Policy statement on research and innovation in Australia

September 2003

President's Foreword

As President of the Australian Academy of Science I welcome the ongoing national debate about science, engineering and technology and am very encouraged by the high level of general agreement across the political spectrum that our economic and social well-being is critically dependent on the ability to capture the benefits of a strong science and innovation system. I also welcome the acknowledgement by the Prime Minister in an address to the Committee for Economic Development of Australia in November 2002 that 'investment in science and innovation is an investment in Australia's economic prosperity'.

In December 2002, the Academy applauded the Government's announcement of the National Research Priorities to guide the funding decisions of the various research and research funding agencies. These priorities are broadly in accord with the Academy's own recommendations, and demonstrate the importance of science and technology in addressing major national issues. I believe that they lay the foundation for the continuing development of a comprehensive agenda for the optimisation of our research and innovation effort to achieve the best possible outcomes for the economic, environmental and social development of Australia.

In 2001 the Academy welcomed the *Backing Australia's Ability* funding package as a first step towards halting the decline in the level of resources available for the national research and innovation system, while noting that it was still 'too little...[and spread] over too long a time frame'.

This policy statement by the Academy reviews progress in the development of Australia's research and innovation system since the release of our *Priorities in research and innovation for the next Australian Government* in October 2001, and presents a view of the current status of research and innovation in Australia.

The Academy supports the current review of the block funding arrangements for universities, and believes that funding should focus on quality outputs and outcomes rather than inputs and simple numerical measures. The fact remains that the overall level of funding available for infrastructure and other costs is inadequate to maintain an effective research capability. The Academy makes a specific recommendation that the Major National Research Facilities Program be established as an ongoing source of funds to meet significant infrastructure requirements. The Academy notes that higher education issues are of increasing concern to the general community. We are concerned at the continuing slide in the level of government funding in the form of recurrent grants, particularly in relation to its effect on teaching in the sciences and mathematics. This funding shortfall is compounded by the disincentive introduced by the HECS scheme for students to look to careers in teaching science and mathematics.

The Academy notes with increasing concern that, the *Backing Australia's Ability* initiatives notwithstanding, Australia's overall gross expenditure on R&D (GERD) continues to decrease as a percentage of GDP. More particularly, the gap between Australia's GERD and the OECD average continues to widen. European Union countries have recently agreed on a target of 3 per cent of GDP by 2010 as an appropriate level of investment in R&D.

As is well known, as a percentage of GDP, Australian government expenditure on R&D is relatively high on the OECD table. But business expenditure is very low, bringing the total national GERD down. The Academy welcomes initiatives to address this issue, and notes that business investment in R&D has increased for the second year running, but from a low base following declines in the previous few years. The gap between Australia's level of investment in R&D and the OECD average continues to widen.

The Academy is concerned that too high an expectation on the private sector to dramatically increase its support for higher education and R&D, and therefore any call to reduce public funding, is misplaced.

The Academy is convinced that a strength of the Australian science and innovation system is the pluralistic nature of the funding arrangements and the management structures of the various organisations in the system. The Academy believes that the response of these organisations to the requirements imposed by the Government's National Research Priorities will further strengthen the system, and enhance the competitiveness and contestability of that system.

Dr Jim Peacock
AC, PresAA, FRS, FTSE

Recommendations

1. That government extends the *Backing Australia's Ability* funding initiatives, both in time and funding level, to address the continuing decline in Australia's overall R&D effort, and to ensure the realisation of the national benefits to be achieved as outcomes of the National Research Priorities, announced in December 2002.

2. That government revisits its strategy to encourage investment in R&D by the private sector.

3. That government considers implementing a formal offset program when giving assistance to major industrial developments.

4. That government reviews the quantum of funding allocated to CSIRO for the next triennium, to capitalise on the multidisciplinary capacity of CSIRO to engage as a coherent partner with the rest of Australia's innovation system.

5. That government establishes a Higher Education Funding Council to drive the process of developing a shared vision for Australian higher education, in which government, universities and the private sector work for the common good of Australia.

6. That government introduces a research assessment process within the framework of the proposed Higher Education Funding Council, to inform the process of allocating research-related funding to universities.

7. That government restores the level of public funding for universities to compensate for the decline in total funding available for teaching and research.

8. That HECS-exempt scholarships be provided for students commencing science teacher education and a percentage of the HECS debt of science and mathematics teachers forgiven for each year of teaching service.

9. That the ad hoc nature of the Major National Research Facilities Program be replaced by the inclusion of a one-line budget item in the Science and Technology Budget each year, even if there are competitive rounds on a less-than-annual basis.

10. That government works to maintain bipartisan support not only for the Cooperative Research Centre Program, but also for education, research and innovation more broadly.

11. The Academy proposes a model for enhanced collaboration in the Australian innovation system via a competitive Collaborative Fellowship scheme involving universities, Publicly Funded Research Agencies and industry, to be administered by the Joint Academies.

12. That government retains the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) and upgrades the Commonwealth, States and Territories Advisory Council on Innovation.

13. That government ensures that Australia retains a creative scientific community capable of pursuing internationally significant science, and makes specific provision for the maintenance of international linkages with Australian research and researchers.

Building a knowledge economy

Recommendation 1
That government extends the Backing Australia's Ability *funding initiatives, both in time and funding level, to address the continuing decline in Australia's overall R&D effort, and to ensure the realisation of the national benefits to be achieved as outcomes of the National Research Priorities, announced in December 2002.*

The Academy continues to welcome the broad coincidence of views between the various sides of politics on the overall agenda for R&D in Australia. The Chief Scientist's 2001 paper, *The Chance to Change,* which led to the *Backing Australia's Ability* package, the outcomes of the Innovation Summit in 2000, and the Australian Labor Party's *An Agenda for the Knowledge Nation*, have all recognised the need for a vigorous and comprehensive national research and innovation system.

This bipartisanship has led to an environment in which the overall agenda is broadly owned by the business, science and education communities, and is receiving increased attention from the community at large.

There is a wide acceptance of the view that the continued development of our economic system is based on innovation. Investment in R&D is essential if Australia is to become a generator and exporter of knowledge-intensive products, thereby contributing to its economic, social and cultural development.

However welcome it was, the *Backing Australia's Ability* initiative does not arrest the current 8-year decline in overall national investment in R&D as a percentage of GDP – and, perhaps more importantly, relative to the OECD average.[1] Moreover, the heavy weighting of the funding profile towards 2004 and beyond has impeded the rapid implementation of programs and activities addressed by the initiative. The limitation of the committed funding profile to the 3-year period covered by the forward estimates provided by the Department of Finance and Administration has created uncertainty about the longer-term availability of funding, and reduced the ability of the R&D community to plan effectively, thus reducing the overall impact of the *Backing Australia's Ability* package as a whole.

The Academy applauded the announcement by the Prime Minister in December 2002 of a set of National Research Priorities to guide Australian research institutions and research funding agencies in their strategic planning. These priorities are broadly similar to the Academy's recommendations, and the Academy believes that they represent an appropriate balance between breadth of scope and specificity, and between the pursuit of opportunities for wealth creation and attention to the risks that we face to our health, safety, and the environment.

They are a significant step towards the development of a long-term strategy for Australian science and technology, and will provide researchers at all levels with a framework to guide the strategic planning of their research programs.

At the level of the research agencies and research funding agencies, the priority framework will provide a test of the appropriateness of proposed research programs in terms of their anticipated outcomes in the priority areas.

However, the successful implementation of a long-term strategy requires a long-term commitment to the funding and resources necessary for the realisation of the desired outcomes of that strategy. The Academy is concerned that the level of resources available to support R&D in Australia is not adequate for the task. The establishment of a priorities framework should not be based on the assumption that Australia already spends an adequate amount on R&D, and that a more efficient allocation of existing resources will provide a major increase in realised national outcomes.

In terms of international comparisons, Australia trails the fourteen or so countries of the OECD with whom we would expect to compete as a truly first world nation.[2]

[1] There are a number of sources for this statement. Probably the best recent summary of the overall situation is the Group of 8's *Benchmarking Australia's investment in R&D,* 18 September 2002. (www.go8.edu.au/papers/2002.09.18_update.html)
Basic information is available on the OECD website (www.oecd.org) under *OECD science, technology and industry scoreboard 2001 – Towards a knowledge-based economy*.

[2] *Discussion paper for participants*. Science and innovation mapping experts workshop, Department of Education Science and Training, 31 March 2003.

The problem remains that Australia places a disproportionate reliance on exports of primary commodities, agricultural and mineral, with a concomitant sensitivity of the economy to fluctuations in global commodity prices. It is important to note that Australia has been able to maintain its position as an exporter in these areas largely as a result of highly focused and effective R&D. This investment must continue to underpin our economic well-being and growth for the long term.

A greater investment is necessary to address the serious shortfall in Australia's competitiveness in non-primary, high value-added goods and services. It is in these areas that international trade is growing most rapidly. This is the area that current policies are failing. There is a small and enthusiastic community of small companies producing high value-added products in a number of fields. However, the total volume of this activity is at least an order of magnitude less than that required to make a serious impact on Australia's international competitiveness in innovation.

The information and communication technology (ICT) area is a case in point. Much is made of the undisputed fact that Australia is generally an advanced user of new technologies. ICT is a spectacular example of that characteristic. Australia ranks fourth among OECD countries on expenditure on ICT products as a percentage of GDP, and is only marginally behind the leaders, the UK, USA and New Zealand.[3]

There is no doubt that a significant proportion of these imports of ICT products is essential to maintain the competitiveness and effectiveness of Australian industry and other activities, and that other leading OECD countries also import significant quantities of ICT equipment. But the fact remains that Australia runs a huge deficit in ICT equipment, about $14 billion per year.

On the other side of the coin, the production of ICT goods and services in Australia is very low. There has been good growth in Australia's exports of database and consultancy services, but from a very low base. Overall exports in ICT goods and services in 2001-02 were $2.3 billion, resulting in a deficit of $725 million for that year.[4]

[3] *Australia and the ICT revolution*. Brian Anderson, National Press Club, 25 July 2001. (www.science.org.au/academy/media/npc.htm)

[4] *Australian ICT industries update 2003.* John W Houghton, Centre for Strategic Economic Studies, Melbourne, 2003.

The Academy welcomes the establishment of National ICT Australia (NICTA) as the ICT Centre of Excellence announced in the *Backing Australia's Ability* package. Because the lead-time for the development of commercialisable outputs from NICTA could be from 5 to 10 years, it is important that government maintain its support for this initiative into the longer term. Participating organisations must also be able to maintain their commitment.

An additional emerging priority area is the environment. Decades of bad practices have built up an enormous backlog of essential remediation in water systems, land management, air quality, and greenhouse gas amelioration. The R&D resources needed to address these issues adequately cannot be sustained within the current envelope.

State governments have been sensitive to voters' perceptions of the value of a knowledge-based economy, and in some cases have made significant financial commitment to attract R&D investment to their respective States. This interest is laudable, and has provided a valuable focus for the development of centres of research activity. However, it must not be allowed to degenerate into a destructive competition for investment, as has sometimes happened in the past. The constructive engagement of the States requires strong leadership from the Commonwealth government, through a comprehensive national innovation strategy.

Private investment in research and development

Recommendation 2
That government revisits its strategy to encourage investment in R&D by the private sector.

The Academy welcomes the latest (2001-02) data from the Australian Bureau of Statistics on the level of business expenditure on R&D, showing an increase for the second year running, following a steady decline since 1995-96. However, at 0.78 per cent of GDP, this latest figure is below the peak of 0.87 per cent achieved in 1995-96, and maintains Australia's position in the bottom half of OECD countries.

This recent increase may well be partly due to measures taken since the 1995-96 cut to the R&D tax concession, such as the provision for

some limited higher level concessions, and to the provision of a refundable tax offset designed to assist small companies without the necessary level of income to take advantage of the tax concession.

The fact remains that business investment in R&D ('BIRD') remains very low by international standards, and has the effect of pulling Australia's gross expenditure on R&D (GERD) well down the OECD table, a rank of about fourteen .[5]

A further difficulty is that some 30 years of an essentially bipartisan approach to the issue has not produced a level of 'BIRD' that is close to comparable with a number of countries with which we would see ourselves as competitive.

Coupled with an essentially static level of government expenditure on R&D, even taking into account the *Backing Australia's Ability* initiatives, Australia's overall investment in R&D is falling as a percentage of GDP, and even more dramatically relative to the OECD average, which is increasing steadily. European Union countries have recently agreed on a target for GERD of 3 per cent of GDP by 2010.

This is a serious situation that should have all sides of politics, and indeed all Australians, very worried.

The Academy welcomes the report of the House of Representatives Standing Committee on Science and Innovation[6], which makes a number of recommendations designed to increase the level of business investment in R&D. These recommendations include several put forward by the Academy[7] seeking to remove impediments experienced by small business and start-up companies attempting to access the R&D tax concession, particularly the Premium 175 per cent concession. Other recommendations supported by the Academy address such issues as the assessment of risk, the definition of 'eligible work', and increasing the eligibility of work leading to 'incremental' technical change. The Academy commends these recommendations to Government.

It is essential for the credibility of the changes to the Industry Research and Development scheme, and indeed of the Innovation Action Plan in general, that any indicative trends of unwelcome outcomes are quickly spotted and responded to before they discredit the new arrangements. The Government may wish to consider foreshadowing in the near future its willingness to adjust policy on an ongoing basis in the light of experience.

Other incentives to stimulate private investment in R&D

Recommendation 3
That government considers implementing a formal offset program when giving assistance to major industrial developments.

In building the innovative capacity of the nation, more attention might be given by government to a formal offset program. An Australian-based R&D component, which includes the building of capability, would be required whenever the government provides assistance to major industrial developments. One example where this has operated satisfactorily in the past is the Pharmaceutical Industry's Investment Program, which encourages investment by pharmaceutical companies. Even when government assistance is given to industries with mature technology, R&D may be necessary to adapt the technology to Australian conditions. It should be a requirement of the assistance package that this R&D is carried out in Australia whenever possible.

The Academy notes that development agencies in many countries have been successful in attracting major investment through the ability to negotiate and make decisions quickly on a national basis. Australia's effort in this respect is seen as uncoordinated and overlapping.[8] Simplifying unduly complex administrative arrangements would be a step in the right direction.

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5 *Discussion paper for participants.* Science and innovation mapping experts workshop, Department of Education Science and Training, 31 March 2003.

6 *Riding the innovation wave – The case for increasing business investment in R&D*. House of Representatives Standing Committee on Science and Innovation, June 2003.

7 *Inquiry into business commitment to R&D in Australia - A submission to the Standing Committee on Science and Innovation of the House of Representatives*. Australian Academy of Science, August 2002. (www.aph.gov.au/house/committee/scin/randd/subs/sub045.pdf)

8 *Winning investment - strategy, people and partnerships: A review of the Commonwealth's investment promotion and attraction efforts*, I. Blackburne, A report to the Prime Minister, August 2001.

There is the need to continue taxation reform to ensure the international competitiveness of Australia's company and personal taxation rates.

Other incentives to stimulate private investment in R&D could include provision for scientists in publicly funded research agencies, such as CSIRO, to share in revenues flowing from their intellectual property.

CSIRO and other Publicly Funded Research Agencies

Recommendation 4
That government reviews the quantum of funding allocated to CSIRO for the next triennium, to capitalise on the multidisciplinary capacity of CSIRO to engage as a coherent partner with the rest of Australia's innovation system.

CSIRO and the other Publicly Funded Research Agencies (PRFAs) represent an important component of Australia's pluralistic system of science and innovation funding and management. The Academy supports this pluralism as an essential element in maintaining the overall robustness of the national science and innovation system.

Furthermore, in the context of priority setting and contestability, the Academy notes that there is considerable contestability in the level of funding made available to PRFAs in the first instance. Each agency applies a high level of internal contestability for the support of research activities, traditionally within the priorities framework established by the agency and, more recently, in response also to the National Research Priorities established by the Government.

As part of that process of contestability, all the agencies undertake regular reviews of research programs and projects on a competitive basis.

The Academy welcomes the removal of the mandatory external earnings target for CSIRO and the other agencies. The Academy acknowledges that there may have been some justification for the initial imposition of the requirement as an incentive for CSIRO to develop closer links with industry. However, the Academy believes that the targets proved to be an inappropriate driver for the development of the more strategic objectives of CSIRO, including the commercialisation of research outputs, and the longer-term strategic collaborative arrangements on which CSIRO is now placing a high priority.

The Academy believes that government should provide sufficient funding for CSIRO to allow it to maintain its core competencies at an internationally competitive level, and to support the long-term strategic research that underpins these competencies.

The Academy also believes that CSIRO should be supported both by government and industry in its aims to achieve a 50 per cent growth over the 5-year period to 2005. However, to the extent that that growth is to be driven by internally imposed earnings targets, the Academy would have the same concerns as were raised in connection with the previous mandatory target.[9] It is important that CSIRO is able to enunciate an independent research-based position on important issues of public policy such as the environment, water usage and salinity, without the risk of being compromised through too heavy a reliance on the financial support of the corporate sector.

Higher Education System

Recommendation 5
That government establishes a Higher Education Funding Council to drive the process of developing a shared vision for Australian higher education, in which government, universities and the private sector work for the common good of Australia.

Australia needs a thriving and vigorous Higher Education System to achieve its aspirations as an innovative nation. Universities play a special role in the knowledge economy through:

- the production of qualified graduates and trained researchers;
- fundamental and applied research to underpin the innovation system;
- technology transfer and other linkages to the wider innovation system;
- the professional development of the workforce.

[9] *Submission to the Review of the External Earnings Targets Policy applying to the Science Authorities (CSIRO, ANSTO and AIMS).* Australian Academy of Science, 18 December 2001. (www.science.org.au/academy/media/earnings.htm)

If a nation's university system is inadequate, it will not succeed in the knowledge economy of the 21st century.

Australia's university system is failing: class sizes are too large for effective teaching, salary levels are too low by national and international standards, making it difficult to attract and retain competent teaching and research staff. Morale is low. There is a clear need to increase student per capita funding to allow universities to meet the increasing requirements being placed upon them.

The Academy welcomes some aspects of the recently announced higher education reform package, while noting that the major benefits again tend to be in the out-years.

The Academy has welcomed the opportunity to provide input to the recent reviews of the Higher Education System.[10, 11] However, it believes that the Government has a responsibility to act promptly to initiate reforms, rather than foster protracted uncertainty through extensive periods of debate. There is too much emphasis on the redistribution of existing funding and on increasing activity as a means to increasing income. Instead, the parlous state of overall funding for the Higher Education System, particularly as it relates to scientific teaching and research, should be addressed.

There is a tendency in government and elsewhere to criticise the university sector for its perceived failure to address the needs of Australian industry. The fact is that universities have made huge changes in the past decade. For example, universities contribute 23 per cent of the resources available to Cooperative Research Centres (CRCs) compared to a contribution of 17 per cent from industry. The research programs of CRCs are strongly focused on research users, including industry.

The Academy believes that government should establish a Higher Education Funding Council to drive the process of developing a 'shared vision' for the role of the higher education sector in the national innovation system. It should also provide a framework for funding individual universities that is somewhat 'arm's length' from government.

The Higher Education Funding Council would form a key element of a pluralistic arrangement involving the existing research councils, ARC and NHMRC, government research agencies such as CSIRO, the Australian National University's Institute of Advanced Studies, and the various medical research institutes. This arrangement would help ensure the relevance of the universities' research activities and research training at postgraduate and postdoctoral levels to the broader research agenda.

Recommendation 6
That government introduces a research assessment process within the framework of the proposed Higher Education Funding Council, to inform the process of allocating research-related funding to universities.

There are some broad policy questions about the current system of higher education research funding formulae. Formula-driven funding will, by definition, work against cooperation, differentiation and specialisation. Formula funding is a recipe for homogeneity and wasteful duplication.

Recent reports[12] show that Australia's share of scientific publications increased markedly over the 1990s, but the relative impact of those publications, as measured by citations, declined and continues to fall behind most other OECD countries. Moreover, the increase in university output has occurred disproportionately in journals of lower impact. Significantly, a similar effect is not seen in the output of other research agencies, such as CSIRO. This outcome appears to be the result, at least in part, of the funding algorithm used as the basis for the calculation of block grants to universities, which relies in part on the total number of publications, without regard to quality.

It is vital that the performance measures driving this unfortunate trend towards low impact publications by university researchers

[10] *Submission to the Higher Education Review*. Australian Academy of Science, 28 June 2002 (www.science.org.au/academy/media/28june02.htm)

[11] *The funding of research and research training in Australian universities: A response to the Commonwealth Department of Education, Science and Training's issues papers.* Australian Academy of Science, 13 September 2002. (www.science.org.au/academy/media/13september02.htm)

[12] *Monitoring Australia's Scientific Research*. L Butler, Australian Academy of Science, October 2000.

be addressed urgently. In a recent report,[13] Narin points out that it is well-established that citation impact is a strong indicator of quality, and thus propensity for innovation and commercialisation. He concludes: 'There is no field in which mediocre research stands much chance of contributing to innovation.'

Current practice has placed an excessive emphasis on competition between universities, based on inadequate criteria, and it has proved to be an inappropriate driver of excellence in research.

The Academy believes that the block funding schemes should be based on formulae that reward quality, outcomes and impact.

The Academy acknowledges that the quality of research and research training are more difficult to evaluate than simple publication counts, and that the relative size of the overall Australian research environment probably precludes the implementation of a process on the scale of the Research Assessment Exercise (RAE), that has been implemented in the UK.[14] However, the Academy has proposed a scheme that corrects the major deficiencies of the current approach,[15] and would establish a more robust and equitable scheme for the distribution of research funding.

In the UK, the RAE has not only improved the quality of research outcomes, but has contributed significantly to public and government awareness of the excellence of its scientific enterprise. A modified RAE would have the added advantage of concentrating excellence in particular institutions, permitting a concentration of resources and research infrastructure to underpin the creation of a critical mass of research capability.

Recommendation 7
That government restores the level of public funding for universities to compensate for the decline in total funding available for teaching and research.

Commonwealth expenditure on higher education, as a percentage of GDP, declined from 0.60 per cent in 1999-2000 to 0.54 per cent in 2002-03.[16]

University funding must increase and must increase in per capita terms. It is also time that future funding is indexed in a way that better reflects the cost drivers that impact upon the sector. It has in the past been sophistry for government to argue that issues such as salary levels and teaching costs in science are issues for universities to handle, when the 'price' that the universities can charge their main client for undergraduate teaching has been fixed by that client—the Australian government. The reforms currently before the Senate that provide universities with some flexibility with respect to student fees are welcome.

Backing Australia's Ability included several welcome initiatives: more places in science and technology, increased infrastructure funds for universities and a postgraduate coursework loans scheme. All pertained to increased university funding but all came with increased compliance costs in application and accountability. The distribution of the science places and their funding, at a marginal cost of $10,000 per Equivalent Full Time Student Unit, hardly appears to be a major investment in an area critical for Australia's development as an innovative society.

The Academy recommends that the government simplifies the multiplicity of small programs in which universities unnecessarily compete for relatively limited resources and instead looks to increase the core undergraduate per capita funding, particularly in science, engineering and technology.

The Academy is concerned at the emerging trend to look further to private sector support for university research. Universities encourage researchers to engage in contract research, but too heavy a reliance on that source of funding can compromise the ability of the

[13] *CHI's Research*, Vol VIII, No. 1, F Narin, July 2000. (www.chiresearch.com/about/newsletter/jul00.php3)

[14] *Evaluating university research: The British research assessment exercise and Australian practice*. P Bourke, ARC/HEC Commissioned Report No. 56, July 1997.

[15] *The funding of research and research training in Australian universities: A response to the Commonwealth Department of Education, Science and Training's issues papers.* Australian Academy of Science, 13 September 2002. (www.science.org.au/academy/media/13september02.htm)

[16] *Key statistics on higher education*. Australian Vice-Chancellors' Committee Resource Analysis, 2002. (www.avcc.edu.au/policies_activities/resource_analysis/key_stats/kstats.htm)

university to maintain an adequate throughput of basic research and research training on which the ability to attract contract research ultimately depends. To look for untied funding from industry to replace government support for basic research is simply unrealistic.

Science and mathematics education and awareness

Recommendation 8
That HECS-exempt scholarships be provided for students commencing science teacher education and a percentage of the HECS debt of science and mathematics teachers forgiven for each year of teaching service.

A strong education sector is vital to creating and sustaining a knowledge-based economy. The primary purpose of school science education is to develop scientifically literate citizens with the skills to make informed decisions on issues of science, technology, the environment and their own health and well-being, as well as to prepare students for science-related careers.

The current level of recruitment of high-ability students into the enabling sciences of physics, chemistry and mathematics at the secondary school level and, as a consequence, at the university level, has fallen to such a low level that it is doubtful that Australia will have the capacity to support the skilled workforce necessary to prosper in an innovative and competitive global environment.

Teachers are the key to change. The best science and mathematics graduates need to be attracted to school teaching and adequately remunerated and resourced. Science teachers pay higher HECS than humanities teachers but do not receive higher salaries. This anomaly may well deter students from entering science teacher education courses, and can at best lead to a further disgruntled cadre of science teachers.

The average age of secondary science teachers is the late forties. A recent study[17] showed that 50 per cent of science teachers would prefer a change of career. There are also disturbing indications that the supply of qualified science and mathematics teachers will not meet future demand.[18]

There is wasteful duplication in the development of resources amongst the various educational jurisdictions. There is also no consistent system to collect accurate national data on the supply and demand of science teachers and the participation of students in upper secondary science courses.

Although school education is primarily a State responsibility, new initiatives could be promoted by the Commonwealth government. For instance, programs could be introduced to attract high-ability students into the enabling sciences at secondary school and, consequently, university.

The Academy welcomes the recent announcement by the Minister for Education, Science and Training of a proposed approach to establish uniform national curricula. A coordinated approach to making science a pervasive part of primary school literacy and numeracy programs could be an exciting place to start.

Major National Research Facilities

Recommendation 9
That the ad hoc nature of the Major National Research Facilities Program be replaced by the inclusion of a one-line budget item in the Science and Technology Budget each year, even if there are competitive rounds on a less-than-annual basis.

There is an ongoing need to maintain internationally competitive infrastructure for R&D.

The Academy welcomed the announcement in the May 2003 budget of an initiative aimed at developing a National Strategy on Research Infrastructure. This initiative will address, *inter alia*, a coordinated approach to high-end research instruments in priority areas of research, and target funds to ensure access to key overseas research instruments. The Academy believes that this initiative addresses a real weakness in policy in this area, because

[17] *The status and quality of teaching and learning of science in Australian schools*. Department of Education, Training and Youth Affairs, 2001.

[18] *Demand and supply of primary and secondary school teachers in Australia*. Ministerial Council on Education, Employment, Training and Youth Affairs, 2003. (www.curriculum.edu.au/mctyapdf/demand/demand.pdf)

investment in infrastructure is not tied directly to national competitive grants.

The Academy believes that Australian policy makers have little information on the nature and extent of unmet demand for research infrastructure funding. To address this issue, the Academy has released an issues paper[19] which includes a study of the Major National Research Facilities (MNRFs) established in the 2001 selection round, as well as the current status of the activities of groups whose proposals were unsuccessful in that round

Of the 70 unsuccessful groups, 44 have continued to maintain some level of operation, and have raised a total of $113.8 million in funding from their participating organisations. The fact that these groups have been so tenacious in pursuing their objectives is compelling evidence of the merit of their research infrastructure requirements, estimated at $300 million in government-sourced funding.

The States and Territories, together with overseas agencies and international organisations, are in a position to make substantial contributions to MNRF and larger-scale research facility funding. As exemplified by the 2001 selection round, the uncertainties created by the ad hoc nature of the timing of any selection round, the tight time-frame for the preparation of bids, and the lack of any coordination between the Commonwealth and State processes restrict the potential for achieving such leverage.

The Academy's issues paper makes a number of recommendations addressing the requirements for an effective MNRF Program, including:

- a more strategic approach to the planning of MNRF requirements and the selection process should be coordinated by the Office of the Chief Scientist;
- the Commonwealth government should remove any uncertainty by establishing the MNRF Program as an ongoing commitment, identified as a line item in the budget, with a rolling investment fund to allow for funding to be provided for new facilities every 3 years;
- the development of a protocol for partnership funding of MNRFs between the Commonwealth and the States, or by international bodies;
- ensure continuing access to major overseas research facilities, such as the Hubble Space Telescope and the Ocean Drilling Platform;
- ARC and NHMRC research applications should include provision for funding for researcher use of MNRFs, to avoid ineffective duplication of infrastructure.

[19] *Australia's Major National Research Facilities: Issues to consider for the next phase of Backing Australia's Ability*. Australian Academy of Science, July 2003. (www.science.org.au/academy/media/23july03.pdf)

Cooperative Research Centres

Recommendation 10
That government works to maintain bipartisan support not only for the Cooperative Research Centre Program, but also for education, research and innovation more broadly.

Cooperative Research Centres (CRCs) have emerged as a powerful force in the overall pluralistic framework of support for science and innovation in Australia.

CRCs have been able to establish a wide range of valuable international links with universities, research institutes and industry. They have provided many opportunities for their postgraduate students to participate in international conferences and visit laboratories. CRCs have also been able to provide for their researchers an enhanced level of interaction between public and private sector organisations, defence and civilian sectors, and national and overseas organisations, along the lines of the European Union Mobility and Training Program (albeit on a smaller scale).

The CRCs appear to have more flexibility in the allocation of their resources than universities. They have been able to support more overseas visits by their students and early career researchers. There is scope, however, for the CRCs to selectively train more overseas graduate students.

The CRC Program has set an international benchmark for collaborative R&D between industry, universities and government research organisations. Research funded through the program flows through to commercialisation and wealth generation.

Government should adjust the guidelines to ensure that centres are set up in emerging

industries and that better ways are found to involve small and medium enterprises, even at the expense of lowered expectations of the leverage on funding that can be achieved. It should provide more funding to assist processes of commercialisation.

An emerging problem with the establishment of CRCs is the limitation on the flexibility of participating universities, as well as the research agencies, to contribute the cash and in-kind resources necessary to maximise the benefits to be achieved from the collaborative arrangements embodied in the CRC. This problem is a manifestation of the issue of the overall level of discretionary funding available to universities as addressed under *Recommendation* 7.

Government should limit its expectations on the leverage of CRC Program funds to be obtained, particularly from users and industry. After rising strongly over the first few years of the program, the level of industry funding has tended to plateau, representing an equilibrium between the capacity of industry to support longer-term strategic research, and its expectations of short-term problem solving research by a CRC. There are some activities within CRCs, particularly in the areas of basic research and education and training, that industry simply does not see as its role to support.

Recommendation 11
The Academy proposes a model for enhanced collaboration in the Australian innovation system via a competitive Collaborative Fellowship scheme involving universities, Publicly Funded Research Agencies and industry, to be administered by the Joint Academies.

The Academy has long been supportive of the role of PFRAs in contributing widely to research training at postdoctoral level. We welcome the new initiatives within PFRAs that aim to provide greater focus on partnerships with universities and other research providers.

The Academy believes that a scheme is needed to expand this interaction between research providers to include industry. This would provide researchers with the opportunity to work outside the Higher Education System, on projects that could be at any stage from fundamental science to industrial innovation.

The Academy proposes[20] that a new Collaborative Fellowship scheme be made available to the Joint Academies Fellowships Committee for allocation, and administered by the Academy of Science. The scheme would be similar to one operated in the UK by the Royal Society. Candidates would normally hold a substantive post in a university or similar academic institution, at an early-career stage, or be employed as a scientist, mathematician or engineer in industry or a PFRA. The Academy's proposal also allows for the possibility of a fellowship award to new postgraduates. Fellows would be placed in a research institution or industrial company, for up to 3 years in the first instance.

The roles of State and Commonwealth governments

Recommendation 12
That government retains the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) and upgrades the Commonwealth, States and Territories Advisory Council on Innovation.

The Academy welcomes the strong positive role that PMSEIC has played in the development of the national agenda in science and innovation over the last several years, and urges the Government to maintain and strengthen that function even further.

Similarly, the Academy welcomes the active role played by the Chief Scientist in the number of reviews and consultative activities with which he has been involved over the last few years. The Academy urges the Government to expand the coordinating role of Chief Scientist, for instance in guiding the process of the identification of major research infrastructure requirements, as discussed under *Recommendation 8*.

Now that the States have a greatly increased capacity for direct investment in R&D initiatives, there is the potential for fragmentation and duplication, and counter-productive competition. Federal leadership and leveraging, as well as streamlined

[20] *Review of Closer Collaboration between Universities and Major Publicly Funded Research Agencies.* Australian Academy of Science, A submission to the Department of Education, Science and Training, 17 August 2003. (www.science.org.au/academy/media/27august03.htm)

administrative processes, are needed to avoid fragmentation.

Because State priorities in R&D will differ, and formulating whole-of-government approaches takes time, new Commonwealth government initiatives should be flagged well in advance to ensure that States can play to their strengths.

CSIRO, with its national remit, has a critical role to play in the linking of State government needs and activities into regional and national collaborations and programs. There are opportunities for CSIRO to link more closely with State government-funded research providers. It has, like the Commonwealth, a critical role in facilitating inter-State initiatives around such major projects as salinity, greenhouse, biodiversity, energy and sustainability.

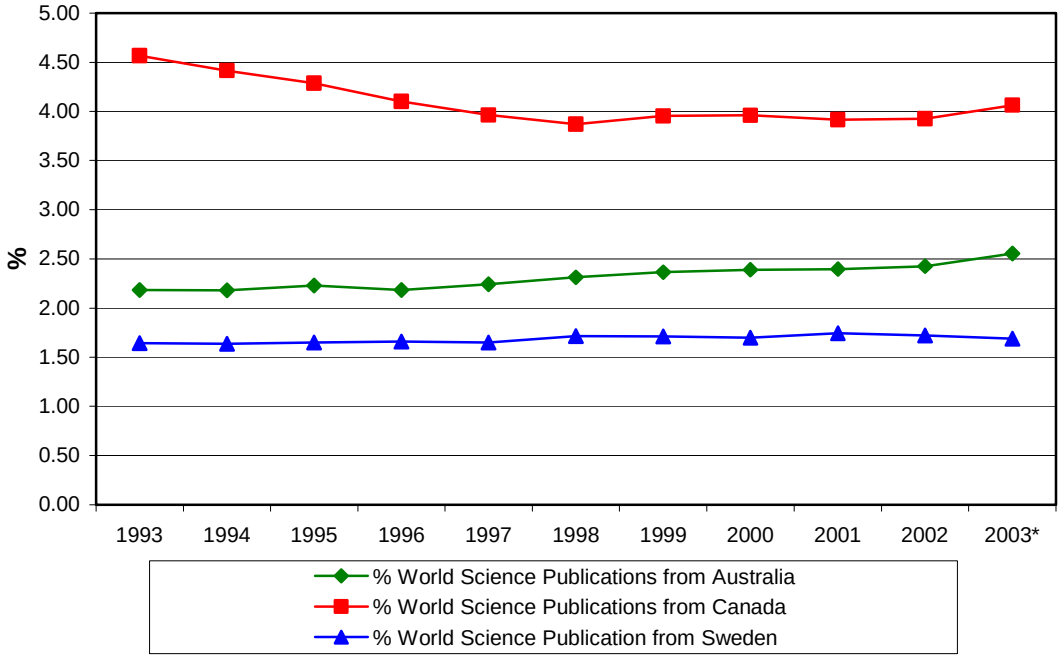
An advisory group that embraces science and territory stakeholders in the States becomes important. The current Commonwealth, States and Territories Advisory Council on Innovation could be upgraded to facilitate two-way traffic in science and technology activities and policy between the States and the Commonwealth.

The international dimension

Recommendation 13
That government ensures that Australia retains a creative scientific community capable of pursuing internationally significant science, and makes specific provision for the maintenance of international linkages with Australian research and researchers.

The establishment of the National Research Priorities provides a natural focus for the maintenance of internationally significant science. Part of the process of assessment of programs contributing to those priorities must be the international significance of the science, which is a very important indicator of the intrinsic quality of the research.

It is often asserted that Australia outperforms the rest of the world in scientific research on a *per capita* or similar basis for comparison. There are several positive indicators of the strength of involvement of Australian science in the global scene. For instance, one-third of Australian scientific publications have at least one overseas co-author. Australia accounts for about 2.5 per cent of the world's scientific publications, a figure significantly greater than might be expected on the basis of comparison of levels of expenditure on R&D.



*as at 31.07.03

However, simple statistics can be misleading, as can be seen when we compare the scientific publication output for Sweden, Australia and Canada, countries with populations of close to 10 million, 20 million and 30 million respectively. Sweden and Canada were selected as examples of countries that are often seen as models for comparisons with Australia's innovation performance. The graph shows that Australia's publication rate is below the level expected on the basis of the ratios of the populations of the respective countries, and that this has been the case for many years.

There are some other very worrying indicators. As discussed under *Recommendation 6,* the significance of the number of scientific publications emanating from Australia is weakened by the fact that an increasing number are published in 'low-impact' journals, and thus their significance is diminished in terms of a broader innovation capability.

Australia under-performs in world terms in a number of specific important disciplines, particularly in ICT related areas, as discussed under *Recommendation 1*.

Whatever the precise level of Australia's contribution to the global R&D effort, the fact remains that Australian researchers must maintain their access to the 98 per cent or so of that effort that is performed overseas. This outcome can be achieved through a number of channels.
As discussed above, the quantum of resources available in the Australian R&D environment must be adequate to support world-class research, an essential pre-requisite for establishing international collaborative links.

A test of the international recognition of the standing of Australian research is the willingness of overseas scientists to spend time in Australian laboratories. The Academy welcomes the Government's recent announcement of funding to assist graduate students from the USA to work in Australian laboratories.

There must be sufficient flexibility in the system to allow Australian scientists to work in overseas laboratories on sabbatical or similar arrangements. The Academy also welcomes the Government's recent announcement of the Young Australian Researchers Programme, which provides funding to assist Australian graduate students to work in Europe and the USA.

Healthy international linkages are essential for an innovative society so that it has early warning of emerging technologies and is alert to opportunities. Resources must be available for Australian scientists to participate in overseas meetings, conferences and workshops. The Academy's role as coordinator of the linkages with the international network of scientific academies and international scientific committees must be supported.

One critical aspect of the requirement to develop overseas linkages is the need for Australian scientists to gain access to major overseas research facilities. The Major National Research Facilities Program has supported access to the synchrotron radiation sources at Tsukuba in Japan and Argonne in the USA. Access to other facilities such as the Hubble Space Telescope and the Ocean Drilling Program have relied on Australian scientists competing on merit, and using whatever resources they can access from within the Australian system to fund their participation. Support for access to these and other facilities should be supported on an ongoing and systematic basis.

Abbreviations

AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ARC	Australian Research Council
'BIRD'	business investment in research and development
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
GDP	gross domestic product
GERD	gross expenditure on research and development
HECS	Higher Education Contribution Scheme
ICT	information and communications technology
MNRF	Major National Research Facility
NHMRC	National Health and Medical Research Council
OECD	Organisation for Economic Cooperation and Development
PFRA	Publicly Funded Research Agency
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
R&D	research and development
RAE	Research Assessment Exercise