation and commercialisation e) Provide training of scientists in R&D leadership and translation, especially at an early career stage f) Increase collaboration skills with respect to sharing information, strategies, ideas and potential joint ventures. It is essential to increase Australia's understanding of the art of "coopetition" or knowing when to collaborate and delay competition.

3. Evaluation of decision-making principles and program design.	
Participants are invited to nominate topics for case studies which could illustrate impediments to innovation or the influence of decision-making principles and program design on the impacts of public support for science and innovation.	
Example	The well-recognised role of the Ludwig Institute for Cancer Research and the Walter and Eliza Hall Institute in the discovery and development of G-CSF and GM-CSF provides a strong example of issues in discovery, translation and IP decision-making. Combined, these largely publicly funded discoveries have resulted in direct benefits to over 8 million patients (an estimated 200,000 Australian patients). At the time of commercialisation the discovering institutes needed to make decisions with respect to patent prosecution and elected to protect GM-CSF. This provided Amgen with the opportunity to exploit G-CSF and become a leading biotechnology company. The purpose of this example is not to question what were reasonable decisions at the time, but rather to focus on the need for funds to support IP development to secure both direct and indirect returns to the Australian taxpayer.
Should total levels of public support for science and innovation in aggregate, or for particular components such as R&D, in Australia be increased or reduced, or is it about right? Please explain what objectives such changes should be designed to meet.	*GERD performance* - The reason for Australia's low GERD is the very small component of BERD. This strongly exacerbates the funding gap described above and emphasizes the potential value of additional Government expenditure on commercialization infrastructure grants. By allowing institutions to develop their intellectual property to a more mature commercial stage the pool of real commercial opportunities to Australian business will increase and therefore encourage a greater investment by business in those opportunities. We are currently in a vicious cycle that can be broken by commercialisation infrastructure grants leading to an increase in BERD and hence GERD.
What are the reasons why many other OECD countries have relatively higher levels of GERD and BERD than Australia, even though public support in those countries appears relatively less?	*Investment environment* - The reasons why other OECD countries have higher levels of GERD and BERD are many and varied. In some countries there is a much more accepted culture of interaction between academics with businesses (e.g. UK, Scandinavia, US). In some, the nature of business enterprises is more research intensive (high tech) and concentrated than in Australia and therefore investment in R&D is considered a core activity. In other countries there is a bigger pool of investment funds willing to invest in higher risk ventures than in Australia and the unit invested in each business is more likely to lead to success of the business. Australian investors tend to follow cycles flowing between resources and technology, whereas other more technology-driven markets have more sustainable levels of investment capital available for technology.

	Explore specific sectors - It is important that the analysis of the underlying drivers of BERD must be related to specific industry sectors, for example pharmaceuticals and diagnostics, rather than economy wide. The fact that, with the exception of CSL, ResMed and Cochlear, Australia's pharmaceutical R&D sector is dominated by a large number of small SMEs highlights that different explanations and measures will be required. For example, trying to convince a large transnational company with largely centralised R&D in New Jersey to invest in R&D in Australia (e.g. through the P-3 Scheme) is very different from needing to secure early stage funds to enable Australian SMEs to incubate local IP. It should be noted that large pharmaceutical companies are increasingly depending on SMEs for IP[7] and this is the critical sector for the development of Australia's pharmaceutical industry. The specific drivers of these two different strategic scenarios are not fully exposed in macroeconomic analyses.
What other factors influence the (relatively low) level of R&D funded by business in Australia?	*Low BERD* - There are three additional factors contributing to the lower level of BERD in Australia: a) An inconsistent and often less favourable taxation environment has not provided companies with the incentives for greater investment in R&D b) Short-term focus on company performance by the market inhibits medium and long term R&D investment – R&D tends to become incremental and less radical c) The risk profile of the capital markets is relatively low with respect to high technology thus creating the funding gap referred to above or diffusion of IP to other markets – angel investors are rare, pre-seed funds act like seed funds and seed funds act like later stage venture capitalists. Competition between funders must be increased through new approaches and funds.

[7] Kalorama Inf (2004) Outsourcing in drug discovery (KLI-827058)

What general principles of funding allocation to, and within, particular programs are most likely to foster an efficient and effective innovation system in Australia?	We identify seven basic principles to foster a strong innovation system with respect to medical research: a) Apply pluralistic principles with a long-term strategic balance to public investment in a range of science disciplines. b) Achieve an appropriate balance between investment in "big science" and individual investigator-driven science. The current funding "crisis" in the US largely stems from the balance having been shifted too much in favour of "big science" at a time when there is insufficient growth in funding to support the next generation of young investigators who rely on success in individual investigator-driven science[8]. c) Ensure that funds are available to enhance both clinical and commercial translation and specifically address the "pipeline blockage" that characterises Australia. d) Provide academic organisations with access to well-administered funds for early IP protection. e) Invest adequately in early career scientists to avoid the likely generation failure that currently confronts the US[8] (improved succession planning). f) Expand peer base since the traditional academic peers do not necessarily reflect world-class value to the community upon successful translation. g) Encourage strong clusters of excellence collaborating at all levels including basic research, clinical translation and commercialisation In considering the above it is essential to reach agreement on what constitutes an "efficient and effective" innovation system and how it should be measured.

[8] Weinberg RA (2006) A lost generation. *Cell 126:9-10*

How to weight and measure emphasis for various type of research (basic, directed strategic, applied, public health, prevention/intervention)?	*Portfolio* - As noted above we strongly recommend a pluralistic approach that balances a portfolio investment in all types of research. It is essential to maintain capabilities across many basic and applied disciplines so that the vastly different challenges of, for example, infectious disease, cancer, mental illness, diabetes and child development can be addressed. An inclusive process recognizing the value of all types of research with is essential to scientists promoting the case for public support. *Measurement* - With respect to measurement we identify a misalignment between ANZSIC categories followed, for example by ABS, and the realities of the medical research sector and its economic classification relative to the public investment in medical research. Current classification[9] makes it virtually impossible to link investment with measurement of outcomes. This should be addressed as a matter of priority given Australia's large public investment in medical research. Similarly, the use of "biotechnology" must be more rigorous since it applies to a series of platform technologies and interests that are applied in different areas and sectors.
Particularly given Australia's small share in global expenditure on science and innovation, should public support be mostly concentrated on assisting Australia to build on its current strengths, or to overcome areas of weakness?	*Focus* – Australia should clearly focus on its strengths according to globally recognised performance discussed above. We simply do not have the resources to address all weaknesses, but where a weakness could threaten exploitation of a strength it should be addressed. A clear example is Australia's strength in biology not being matched by a similar strength/capacity in medicinal chemistry. This gap is exacerbated by the failure of current NHMRC funding schemes to support medicinal chemistry within the academic sector. As a consequence we risk innovative drug targets not being supported by strong composition of matter IP founded on drug optimisation. *Infrastructure* - Research funding must increasingly cover infrastructure costs to capture the full cost of research and the increasingly more complex and expensive infrastructure that is required (see further below). *Career development* - Public support should also focus on attracting the best minds to Australia. Competitive advantage is based on people and therefore Australia should adopt a strong focus on career development strategies. The argument for simply retaining our "best" is simplistic, captive and ignores a tactical component that has been effectively exploited by other economies. Australia should encourage early research experience

[9] Classified under property and business services or other manufacturing

	overseas and then re-attract early-mid career scientists with this experience to Australia. The Scandinavians and Japanese are historically good at this strategy. If well applied funds for such scientists could be very attractive and could have a greater impact to the community investment than the current Federation Fellowship plan.
What criteria are most appropriate in guiding the allocation of available public funding? Past performance? National priorities? New ideas?	*Criteria* - We believe that each of these proposed criteria has its place and all should be considered in the final evaluation. For established researchers past performance is usually a good guide to future performance although one might want to track the timeline of their performance to ensure that one does not fund past performers who have become out of touch in recent years. *Focus on young scientists* - Younger researchers or researchers who have had career interruptions should be tested primarily against the quality of their ideas. Similarly this scheme might be used to address specific calls for proposals in identified problem areas although in this case it would be applicable to all researchers. Within both of these categories some funding can be quarantined for applicants working in strategically important or priority areas. The major difficulty will be in allocating funding percentages to each scheme but this will constitute the major strategic decisions made by policy makers. *Patent and publication* – The track record of the organisation in capturing invention disclosures and complying with laboratory notebook requirements is important. We believe that provided funds are available there are few conflicts between patent and publication. *Encourage links* - Skills and experience with networks and multidisciplinary collaborations (for example combining chemistry, physics and biology) will provide the greatest opportunity for synergy, lateral knowledge development and diffusion.

What are the advantages and disadvantages in providing for contestability in the allocation of public support for science and innovation — that is, competition for funding?	*Competition critical* - Contestability is required to ensure that the limited funds available are delivered to the projects most likely to produce the desired outcomes. The only disadvantages are that this increases the time delay between the idea and its initiation and it requires considerable effort on the part of policy makers to achieve correct judgment and on the reviewers to do their job diligently. These are opportunity costs but the alternative of not formally assessing and ranking proposals would make it difficult to justify that the expended funds were used in the best interests of taxpayers. *Portfolio risk management* - There should be agreed principles for a balanced risk portfolio of projects since there is a tendency to focus on low risk more incremental proposals. Truly innovative and speculative proposals are often perceived as being too risky. One possibility to overcome this dilemma is to provide organisations of established excellence with a renewable 5-year "innovation grant" of the order of, for example, 20% of its total competitive funding. This grant would be for the organisation to foster risky long-term areas. *Development grants* – There must be contestable allocation to development grants. Early stage development and reduction to practice are under-funded in the medical science sector. Medical research institutes are not eligible for pre-seed funds and NHMRC Development Grants are often too small, are applied to a too short time line and often suffer from apparently an arbitrary reduction not linked to the proposed development plan. Improved input from individuals experienced in translation and product development is essential.
How can different programs be better coordinated — including between and within governments — to improve outcomes while minimising administrative and compliance costs?	*Coordinate all components of funding* - Current academic funding schemes in Australia are considered grants-in-aid (partial funding) and the funding agencies hope that the additional funding required to fully fund a project will somehow be found from other sources. (Paradoxically, however, if another grant is found to fund the project, the spectre of 'double-dipping' is raised.) Fully funding a typical program within a medical research institute currently requires the following: - The team leader must succeed in obtaining an NHMRC fellowship to fund his/her salary. Competitive grants must be won by the team from more than one research-funding agency to cover the direct research costs and technical salaries associated with the project. The research organisation must then cover the indirect costs associated with the research (internationally accepted as approx. 60 cents for every $1 spent on direct costs[10]). The Federal Government now provides independent

[10] May RM, Sarson SC (1999) Revealing the hidden costs of research. Nature 398:457-459

	medical research institutes with 20c in the dollar of the NHMRC grants to fund indirect costs. The Victorian State Government applies a complex formula to provide additional indirect costs but the formula is not based simply on the indirect costs needed to support the research grants but on other criteria as well such as contributions to innovation in the State. The shortfall for indirect costs must be made up from Institutional endowment funds or public fund-raising schemes. It would obviously be much more efficient and transparent if all these funding mechanisms were directly linked to the research proposal. If the anticipated outcomes of the project are considered worthy of funding then all the components of funding should be delivered to the project team to ensure that the project can be delivered. As in the NIH funding system in the US the grant should be delivered in two components – the costs required to support all salaries and consumables and the indirect costs determined by auditing the individual institution. *Planned distribution of science centres* - The geographically dispersed nature of our science means that we must accept investment in several centres of excellence across the country rather than force marriages between distantly located teams as a "virtual centre". This investment must be well coordinated and strong links fostered between centres of excellence to eliminate unnecessary duplication or unproductive competition. The advantages of proximity, co-location and clustering must be considered in evaluating all strategic investments.
Do current funding and allocation arrangements promote an undue focus on short-term results at the expense of worthwhile medium and longer-term objectives?	*Differentiate assessment* - Several funding schemes emphasise recent productivity (usually last five years) as one of the assessment criteria. This may seem natural because the funding scheme is usually for research to be carried out in the next few years and the funding agency needs to be convinced that the applicant is currently an active researcher. For many types of research however real societal outcomes from the research may take a decade or more to become evident (this is especially so in medical research where the time from discovery to clinical usage is often 15 years as a result of regulatory requirements). This problem could be addressed by giving separate weightings to whole of career performance (perhaps divided by research active years) and recent performance depending on the aims of the funding scheme.
To what extent do current projects receive funding from a number of different sources? What problems, if any, are caused by such multiple source funding? Is there any 'double dipping'?	*Fragmented* - Almost all academic research programs are funded from multiple sources. Even when the primary funding is from Government there is a lack of integration of the funding for the research program. For example the direct costs of research are (inadequately) funded by research grants but the funding of researchers' salaries (e.g. through fellowships) and the indirect costs of the research program (e.g. through

	research infrastructure block grants) are funded by completely different schemes so that consistent and full funding of the research is difficult to achieve. A business would not run its R&D program this way! *Misconception* - The concern about double dipping is misplaced as the result of the misconception that a research grant provides full funding for a research project. The concern ought to be that all research funding is applied to the purposes of the grant and there is no financial fraud or misdealing. This can be detected by random financial audits of administering institutions where expenditure against each grant can be acquitted. *The perils of co-mingling* - Consequently most academic research programs have multiple funding and funders. One unfortunate consequence of this is that each funder may feel that they have IP rights as a result of their (partial) funding and many government (especially State) and philanthropic funders now include statements in their research contracts asserting ownership or a share in the commercial returns of the outcomes of the research program. The issue of multiple ownership of IP of course creates great impediments to commercialization and the issue of commercial returns to non-commercial funders may remove much of the institutional incentive to commercialise. The net result of these requirements by governments and philanthropic agencies is the exact opposite of what they desire – they prevent the development of products that may benefit society and they stifle the growth of new or existing commercial entities.