# *Australian Academy of Science*

November 1999

## Submission to the Chief Scientist's review of the Australian science, technology and engineering base


## Summary

An important element of any nation's innovation system is the basic research performed, for the most part, by its universities and research institutes with public funding. This submission is concerned with maintaining and improving the capacity of our research base to contribute to a higher rate of innovation in Australia.

Since the establishment of the Unified National System of universities there has developed a policy vacuum, as a result of which both research and teaching in science have been placed under stresses that will reduce the productivity of our research base unless they are attended to. In the second section of this submission we propose policies that will improve the situation significantly. These include measures for better allocating public resources for science research and teaching, boosting industry-critical areas of research and nurturing young research talent.

We also characterise the science base and identify other particular aspects that need urgent attention, including infrastructure, international networks, and adequate funding.

Finally, we note that government support for the research base, and for the development of links between it and its users, must continue over a long time-scale reflecting the time taken for the knowledge and skills produced by basic research to become available for private and public use.


## Introduction

1. Australia's present innovations are largely based on past achievements of the science base, and future innovations will be based on present achievements and investment. In recent years, funding for the major component of the science base, research in our universities, has fallen behind what is needed to maintain standards in the long term. There has developed an alarming policy vacuum and clear policies are needed now to allow our science base to adapt without a serious loss of our national capacity to innovate.

**Cost Benefits**

2. This submission is concerned mainly with the basic research component of the science base as it has been defined in this review. The Academy has commented elsewhere on the need to stimulate industrial R&D.[i,ii] It is nevertheless not out of place to signal just three examples of clear large scale benefit to the Nation that have come from past investment through Australia's Universities and the CSIRO. These examples are given in Attachment I and are:

    - Development of the drug "Relenza" using basic knowledge from the CSIRO and Australian National University
    - Development of the Australian Photonics CRC and its spin off companies from basic knowledge at Sydney University and other Universities
    - Development of the SHRIMP microprobe mineral analyser using basic knowledge from the Australian National University

The current and expected benefit from such developments as these are large, the lessons they provide about Australia's need to improve "industry pull" from the science base and the time scales for innovation – are salutary.

## Policy for the science base

3. *To address the "policy vacuum" mentioned above and the problems outlined in the following sections we need to maintain a strong internationally-competitive science base* by

- ensuring that in the Unified National System of Higher Education structures develop to reward high quality teaching in science
- increasing funding, including infrastructure funding, to the most gifted and able researchers to ensure our most talented researchers can return to work here and
- ensuring a sufficient concentration of effort for the performance of high quality internationally-competitive research. This requires

    a. allocation of higher education block funding by quantitative indicators of the quality of research outputs through a Research Assessment Exercise Attachment II)

    b. bench-marking of funding for high quality university research by best international standards.

4. *We need to develop better methodology for the allocation of public resources between the disciplines* in the science base and in research generally. In the UNS the distribution of funds between the major disciplines has to an unhealthy degree become fixed in historical ratios. We recommend the use of a

research assessment exercise as a basis for future resource allocation.

5. To counteract part of the damage done to the research base since the introduction of the Unified National System, we should *define and boost support for industry-critical areas of research and teaching* that have suffered loss of funds through student-driven formulae, or have failed to reach critical mass.

6. *We must nurture young talent* by providing on a competitive basis adequate resources to the ablest junior academic staff at the start of their careers. In particular we should provide much better opportunities for post-doctoral training in overseas laboratories to establish new international networks and promote future successful international collaborations.[iii]

7. To create a demand-pull from industry, *we should set a target growth rate and a steady-state target for industrial R&D*, bench-marked to appropriate overseas comparators, and provide incentives to ensure that target is reached.

## What is the science base?

8. It is first necessary to define the meaning of "science base". We take it to be the base of activity in Australia for the production of new scientific and technological knowledge of international quality.

9. In Australia the key components of the science base are research in the universities, the research institutes, special research centres and a significant component of the work of CSIRO, ANSTO, AIMS and DSTO.

10. A key role of the science base is to produce broad ranging "public good" understanding of fundamental matters underpinning health, the environment, and our natural resources.

11. This work is often called "blue sky" research and is largely done in universities. A key question is how much of this work should be done and how this may be decided. This question needs to be addressed in terms of the social and economic purposes basic research serves. One useful summary is that the science base:

    - Contributes to the growth and dissemination of knowledge
    - Provides research training for those entering public and private research
    - makes useful inventions
    - evaluates and exploits the research bases of other countries
    - supports innovation in industry and policy development in government
    - helps inform public opinion

12. Put another way, the science base is a key component of the way in which the country develops and manages its knowledge assets for use in government, industry and the community generally.

13. How well the science base achieves each of these objectives requires a separate evaluation. Many of the human, financial and organisational ingredients for a flourishing science base are the same in whichever way that base is employed. The linkages to end uses differ.

## What does the science base need?

14. Published Australian research accounts for about 2% of the world's total. Effective international links are essential to provide access to the leading edge of world research and technology. Conducting high quality, internationally recognised research in Australia provides the entry ticket into the world community of researchers and develops the capacity to filter research produced abroad. International collaboration in research is also recognised as important for the visibility of Australian research.[iii]

    A high quality science base needs:

    - talented researchers
    - an adequate and up-to-date research infrastructure
    - adequate and targeted funding
    - good linkages to the best science overseas
    - effective linkage to local users of knowledge and expertise
    - consistent support over a long time-scale

### *Talented researchers*

15 The recruitment and retention of talented researchers are essential for the establishment and maintenance of research groups of high quality as benchmarked against world standards and performance. Employment conditions should be comparable to those in the USA and Europe since "low rewards in academia are driving quality staff to other fields of work or universities overseas" (Kemp). An issue for Australia is the proportion of researchers in tenured positions, compared with those on five-year renewable contracts or fixed-term appointments. Not everyone retains their research effectiveness for their whole working life, but in the universities the teaching, research and administrative loads can be varied.

**Nurturing young talent in universities as well as in public research agencies is very important for the future health of the science base.**

***Research infrastructure***

16. Figure 1 shows the change in Higher Education funding (including HECS) from 1990 to 2000. A key problem in the university system is the unrealistic expectation that adequate research funding and research infrastructure will be available across all sections of higher education teaching. Particularly in some of the more expensive scientific disciplines research resources should be concentrated in fewer established institutions. Some key parameters are given in attachment III. While the funding base has grown, this is largely the consequence of student numbers and HECS and salary cuts.

17. Overall, from 1986 to 1996, the tertiary student growth was at a compounded rate of 4.4% per annum, the post-graduate rate was at a compounded rate of 5% per annum. In that period science PhD completions doubled from 2,100 to 4,700. An analysis of Attachment III shows the very great increase in the higher degree – coursework proportion of second graduations and the continued increase to 1998 of the higher degree by research completions. However from 1996 to 1998 there has been a 12% drop in the numbers of science (teaching and research only) staff (ie from 6357 to 5563).

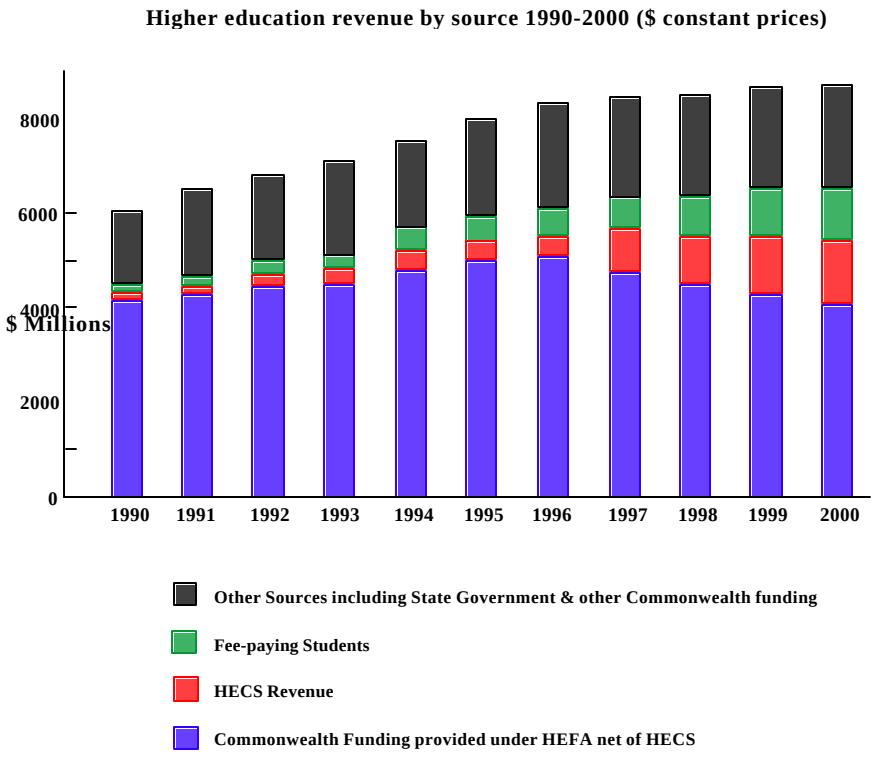


*Figure 1: Higher education revenue by source 1990-2000 (DEETYA Higher Education Budget Statement, 1998)*

However, Attachment IV shows that the proportional growth in science and engineering was smaller than in other disciplines. The current level of university research infrastructure funding if it continues to be applied with present mechanisms of distribution and salary funding is that the escalating

deterioration, so apparent since 1996-1998, in libraries, scientific and technical personnel as well as major infrastructure will get worse. For example, in the three years from 1996 to 1998:

- the average price per serial title increased by 60%
- serial subscriptions in science, technology and medicine decreased by 60%
- the number of serial titles decreased by 56%, and
- expenditure on serials declined by 30%.

18. World-class scientific research in the year 2000 will not be possible with the 1996 equipment and support. Australia must reinvest in new research technology, database and library access systems as well as recreating a technical support base.

19. In our comment on the recent Green Paper on higher education research we proposed that competitive research grants should be accompanied by an infrastructure component at 60% of the value of the research grant.

***A model for support of university research***

20. The Academy of Science strongly supports a dual system of university funding with
    - a system of peer assessment of researchers and research projects, and
    - research block grants distributed according to the quality of research outcomes informed by a broad scale of indicators.

21. To enhance "differentiation" in the present Unified National System, recognition of excellence in teaching as well as research is needed and provision for maintaining research capacity (although not necessarily PhD programs) in smaller institutions must be recognised. New strategies for these matters are needed.

    ♦One model for increased diversity is for smaller universities to follow the American four year liberal arts college model for some of their subject areas. A prime focus would be on excellent teaching and research but without a PhD program. PhD students would benefit from working with their peers in this situation and being subject to competitive selection for entry.[iv]

22. The Academy believes that the most gifted and able people should have adequate resources to enable them to perform research that is of high quality and significant in the international context. As the UK Research Assessment Exercise has show, this quality is not necessarily coupled to institutional size where quality indicators are set broadly.

    **We recommend that the allocation of funds for both research recurrent expenditure and infrastructure be subject to a competent Research Assessment Exercise, based on a broad range of indicators (<u>Attachment II</u>), coupled with a significant increase in the quantum of funds made available over a period of years.**

### *Adequate and pluralistic funding*

23. The Academy of Science supports the continuation of a plurality of funding sources for research in universities while emphasising processes of peer assessment of research proposals and evaluation of performance and outcomes. The present success rate of about 20% for applications for research grants from the large grant scheme of the Australian Research Council (ARC) is putting enormous pressure on the selection process and denying opportunities for many talented researchers. In actual dollar terms (at constant prices) the total level of funding in the higher education sector increased across all fields over the period 1984-1992.

24. Across the period 1991-1996, there was little change in the total research expenditure per research scientist and engineer, indicating no change in the intensity of funding despite the enlarged sector as a result of the "Dawkins reforms". No account has been taken, however, of the significant escalation in the costs of performing top quality internationally competitive research in many areas of science during the same period.

25. Important elements in the strength and reputation of Australia's science base are centres of research excellence, such as the ARC Special Research Centres, medical research Institutes and the Research Schools and Centres of the Institute of Advanced Studies of the Australian National University. Such centres bring together a diversity of skills and a sufficient number of researchers and state-of-the-art equipment to tackle difficult research topics and mount long-term research programs in an internationally competitive way.

26. The 1995 Review of the Institute of Advanced Studies of the ANU, commissioned jointly by the ARC and ANU, provide ample evidence of the high standing of research in the Institute of Advanced Studies. The Review demonstrated the important contributions to knowledge, and the science base in Australia, made by researchers at the Institute. The following quote is from the review report of the Institute as a whole.

> "The Institute has acted as a magnet for talent. Its social, cultural and scientific environment has been such as to attract scholars of the highest calibre from all over Australia and indeed from all over the world. As a result the IAS is now a world player in every field in which it has well-established scholarly and research activity."

### *The importance of international networks in research*

27. Overseas experience particularly at the post-doctoral level, or for PhD training, is an important way in establishing and maintaining networks. The proportion of academics in Australian universities who obtained their first degree in Australia and their PhD overseas has decreased from 21.5% in 1970 to 11.7%

in 1994 (a decrease of 45%). Although it is difficult to obtain reliable statistics on post-doctoral training overseas by Australian graduates, the opportunities have declined because sources of adequate overseas funding are more difficult to obtain. There are very few funding schemes in Australia to support overseas postdoctoral experience.[v]

28. Another key linkage method is through Australia's participation in Major National and International Research facilities. Australia cannot expect to afford all of the "cutting edge" facilities it needs for the research base but it does have, and will have unique facilities to share and trade regionally and globally. The Academy has a working group and consultancy developing policy in concert with the Co-ordination Committee on Science and Technology (CCST) in this area. The important human development aspect of creating networks to share national and international facilities has recently been emphasised by the CCST.[vi]

> "The emergence of a global economy raises challenges for Australia if it is to exploit to the full and build on its competitive advantage in particular areas of innovation. Foremost among these is its capacity to link into international innovation networks via local networks involving business, science and technology that have the necessary scale and access to knowledge and skills capabilities that will attract foreign investment."

29. A recent survey of Australian scientists working abroad who intended to remain abroad, showed that they were most concerned about losing research resources and contact with their colleagues. (Attachment V)

**30. The Academy of Science believes that the lack of post-doctoral fellowships for training overseas is an important policy issue which has a bearing on future successful international collaborations. If current funding provision continues, the involvement of Australian researchers in international collaborations is likely to decrease, relative to the increase in international collaborations and the growth of new national players in scientific research. Funds for this purpose need to be allocated competitively to ensure that only high quality researchers are supported.**

***Linkages between the science base and users***

31. How does industry use the science base? The work of Pavitt[vii] has shown that innovating companies make intensive use of basic research (as measured in the knowledge sources of patents, for example) but do so largely by tapping directly into the expertise available in the researchers themselves. For industry, solving complex problems requires access to the people who have the latest knowledge, skills and technologies across a wide range of disciplines. Published knowledge is of secondary importance to industry.

32. The effective management of the knowledge assets of the science base requires a stronger R&D effort in the private sector and the establishment of stronger links between universities, government research agencies and

industry. *It is important not to put at risk the performance of the science base in universities and government research agencies by a confusion of research roles.* The public sector should not be coerced into doing research that is much better performed in the private sector because of its closeness to, and understanding of markets. Nevertheless, public sector scientists do need carrots, such as those provided by the CRC scheme and SPIRT grants, and in promotions, pay and conditions, to develop useful interactions with industry, especially when linkages contribute to the growth of knowledge.

33. It is important to recognise two distinct forms of science base-industry linkage. Innovation driven by new knowledge produced by the science base is often seen in pharmaceuticals, less often in other industries. Examples are given in Attachment I. More common is the kind of business use of the science base documented by Keith Pavitt, involving sophisticated research users in business who gain access to world-best knowledge, skills and equipment through long-term and intense relationships with researchers.

34. The Academy of Science strongly supports the Cooperative Research Centres Program which is proving very successful in drawing together researchers from universities, government research agencies and industry and strengthening links with the users of research. Another objective of the scheme is a concentration of research resources for leading edge research in areas of national importance.[viii]

35. There is a pressing need to address the low priority given by most managers in industry to technological innovation, so that a more adequate "industry pull" is created.

***Consistent support***

36. Governments fund a large proportion of the research conducted in universities in most nations. For example, in 10 out of 14 countries of the OECD public money accounts for more than 80% of all funds going to university departments for research (Pavitt, 1996). The private sector, particularly in small and middle-size economies, is reluctant to fund long-term, blue-sky research and even strategic basic research because of the high risk and the inability of a company to appropriate the benefits of the research for competitive advantage.

37. In Australia, a substantial proportion of CSIRO's strategic basic research is long-term and high-risk and much of it is broadly applicable to a range of private sector activities. Research in areas of community interest such as the environment and public health is of increasing importance and clearly the responsibility of government.

## Endnotes

[i] Australian Academy of Science (1999). *Submission to the Review of Business Taxation,* AAS, Canberra.

[ii] Anderson, B.D.O. (1999). *Does the knowledge base of today serve knowledge – the industry of tomorrow?* Business / Higher Education Round Table News (issue 5) June.

[iii] Australian Academy of Science (1996). *The impact of Australian science: a discussion paper*. AAS, Canberra.

[iv] Australian Academy of Science (1997). *Submission to the Review of Higher Education Financing and Policy - West Review.* AAS, Canberra.

[v] ibid (1999) Australian Academy of Science, *International Networks.*

[vi] Co-ordination Committee on Science and Technology. (1999) *Interactions between universities and industry*

[vii] Pavitt, K. (1996). *Road to ruin.* New Scientist 3 August.

Pavitt, K. (1997). *Do patents reflect the useful research output of universities?* Science Policy Research Unit, University of Sussex.

[viii] Australian Academy of Science (1997). *Submission to the Review of approaches to greater commercialisation and self-funding in the Cooperative Research Centre (CRC) Program.* AAS, Canberra.