THE AUSTRALIAN NATIONAL UNIVERSITY

THE GRADUATE SCHOOL

IS THERE LIFE AFTER A PHD?

Proceedings from a symposium presented by
The Graduate School

Occasional Paper GS 97/1

Is there life after a PhD?

Foreword

The flippant title conceals a real and serious question. How does one go about building a career after completing a PhD? The larger context includes the motivation for doing a PhD in the first place and the various market places which might employ PhD graduates and their needs. Most students undertake PhDs after successful undergraduate careers that awaken their interests in a particular subject and a desire to penetrate more deeply into it. The implicit expectation is usually a career in research and/or teaching in a university. The rewards and the style that can be expected of a life in the academy have, however, changed greatly over the last two or three decades.

The impetus for arranging the symposium was our increasing concern that students undertaking PhD studies are not sufficiently aware of the shrinking job opportunities and intense competition now endemic in the traditional arena and, conversely, of the potential of other less often considered avenues providing for rewarding careers.

There is plenty of hard, as well as anecdotal, evidence for the first proposition. For example a recent *Nature* (vol. 383, p195, 1996) review of an American study reports that it found that fewer than half of PhDs in academic institutions hold tenure track positions. In the light of this finding, the US National Academy of Sciences recommends that young scientists 'approach their careers with a broad view, with the well-developed set of professional survival skills that today's job market requires'. Good advice surely. But what are these skills and how do you acquire them?

It occurred to us that a good way to explore this question and to illustrate the wider horizons that PhD graduates, and, better, intending PhD candidates, should be scanning, would be to enlist as speakers in a symposium people who had successfully deployed a PhD degree as a spring- board to develop careers outside the conventional sphere. To our surprise there are many such individuals and, more gratifyingly, these outstanding Australians when approached were generous in agreeing to participate in our symposium. As may be judged from the accounts collected here, the presentations were interesting, pertinent and often provocative. We are grateful to the participants for their time, their enthusiasm and for agreeing to provide the written scripts which form the basis of this publication. It was evident from the capacity audience throughout the day and the lively discussion following each talk, that students in the Graduate School do feel the need for creative and practical career advice. It seemed to us well worthwhile to make the proceedings available for continuing reference as a Graduate School Occasional Paper.

For this first symposium we decided to focus on PhDs in science and engineering. Clearly, a good deal that was said was relevant to other disciplines too. Still, we hope in future to broaden the scope of related symposia to include, explicitly, career options for PhDs in the social sciences, humanities and other areas. We hope that Symposia like 'Is There Life after a PhD?' will form a nice complement to the Induction Program-- 'How to Manage Your Research Degree'--offered by the Graduate School, whose emphasis is on giving students good advice on how to equip themselves for a successful career.

The proceedings of this first symposium are a first step in guiding students towards thinking more broadly and examining their skills, strengths and weaknesses and long term aims for their careers. The input that professionals from outside the University can provide should give students the widest possible perspective on the possibilities open to them and how to prepare themselves most effectively for jobs they want. Cohorts of students armed with good PhDs entering business, the public service, government, the media and other professions as well as providing our postgraduates with fulfilling careers would make Australia a truly clever country.

G.A.Craswell (Academic Skills Advisor to Graduate Students

P.D.Jeffrey (Convenor of the Graduate Program in Medical Science

R.H.Spear (Dean of the Graduate School)

Contents

Career Options for Graduates

Professor Sue Serjeantson
Director
Institute of Advanced Studies and Deputy Vice-Chancellor
The Australian National University

They did not care
To travel in
Chartered waters
They preferred
To make the charts themselves

In Germany, conditions for setting up new businesses are bad. This is because of a low-risk mentality in German society. There is a lack of venture capital and banks are cautious about funding new companies. Germany's research minister, Jürgen Ratters, says it is easier in Germany to raise capital on your grandmother's house than on a brilliant idea![1] Does this sound familiar? Until recently, companies could only be listed on the German stock exchange if they were well-established and showed a minimum of three years' profit. This explains, in part, why there are less than 100 biotechnology companies in Germany compared with about 1,300 in the United States[2].

Like Germany, Australia is dominated by a low-risk mentality when it comes to job security, security of home-ownership and security of investments. But I'm going to ask you a question. Please raise your hand if you backed a horse in a Melbourne Cup sweep last week. This is wonderful! You see from the raised hands that unlike Germany, Australia is a gambling nation. And Australian PhD students have another important quality, besides being gamblers: you are experienced in independent research and this gives you the confidence to compete in the global market place.

My talk today urges you to reject the low-risk mentality of Australian society. PhD graduates have a diversity of opportunity never seen before, but as I shall explain, this means taking a more entrepreneurial approach to your career than you may ever have expected.

Let us look at the job destinations of previous ANU PhD graduates (**Table 1**). There are 3,563 ANU PhD members of the Convocation. In 1994 we collated destination data for a sample of about 1,300 graduates. Exactly 40% went overseas, the majority (70%) to academic positions. Others going overseas went to alternative public sector research agencies (14%) or into public service (4%). Only 7% of those going overseas went into industry. The proportion of ANU PhD graduates going overseas, at 40%, is double the national average figure of 20% published by the Graduate Careers Council of Australia[3]. The Graduate Careers Council reports that 2/3 of those going overseas are overseas residents returning to their home country[4]. For ANU, 45% of men PhD graduates and 35% of women graduates go overseas. You should know that the ANU has an outstanding reputation internationally and this gives you a head-start against other universities in Australia and elsewhere.

Destination	Australia	%	Overseas	%	Total	%
Academic	444	57.6	351	69.8	795	62.4

---

[1] Steiger, G. Germans learn to bet on biotech. Nature 383, 744, 1996

[2] Steiger, G. Germans learn to bet on biotech. Nature 383, 744, 1996

[3] Graduate Careers Council of Australia

[4] Graduate Careers Council of Australia

Research (government agency)	52	6.7	25	5.0	77	6.0
Research (government institute)	87	11.3	46	9.1	133	10.4
Research industry	27	3.5	23	4.6	50	3.9
Industry	15	1.9	13	2.6	28	2.2
Public Service	102	13.2	18	3.6	120	9.4
Self-employed	19	2.5	7	1.4	26	2.0
Other	25	3.2	20	4.0	45	3.5
Total	**771**	**100**	**503**	**100**	**1274**	**100**

Table 1. Destination of ANU PhD Graduates (as at 1994)

What has been the traditional job destination for the 60% of our graduates remaining in Australia? Again, academic positions are keenly sought, attracting 58% of our graduates, as shown in Table 1. Those in teaching and research positions slightly outnumber those in research-only positions. Another 18% are in government research agencies and 13% are in the public service. Only 5% were placed in industry, whether in research or in other positions, and only 2.5% were self-employed. The relatively small uptake of PhDs by Australian industry is reflected also in the survey of 1994 graduates by the Graduate Careers Council of Australia[5]. In this survey, 11% of men and 8% of women were placed in industry.

The retrospective analysis shows that ANU PhD graduates have a strong tradition of employment in higher education or in public sector research agencies, such as CSIRO, whether they stay at home or go overseas. It is this tradition that has stimulated today's forum and possibly stimulated your attendance here. At the very time when there is contraction of job opportunities in the public sector, including universities, government research agencies and the public service, there is an explosion in the numbers of graduating PhD students.

In 1983, just under 3,000 (2,954) students *commenced* a higher degree by research in Australia. In 10 years this number had grown more than three-fold. In 1993 more than 10,000 (10,235) students *commenced* a higher degree by research[6]. Although these figures do include masters by research students, many of these students will convert their enrolments to a PhD. Can this growth in PhD student numbers be accounted for by growth in overseas students numbers? In 1993 there were 28,000 students on course (higher degree by research) of whom 4,000 were from overseas[7]. That leaves 24,000 Australian students on course for higher degrees by research. Figures for 1996 are not yet available, but certainly exceed 25,000.

Each year, the ARC awards 100 research fellowships. Of these, 50 have been for PDFs although in 1996, the number was increased to 55. The ANU always does well in the annual competition, in 1996 capturing 22 of the 100 fellowships. The next most successful institution was the University of Sydney, with 12. But in 1996, there were more than 860 applicants for these fellowships. How then can our new graduates achieve their potential and make the contribution to the nation that they are well-trained to make? Is the nation about to lose a critical opportunity, as a potential player of future

[5] Graduate Careers Council of Australia

[6] Selected Higher Education Statistics, 1993, AGPS Canberra, 1994

[7] Selected Higher Education Statistics, 1993, AGPS Canberra, 1994

knowledge-based economies, when it is ill-prepared to capitalise on such a precious resource? In the short-term, the nation may well lose out, as it struggles to adjust employment opportunities so that they are in line with a talented and well-trained potential workforce. There is a desperate lack of government policy in this area, a matter to which I shall return.

What is of more interest to you, I am sure, is information about job opportunities and areas of employment growth. Whatever your specific training, with some adaptability and flexibility, you may be well-placed to exploit those areas of growth.

The two great areas of growth are in information technology and in biotechnology as the world ventures into a revolution in these technologies. In the US the numbers employed in entrepreneurial US biotechnology companies grew from 40,000 to 108,000 between 1986 and 1996, and numbers could increase to 250,000 by the year 2000.[8] In Europe the private biotechnology sector has a growth rate of about 20%. Even here, I must caution that the competition is keen, because there are many countries, in South America, South India and parts of Europe such as Italy and Spain, which are exporting PhD graduates. Recently Glaxo Wellcome advertised for 35 new recruits in the UK and received 2,139 applications.[9] Those who are participating in the biotechnology revolution are not only those trained in the life sciences. There is a critical need for computational biologists, who could have backgrounds in physics, engineering, or computing science, or in modelling of data or in manipulation of large data bases. For instance, one biotechnology company in Maryland, called Human Genome Sciences, has recruited almost exclusively from the defence industry[10] to find people experienced in handling and analysing large data sets. One might have obtained such experience in social sciences, in economics, in financial mathematics and in many other fields. Doors are opening in the area of bioinformatics, where a multidisciplinary philosophy is developing.

The second revolution is in information sciences, where, once again, skills ranging from social sciences to engineering are in demand in the area of multimedia research and in integrative networks. Australia is not well-placed to compete internationally with start-up companies in this area. Our R&D tax concession has dropped to 125%, whereas in the area of information technology, Singapore and Malaysia are offering 200% R&D tax concession in IT. This emphasises the need for our graduates to be alert to the dynamics of the international marketplace in employment opportunities.

You will hear from other speakers in today's forum about other opportunities, but I mention one other area of growth. There is considerable interest in parts of Asia in establishing new, private, English-speaking universities. The New International University in Thailand has recently advertised 35 academic positions.[11] The Vice-Chancellor is Professor William Carroll, formerly Dean of Engineering at RMIT, and the new University has links with Imperial College in London. Some Australian universities are considering proposals for affiliation with other private consortia from Asia. Anyone with career experience in Asia will be well-placed to make major contributions to Australia in the next millennium.

The fact that you are here today tells me you recognise the reality of an explosion in numbers of Australian PhD graduates at a time of contraction of the traditional base for employment, Australia's public sector. You are the children of baby-boomers. Those grey-haired baby-boomers will be holding jobs in the public sector for another 15 years. You will need to think broadly, laterally and globally in seeking meaningful employment. You may need to be entrepreneurial, possibly taking a lower starting salary than you expected. This will mean being adaptable and flexible and possibly working in a very insecure environment.

I'm going to ask you three questions:

> Who wouldn't mind being a millionaire?
> Who wants to be a full-time researcher in academia?
> Who thinks full-time researchers in academia are likely to be millionaires?

---

[8] Ward, M. Tough competition in Europe. Nature 383, 742, 1996

[9] Ward, M. Tough competition in Europe. Nature 383, 742, 1996

[10] Horton, B. Going to work in genes catches on. Nature, 383, 739, 1996

[11] Classified 22, Nature 292, 1996

Let's think about that! There *is* life outside academia!

Our nation has an unparalleled opportunity to capture our most talented and entrepreneurial PhD graduates, to establish a culture change in this country. This will only occur if Government can increase its spending on technology-transfer programs, on biotechnology and on information technology, as is happening in Germany. For our part, the ANU has plans to build an 'innovation building' within the next couple of years, to further encourage academic start-up companies and to provide industry-related employment for some of our graduates. My prediction is that our PhD graduates will experience an entrepreneurial culture overseas and bring that culture back to Australia.

The Graduate Careers Council of Australia[12] reports that for those completing a PhD degree in 1994, 93% had jobs a few months later. Not all of those without employment were looking for work. This is good news. PhD graduates are getting jobs, but graduates need to explore the unprecedented diversity of opportunity that exists today. For women, career options often have an additional constraint, the constraint of personal relationships. In my own case, when I was looking to leave the Papua New Guinea Institute of Medical Research in 1976, my husband refused to live south of Brisbane, having worked in the tropics for ten years. I did explore opportunities in Queensland, but my heart was set on ANU. We came to Canberra.

In placing PhD students under my supervision I have had no difficulty in finding overseas positions for those who want them, because of the fine reputation of ANU and personal networks. However, statistics show that women PhDs are less likely to work overseas. You might be interested in some practical examples of career options and in my address I'll tell you about jobs held by ten women PhD students whom I have supervised. I'm very proud of my former women PhD students, as well as the men, who have brought special talents to rewarding careers.

I want to give you my best wishes, and my best efforts in ensuring ANU remains a prestigious label on your CV, for securing a satisfying career.

They did not care
To travel in
Chartered waters
They preferred
To make the charts themselves.

[12] Graduate Careers Council of Australia

Trailblazing the Twenty-First Century

Julian Cribb
Director, National Awareness, CSIRO

'Here future Newtons shall explore the skies.
Here future Priestleys, future Wedgwoods rise'

Thus did Erasmus Darwin--grandfather of Charles and a celebrated poet and polymath of his day--acclaim in 1790 the glorious prospects which he envisioned for the infant nation of Australia

In invoking Sir Isaac Newton, one of the greatest mathematical minds of any age, and Joseph Priestly, the brilliant freethinker and chemist, Erasmus was clearly prophesying a future for Australia as an empire of the intellect. The odd man out in his exemplary triumvirate might appear to be the industrialist, Josiah Wedgwood, founder of the famous pottery dynasty. But in some ways Erasmus, writing more than two hundred years ago, saw Australia's needs more clearly than many people since. We shall return to Josiah Wedgwood later.

When *HMS Beagle* called at Sydney in 1836, her young naturalist Charles Darwin was at first inspired by what he saw: 'Ancient Rome, in her Imperial grandeur, would not have been ashamed of such a colony', he enthused, even going so far as to rate the settlement among the 100 wonders of the world. But as Darwin explored further into Sydney society and surrounding NSW his view became more jaundiced. Finally he concluded that the depauperate landscape and frequent droughts would preclude substantial agricultural development, obliging the colony to draw its sustenance from commerce and manufacturing industry.

History might have proved Darwin wrong in respect of agricultural development, but history has a funny habit of confounding even the most self-evident of observations. It may be that, at the dawn of the 21st century, it is poised to do so once again. The world of the coming century in which Australia will find itself enmeshed will be perilous and challenging in ways which make the great issues of the 20th century seem modest.

In the past half-century, the central issue of the human destiny has been whether we would ruin civilisation with fearsome weapons of mass destruction. In the coming century, the issue will be whether humanity consumes, pollutes and populates itself into crisis. Human numbers are marching inexorably towards 8.5 billion by 2020, more than 10 billion by the middle of the century. Virtually all this growth will take place in the poorest countries and in the most fragile regions of the earth.

Merely to feed this many people at the most basic level will require the production of an additional 800 million tonnes of grain and 50 million tonnes more fish. Yet 40% of the world's croplands are already degraded, along with a quarter of its forests and its pastures, while in the oceans, the last great source of food, the global fish catch is in decline. The old proverb: give a man a fish and you feed him for a day, teach him to fish and you feed him for life, no longer holds true.

World demand for fresh water is rising at twice the rate of population growth, and already numerous authorities have warned that disputes between nations and ethnic groups over water will be flashpoints for the wars and conflicts of the coming century. Even the atmosphere and climate are at risk. Today the world burns 3.5 billion tonnes of coal. But by 2050, China *alone* plans to burn 5.5 billion tonnes. While human numbers are set to double, economic activity, including the use of energy and water, is forecast to rise fivefold. Despite the great advances in food production and medicine of the past thirty years, 800 million people still go to bed hungry, 1.3 billion remain abjectly poor, and 400 children die from malnutrition-related disease every fifteen minutes.

A world in which so many are hungry and lack even the basic essentials for a healthy and productive life is an unstable world. This instability, as the world's leading military analysts are already recognising, cannot be quarantined to a few, impoverished regions. It will spill over to affect everyone on earth--in food prices, national security, tidal movements of refugees, epidemic disease, disruptions to trade and economic growth, and the progressive undermining of the earth's life support

systems of soil, air, water and biodiversity. As US journalist Robert Kaplan puts it: 'It is time to recognise the environment for what it is... *the* national security issue of the 21st century'.

These are the stark realities with which today's young Australians will have to contend as they make their way in the 21st century. The question I wish to address is how well we are equipping ourselves for the challenge.

There is no doubt that humanity is embarking on a new age, call it what you will--post-industrial, postmodern, the information age--an era that will dwarf the previous revolutions in metallurgy, agriculture and industrialisation. The defining context of this new age is that, for the first time, human wants and needs are coming into direct collision with the earth's capacity to supply them. Until recently most human development strategies were predicated upon the assumption that there would always be an unlimited supply of resources--of food, minerals, arable soil, clean freshwater, timber, energy. It is fast becoming plain that this no longer holds true. Canadian Professor Tom Homer-Dixon of Toronto University warns that "renewable resource scarcities of the next 50 years will probably occur with a speed, complexity and magnitude unprecedented in history".

Australia is the offspring of the resources era; a golden age when there was always a patch of untilled earth, an unexploited forest or fishery, an untapped oil reserve or a mineral deposit awaiting discovery. Our economy and society have largely been shaped by such discoveries, and, equipped with new technologies, there is little reason why we should not continue to add to them for another century or so. But we need to ask ourselves, very carefully, whether it is wise to depend predominantly on such finite resources, when the rest of the world is moving along a different path.

We are at the threshold of a different time. One in which material resources are ever more scarce, but in which human resources are ever more abundant--intellect, creativity, inventiveness. This revolution has been dubbed by Ake Anderson of the Swedish Institute for Future Studies the 'C-society', because, in his view, it will be dominated by the four Cs: communication, cognitive capacity, creativity and competitiveness. These, he argues, are the qualities which will define who wins and who loses in the rough-and-tumble world of the 21st century.

Already the new allegiances on which this society is forming itself are becoming clear. For the past 200 years the world has been demarcated into nation states. But the carefully-drawn map of the globe with which we grew up, with its fastidiously-ruled borders and colourfully-tinted countries is a fiction. It no longer exists, save in the minds of cartographers. It does not mark those places where anarchy has already swept away all semblance of government, where ancient tribal loyalties have resurfaced with a vengeance. It does not mark the new cities, the huge, festering shanty towns where cocaine and the AK47 are the only law. It does not mark the new axes of development which leap across borders, cultures, political and religious beliefs, or the spiderweb of businesses, small, medium and large which now enmeshes the globe.

It is along these new corridors, corridors marked by ideas which travel down optic fibre cables at the speed of light, where the next human revolution is unfolding. Snaking across England, from Cambridge in the east through Stanstead and Reading to Bath in the west is such a wellspring of 21st century creativity, a fountainhead of new ideas, technologies, dynamic young companies with high tech solutions to serious problems. Another begins on the western fringe of Tokyo, and unwinds through Osaka, Kyoto, Kobe and Nara, then leaps across to Seoul and on into communist China, through Shanghai, Hangzhou and Guangzhou. A third spears up the heart of Europe, from Basel in Switzerland, through Karlsruhe, Heidelberg and Stuttgart and on across the Baltic into Gotteborg and Stockholm. A fourth is born in San Francisco, slips down the west coast of California picking up LA, Orange County, San Diego and Tijuana in Mexico.

Along these corridors flow the ideas, discoveries, new technologies and minds which are building the 21st century. You won't find them marked on any map, because they exist only in the photo-electronic ether. They are great webs comprised of universities and private laboratories, foundations, corporations large and small, alliances which bond and dissolve as opportunities come and go. Above all, they are webs of human intellect, artificial brains on a gigantic scale. And they are fountainheads of prosperity and advancement. What sets them apart from the other regions of the world, and even from their own immediate hinterland is a sense of urgency, of striving--to discover, to create, to compete, to succeed.

These ambitions are strong enough to overcome any political, religious, ethnic or nationalistic obstacles. Those who have the vision force their way into the network. Those who lack it are fated to become the provincial backwaters, the outlanders and rustics of the 21 st century.

Where Australia sits in this emerging complexity is not easy to define. In certain fields such as medicine, agricultural and environmental science we are well integrated, but in most areas we are at the periphery, an onlooker rather than a participant. We are the hostages of our history: two hundred years of conviction that resources, rather than knowledge, are our greatest asset. What Donald Horne bitingly termed the 'lucky country' mentality.

How this has paid off for us in recent times is plain to see. For 28 of the past 30 years, this country has traded at a loss. Between 1980 and 1995, for example, Australia lost more than $200 billion on the balance of current account. Over roughly the same period Taiwan, a country also of 18 million people, made a profit of $250 billion. No wonder *The Economist* magazine last year described us as combining 'a third world economy with a first world standard of living'. It is, as they say, no way to run a railroad.

One of the chief reasons for our poor performance is the fact that we have on the whole persisted in the export of products which are simple and cheap, whilst importing those which are sophisticated and expensive--a fact which Barry Jones was rubbing our noses in more than a decade ago. We have also, in 15 years, managed to lift national debt from under $20 billion to more than $185 billion, a point at which it takes virtually the entire earnings of our farm sector, for example, merely to service the interest bill. The consequence of this has been a fire-sale of Australian heirlooms to overseas buyers--from Vegemite, Minties and Arnotts biscuits to *The Sydney Morning Herald*, Qantas, National Mutual, hotels and resorts, real estate, state power and water utilities and soon, perhaps, a third of Telstra.

Not many people seem to grasp the significance of the fact that Australia can now no longer afford its own assets. But by the time our children inherit the continent, it will mostly be owned by others. One of the reasons for this is to be found in the Nobel prize-winning writings of two economists, Paul Ormer and Robert Solow, who argued that the secret ingredient of high performing nations was not capital or manpower but innovation. It was not *what* you knew that was important, so much as what you *did* with the knowledge. This doctrine is known as modern growth theory or simply, the new economics, and though it was discovered almost 20 years ago, has yet to make much impression on Australian economic thought.

Yet you only have to look at Australia in the context of the Asia-Pacific. At a time when virtually every other country, no matter how poor or underdeveloped to begin with, is making its way up the ladder of world living standards, we have fallen from fourth place to 22nd. We have now been overtaken in GDP per capita by Japan, Singapore and Hong Kong, according to the World Bank.

And yet Australia is far more richly endowed in its ability to gain knowledge than most other countries of our region. We have one of the world’s highest levels of public sector investment in science. Our researchers, especially in areas such as medicine, astronomy, agriculture and biology have an impact on world knowledge out of all proportion to their numbers and resources. Our scientific efficiency is rated very high. Despite some fall-off in recent times, we are training new scientists and engineers at a rate faster than most OECD countries -- more than 900 for every 100,000 people aged 25-34 in the workforce, compared with an OECD mean of 650. So what is wrong with us?

The answer is that we are not very good at recognising the *value* of the scientific knowledge which we generate. Nor are we very good at converting that valuable knowledge into commercial and economic success. A recent study by the Bureau of Industry Economics noted that while our science system performs strongly in world terms, the links between it and industry are perilously weak. Private sector investment in R&D is far below the average for either the OECD or newly-industrialising countries. Business investment in our universities, for example, is almost negligible. As a consequence, many of our best ideas and our best researchers are driven offshore to develop and commercialise their discoveries. The venture capital and risk-taking mentality simply does not exist in this country to support them.

This is acutely ironical, considering that Australians risk--and lose--around $ 14 billion every year on slow horses and dogs or one-arm bandits. Every year Australia bets--and loses-- more than $100 million in just three minutes on the Melbourne Cup. But this is not exactly a new phenomenon. In

1892, ten years before the Wright brothers flew at Kittyhawk, Australian inventor Lawrence Hargraves was trudging the Sydney streets in a vain attempt to secure venture capital for his plan to build a powered flying machine. Despite several successful proof-of-concept models, Australian investors were not prepared to fund it, and chucked away the opportunity and prestige of being the nation which first conquered the skies.

A century on, what has changed? The reluctance of Australians to gamble on their own brains, but rather, on everything else including two flies crawling up a wall, is a perilous national condition as we enter an age in which the ability to exploit intellect and creativity will be at a premium.

At the start of my speech I referred to the English potter Josiah Wedgewood, a man whom Erasmus Darwin put on an equal footing to one of the greatest mathematicians and one of the greatest chemists of all time, as the sort of person needed to inhabit and lead the new country of Australia. Jos Wedgewood suffered an attack of smallpox as a child which led to his leg being amputated. His disability, however, proved one of his greatest advantages, because it led his enquiring mind into many important insights and discoveries. Jos Wedgewood was not merely a farsighted industrialist, he was also a scientist, a technologist, a gifted artist whose products graced the royal palaces of Europe as well as homes far more humble, and a shrewd-headed businessman whose company remains an international byword for excellence after more than two centuries. Erasmus Darwin was right: Wedgewood exemplifies the broad combination of talents and skills which Australia today so sorely needs if it is to take advantage of its greatest and most neglected asset, our knowledge base.

If we are not to fall behind our region, Australia needs a new generation of managers who combine business acumen with technological mastery, creativity with understanding. .It is of little use our products being scientifically brilliant if they are not also superbly engineered, aesthetically pleasing, cleverly attuned to customers' wishes and needs and intelligently marketed. The true value is often in the latter part of the chain, a fact which Japan's electronics industry demonstrates with monotonous regularity

Science, technology, design and information will be the determinants of economic success in the coming century. They will decide whether an individual or a company is admitted to the corridors of progress and advancement, or languishes in the provincial hinterland. But when we look around us, we see that Australia is already so richly endowed with the potential to gain admittance to these corridors of the future, that it is a matter for wonder that we have made so little progress.

In my introduction I emphasised that food, population and the environment will be the focal issue of the coming century. Is there any country in the world with richer credentials in the area of sustainable land and water management? Which grows a wider range of animals and plants in so many different environments? Which knows more about the unique system known as Landrace, whereby whole communities come together to manage their catchments and districts more sustainably?

If the world faces a crisis over water, land and food, then Australia also has answers to that crisis. We have the knowhow to defuse disaster. That knowledge, were we so-minded, could become Australia's bequest to the Earth.

Our minerals industry has concentrated for years on the export of raw materials, but in the past five years there has been a quiet revolution. It has become a knowledge exporter. This year sales of mining knowhow will exceed $ 1 billion, as much as copper and more than diamonds and uranium put together. With strong growth in demand for green mining technology, for techniques like the Hi-Smelt steelmaking process, the potential is there for knowledge exports to join coal and gold as one of our top three mineral exports.

In medicine, health and nutrition Australia has a superb scientific track record which is at last starting to be converted into commercial advantage through firms such as AMRAD, Peptech, Biota and the like. However, one of our greatest opportunities lies in the development of systems which *prevent* disease, instead of simply curing it. These range from a new method for detecting cancers up to 12 months before they develop, to foods which are carefully profiled to combat heart disease, cancer and other degenerative disorders. Worldwide, prosperous societies are seeking foods which are not only clean, safe and delicious, but also which preserve one's vigour, youthfulness and good health. Nowhere is demand for such foods stronger than among the rising middle classes of Asia, and this too must surely be one of our greatest opportunities.

I also described how humanity was now in collision with the earth's natural resources. In future we must all make more from less. We must recycle water safely, return nutrients to the land, control pests without poisoning our environment, employ renewable energy, and exploit what many today regard as waste. Indeed, I venture to predict that our urban waste streams will become the mines of the future, literally as well as figuratively. Did you know, for example, that in the sewage of a city such as Melbourne there is at least a kilo or two of pure gold, if we only had the technology to extract it! But there are many other things which can also be harvested from the waste stream: metals and minerals, nutrients, fibre and energy, even fresh water.

Australia is a world leader in devising technologies to recycle and re-use wastes, to protect and monitor natural systems. What we are not good at yet is turning this knowledge to commercial advantage. For that we urgently need this new breed of Australian: technologically savvy, commercially shrewd, and sensitive to issues such as aesthetics, human needs and the environment. They must have the education and training which enables them to penetrate the corridors of progress and development. A science or engineering degree alone is no longer sufficient. It must be mated with other skills: law, commerce, Asian languages, communication, even the humanities and social sciences.

Today one of the greatest challenges facing humanity is how to adapt technology for society, rather than the other way around. We desperately need young Australians who bridge both worlds, who combine both sets of skills, who can understand the technology but are also alive to the concerns and anxieties of ordinary people about how it will change their lives.

A clever country is not merely a scientific society. We are already that. A clever country is one which is adroit at adapting science to people, at communicating it so that they feel comfortable about using it, about packaging it in a user-friendly and unthreatening way. It is also a society capable of imagination, and swift, decisive action. A society of the intellect, as well as one which makes wise use of natural resources. Australia is already richly endowed with the necessary talents and skills. What we need is to think far more clearly about how we can take advantage of them.

The answer to our problems is not hard to find, but it has eluded us for far too long. We have lived for a generation in the complacent belief that our natural resources would always see us right. We have endured a succession of governments which are unique in the Asia-Pacific region in their inability to grasp where the true source of prosperity lies, and we have paid the price in terms of our living standards and assets.

This is a wake-up call to Australia. We have the skills, the intelligence, the science, the creativity and the imagination to succeed in the 21st century. All we need is the vision.

Doctor of What? Who Cares

Dr. David Rosalky
Secretary
Department of Industrial Relations

My daughter asked me recently: 'What are you a doctor of?'
'Philosophy', my son says with derision in his voice. 'What do you think the 'Ph' stands for?'.
'Philosophy!' Peals of laughter
That was my family's reaction. At work, the reaction is the same, if more polite.
'What is your doctorate in?
'Nuclear physics', I reply. Astonishment.
Why does the PhD invite such reactions? What are the perceptions people hold of this mystical degree?

The Nature of the PhD

The mystique and status of the PhD

Despite the proliferation of people with doctorates in all fields of scholarly endeavour, there is still a mystique about the title and the distinctive nature of the qualification; it is not perceived to be in the mainstream and few people understand what it means. It therefore carries an awe, derived from a supposed special knowledge that most professions protect and exploit by encasing their business in special language.

This mystique leads to a special status which seems to have no logical justification but is handy! There is no question that titles play a part in our society of sorting people into categories. Perhaps it is a substitute for 'class'. I don't know. But there is an expectation about a quantum step in value which derives from the degree. An expectation about special skills.

In the workplace, it is expected that along with the conferring of a doctorate comes a high level of professional expertise in one's present field of endeavour. There is a clear expectation that the degree is a form of professional qualification related to the holder's present position. In my case, people expect that I have postgraduate qualifications in economics or industrial relations or public administration. Either way, the generalist nature and the relevance of the skills obtained are not understood by people generally. And I suspect this may be true of the holders of the degrees as well.

The PhD as general education

This raises the question as to what the nature of the PhD actually is as a general education. What is its value to the recipient? What is the value to an employer? What is the value to society? Because one thing is for sure: getting a research degree is a very expensive exercise to individuals and to society.

It is possible that the answer is in the name: doctor of 'Philosophy'. The degree I presume originated from a specialised discipline focussed on investigating the nature of things. The primacy of that pursuit is captured in this great university's motto: *naturam primum cognoscere rerum* (first to learn the nature of things). This generalist aspect of the research degree contrasts with the view I described earlier as being the common expectation: that obtaining academic qualifications bestows particular skills required for employment.

The employment market is reorienting itself in that direction: namely a 'competency based approach. The notion is that any job can be described as requiring a set of competencies. This idea is being used to identify training and development needs, to define criteria for recruitment and advancement, and, more recently, to form a basis for pay--witness the junior rates debate. Are the skills then imparted through gaining a PhD congruent with this 'competency-based' approach to employment?

The general power of questioning: a universal competency

The essence of research, namely the power of questioning is, in my view, a universal competency of great value in any dynamic organisation and in the Public Service, certainly. The inclination to ask 'why' has moved beyond being an assistance to being recognised as a core value in a dynamic Service. The traditional rules-based approach to public administration has given way to the fostering of a learning organisation in which the concept of 'continuous improvement' in, and development of, our business is a key performance parameter.

Other identifiable competencies of the PhD

The research degree also relies on our ability to acquire relevant information, to analyse the problem at hand into its components and the causal relations underlying it, and finally to synthesise. To synthesise is a deceptively difficult part of research, and it is a critical, and often deficient, element in policy work and problem solving generally. Many times I have seen experienced, intelligent and hardworking employees in the Public Service simply unable to make the transition from processing type work to policy work, because they lack the skills needed to repackage learned information to solve a problem.

The ability to acquire, to analyse and to synthesise information is something that a person trained in research work carries as an asset in the competitive business world, and the Public Service is rapidly taking on the same approach and requiring the same skills. As far as a prospective employer is concerned, the acquisition of a PhD is a guarantee of high intellectual abilities and conceptual skills.

But recruitment is an expensive and chancy game and there is a temptation to accept certain credentials at face value to reduce search costs. Postgraduate degrees, especially doctorates, have fallen at times, but not always and I will come back to that, under the description of what is known as *credentialism*. That is, where formal credentials are used as a substitute for directly testing the suitability of a candidate for employment. The 'piece of paper' is seen as demonstrating suitability.

The Australian Public Service (Aps) and PhDs

My recruitment in the 197Os

I would like to shift tack for a moment and to talk about how I have observed the employment of PhD graduates in the Public Service. It is a personal interpretation, not at all scholarly. I have not acquired or analysed information to come to these conclusions.

I joined the Public Service in the early 197Os. Essentially it was my first job after completing my degree, and I had not left learning institutions since kindergarten at the age of five. The shift had a bit of a false start because I did some research with the Navy and then came back to the ANU for a period of postdoctorate work. But essentially I started my career in the Public Service in 1973, two and a half years after receiving my PhD.

This was a critical time for both institutions. Universities were pouring PhDs onto the market and the market was drying up rapidly, especially in the physical sciences. At the same time, the Public Service was trying to transform itself and one of its approaches was to increase quickly the proportion of employees with tertiary qualifications. This was done by recruitment and study assistance schemes. But it does not take much of an imagination to see how welcoming they were to PhD graduates falling in their lap. When I look back now, it was almost obscene--I was lusted after for my degree! So, with barely a check of my good character, I found myself almost shanghaied into the Public Service. My starting job was at the Research Scientist level, which in modern parlance put me at the ASO6 level or just below the Senior Manager stream.

I missed all the early introduction and training that actually teaches an employee about public administration and how the APS works. Like my 'endoctorated' colleagues, I also found rapid promotion. After about eighteen months, I was promoted to the Senior Research Scientist level which is well within the senior management levels. With no real understanding of the Public Service and barely knowing how to spell 'management', I was a 'sort of senior' public servant. Something had to give way under this arrangement. Like most honeymoons, reality raised its ugly head before too long. It is hard to say what the powers that were expected, but the seeds of failure of the game plan were set early.

The disillusion occasioned by early recruitment practices

PhDs were generally recruited the way I was: into professional ranks and without proper induction. There was little lateral recruitment into generalist ranks and, at that time, PhD graduates considered base-grade recruitment beneath them. So, the only way in was such as to raise the expectations of both the employee and the employer but the roots of a successful career were rarely set down. The doctorate was assumed to fulfil the professional needs of the new addition to the Public Service: the highly qualified public servant.

Not surprisingly, there was soon disillusionment on both sides. I think it was less for the graduates than for their employers. There were always, as there still are to a lesser extent, niches for researchers to do the kind of work they were trained for and wanted to do. They did not have to focus on the environment they were in or what their work was needed for. Their bosses though were quickly aware that bringing in highly qualified people was not solving the intrinsic problems of the Service. Moreover, the higher degree holders were commonly badly suited to a Public Service career and did not adapt well. On the other hand, recruits like Admin trainees, with good first degrees and specialised entry training, were the high fliers.

So how have those earlier PhD recruits fared? I have not pulled out the figures, but I expect that PhDs have had a mediocre, though probably better than average progress in the Service. And that, at least in part, is because they are intrinsically bright. I suspect also that, after a while, both higher degree graduates and employers looked on those PhD graduates as indistinguishable, from a formal selection viewpoint, from holders of other degrees.

Improvements in current APS recruitment practices

There is now a well developed and valuable graduate entry channel into the Public Service. We get our best recruits from that scheme and invest much in ensuring that we gain our future managers from them. They include PhDs. And they are all put through structured induction into the Public Service.

An interesting secondary phenomenon is that first degrees have now become as differentiated as a first degree may once have been from a higher degree. There are good courses and not so good; good universities and not so good. The higher degree may have reasserted itself as a selection criterion for good quality tertiary education; if you like: a credential for quality amongst graduates. Be that as it may, the PhD has come to signify a quality 'graduate', but it is not viewed as special because of the nature and standing of the degree.

- development schemes-the EDS

An interesting matter that I should mention here is the appearance of the Executive Development Scheme or EDS as it is affectionately known. EDS is just completing its twentieth year. EDS was established to address the very problem I have been alluding to. It was designed to address the deficiency in the necessary skills of management and public administration theory and methods displayed by skilled people in specialist streams who showed potential to move to higher planes.

Some several hundred people have attended the EDS training year and, I have no doubt, many have moved further as a result and to the benefit of the Service. I mention, as a curiosity only, that I went on the second EDS in 1978, and to date I am the only EDS graduate who has become a department head.

The compatibility of PhDs with an APS career

The question I want to take up here is: are PhDs compatible with a career in the Public Service?

Let me start with an example. At the risk of being personal, I often compare the experiences of my younger brother and myself in this regard. Each of us has a PhD in a scientific discipline. Each of us joined the Public Service after completing our degree and doing some postdoctoral work. Each of us experienced the phenomenon of rapid advancement as the advantages of intellectual capacity and conceptual skills were demonstrated on the job. I think in most areas, my brother’s achievements were better than mine, including a first class honours degree compared to my second etc. But he was most uncomfortable in the Public Service, whereas I found the environment challenging and was prepared to find my niche.

What then was the essential difference between us? After rejecting the possible explanation that either he was too stupid to stay in or I was too stupid to get out, I tried to discern what motivated each of us. I came to the conclusion that there were aspects of Public Service work that were

fundamentally outside the experience and training, and perhaps even the value system, of research graduates. Some people coped and adjusted, and even thrived. Others rejected the very premises on which Public Service business was constructed.

The APS environment: uncertainty, incomplete information and ambiguity

Much of Public Service work relates to supporting policy formulation and administering the resulting programs. I distinguish this 'mainstream' activity from the 'niches' of research I referred to before. In carrying out that principal function, the Public Service presents a world of uncertainty. The real world provides very incomplete information to decision-makers. Systems are highly complex and do not easily lend themselves to abstraction which can be modelled utilising limited measurable information. Causation is rarely established and a high level of subjectivity enters the deductive process.

Research, where it exists and is relevant to decision-making, is rarely directly applicable and, because objectives are not well specified normally, there is a lot of extrapolation of results to a given problem. All of this leads to a deal of subjectivity and lack of rigorous analysis. Objectives are very hard to define and often not what they seem on the surface. Political objectives are usually myopic and highly compromised. Decision-makers therefore and their advisers live with considerable ambiguity. Weighing up competing objectives, some of which may not even be articulated, adds to the subjectivity of the process.

the OR example: a case in point

I learnt the lessons of uncertainty very early in my Public Service career when I worked for the Defence Science Organisation in Operations Research (OR). I considered myself to be a scientist and to be there to apply analytical rigour to decision making.

It became obvious to me quickly that the real problem was to define the problem. To articulate the real objective. This is something that was a matter essentially of gut feeling. To force people to analyse their instincts and to specify how they defined an issue and came to a decision on it highlighted the ambiguity of the world we were operating in. It was an important lesson which I think began to put me on the path of transition to being a 'successful public servant.

Judgement: a key functional competency in the APS

All of what I have been trying to describe above highlights the substitution of judgement for deduction: judgement about the real aims, judgement about the relevance of information impinging on the issue, judgement about the motivations and trustworthiness of other people. These are skills learnt only through experience, often bitter experience. Gaining a PhD certainly did not teach me these skills or prepare me for this aspect of my profession. I will go further: the scientific training I went through may even have been inimical to effective operation in the world of ambiguity. It is my recollection that the application of some educated guesswork was frowned upon and even, at times, derided. Uncertainty was rejected.

I recall wondering about the black and white nature of my chosen discipline. There was a right conclusion and a wrong conclusion derived from measured facts. Judgement about the quality of data, the circumstances in which they were produced and even the human circumstances or foibles of the researchers concerned was viewed as a distraction. The academic pressures are, and always have been, enormous and much key work is affected by those pressures.

Yet we have to understand people and processes to evaluate information. I do not believe that traditional academic training prepares for handling these ambiguities and uncertainties. It has a somewhat moral approach: research is good or bad and results right or wrong. Judgement, as I conceive it, operates in a much more nebulous world. It is also more complex than may appear from what I have already said. Public Service work does need a lot of rigour and analysis--more than we allow now. We downgrade that input at our peril. But we have to blend that work with judgements of the nature I have been describing. We have to have the confidence to exercise discretion. As well as analysing information to deduce causal relationships, say, we have also to synthesise data with more subjective information and to build an uncertain picture adding discretion, judgement and (sometimes not very) educated guesswork.

- the G.R.A.D.E. model of decision making

So, how closely can we align competencies developed in the PhD with those desired for an APS career? I recently saw the management paradigm described by the initials G.R.A.D.E. which stand for **gather** (information), **review** (for relevance and usefulness), **analyse** (to conclude relationships), **decide** (from what is before us), and **evaluate** (to see if we were right). The research paradigm could be described in the same terms except, perhaps, by substituting deduce for decide. It is in the deciding that our judgement is tested.

The APS as a Career Choice

Is it for you?

I have been describing what I believe is the nature of the transition from a research degree to work in the Public Service. Ultimately, it is all a matter of career choice, a choice I don't think is made easy by the sort of training I went through and I don't know how much that has changed. From what I described above about how some people have reacted, positively and negatively, to business in the Public Service, it is not the right choice for everybody.

But I don't believe that this is a choice about rigour versus uncertainty, hard versus soft sciences or those sorts of contrasts. To my mind, we are talking about a more complete and demanding intellectual endeavour. And I do not think that what I have been describing is characteristic just of the Public Service. Clearly much of the business world demands these sorts of skills. It is true though, that a key differentiating factor between the Public Service and the business world is the woollier objectives and greater degree of ambiguity in the Public Service. But this is a matter of degree.

My conclusion from all this is that, despite my cynicism, I would not have swapped my time in the Nuclear Physics Department for anything. It was exciting and challenging. Most importantly, it gave me a grounding in those universal competencies: the power of questioning and deductive logic. To that I have had to add many facets of judgement and learning about people. But I still do not have an answer to the question I confront frequently: Your PhD is in Nuclear Physics--how did you end up in Industrial Relations?

Life Beyond the Laboratory

Dr. Lesley Russell
Public Relations Consultant

It does not seem so long ago that I was sitting where you sit today--both literally and figuratively. There are many possibilities and many futures stretching before you. I imagine that I am here today because I have taken some of the less obvious options. I have strayed far from my original course, the one I was apparently on when I sat in your place. So perhaps I should preface my talk here today with a warning that what you will here from me may be classified as heresy in certain quarters.

The idea that I have strayed from my original course assumes that I once had my feet firmly planted on a straight road leading to a definite destination. Despite the fact that my teachers clearly enunciated that any road other than that leading to a full tenured professorship was clearly the road to corruption, and possibly money, I don't think I ever really saw myself in this role. When I think about it, I see that my working life has developed because of the need to bridge the communication gaps that exist in our communities, and because I have been able to capitalise on, and enjoy, this niche market. Perhaps it has also helped that I am not risk adverse, and sometimes I've been willing to jump into a new situation.

Talking across groups, across disciplines and across cultures is the essence of communication. Failure to do this means that we all live in our own parochial backyards with the gate shut, with the resultant loss of opportunities at all levels for individuals, for science, and for society as a whole. I hope I can go some considerable way towards making this case today. You must all become effective communicators, regardless of where your future lies.

This is really a talk about bridges, and about how important bridges are in communication. It's given from my own personal perspective; it's the paths I have trodden and the bridges I have crossed. It will be up to you to draw your own conclusions about what all this means to you individually in the greater scheme of things. Perhaps if you disagree we can have a good discussion later.

I started out as an organic chemist at a time when that meant there was something wrong with your hormones and/or your social life. Later I saw the light and switched to biochemistry. I worked in research here at ANU and overseas in labs in London and Tel Aviv, and there was an enjoyable diversion to do an arts degree part-time. Only then did I make a late start on a PhD. Actually I nearly didn't get started at all, because a senior professor was resistant to the idea of giving a 30-year old woman a precious John Curtin School Scholarship. Fortunately, my future supervisor and my publications record came to my support.

At the end of 1979, I went to the United States to teach and do research at the Department of Defence Medical School in Bethesda, Maryland. This is situated literally across the street from the National Institutes of Health, and for a while I described myself as the only part of Ronald Reagan's defence budget I approved of.

In 1984 I was awarded a Congressional Science Fellowship to work on Capitol Hill in the US Congress for 12 months. These fellowships, which are given competitively under the auspices of the American Association for the Advancement of Science, have been operating for over 25 years and have a proud tradition. It's one I'd like to see adopted in Australia. My fellowship year changed much about my life. It served as a bridge to a new career, to new ways of looking at the world, and to new groups of people. Most importantly, it taught me about the need for bridges between the science community and the political community.

I came to my fellowship year with a healthy respect for the importance of politics in our everyday lives. I had come of political age at a time when Australia was going 'all the way with LBJ'. I had spent time in Israel, where the midday news bulletin is played on the streets and on public transport, and I was married to an American who worked in Washington's political milieu and loved it with a passion. He has only just returned from the States and the successful Clinton/Gore campaign. In our home,

But I also love science and research, and I am alternatively saddened and enraged when individuals see science as boring, frightening or irrelevant and either reject the products of scientific research or accept them without thought or appreciation. As a community, we would never turn aside from art, literature or music as we turn our backs on the intricacies and excitement of astronomy, biochemistry and physics.

In the US, perhaps more so than here, the early 1980's was a time of considerable debate about genetic engineering, the environment, animal welfare and bioethics. Many evenings I watched these issues being hashed in unworthy emotional debates on television, or I engaged in fruitless dinner table conversations with otherwise well-educated people whose lack of understanding of science left them ill-equipped to make the needed value judgements. I'm sure this is a situation familiar to many of your today, even in the late 1990's in Australia.

So I decided to stop talking and to act. Although I was fairly sure that this step was going to mean a permanent career change, I was nevertheless nervous about leaving the university career track that I had taken so long to build, and perhaps wasting the results of that precious PhD scholarship. The Congressional Science Fellowship program provided me with a means to explore the possibilities of a new career path in such a way that I was not burning my bridges. Furthermore, it provided me with virtually the only route for a scientist into Congress and politics, since I had already discovered that a PhD in biochemistry intimidated most congressmen, who did not seem in the least fazed by lawyers.

I went to work for the Democratic Chairman of the oldest, largest and most powerful committee in the US House of Representatives. Initially I worked on the Oversight and Investigations Subcommittee--the one portrayed in the movie *Quiz Show*. In my year with the Subcommittee, I worked on biotechnology issues and vaccine development, and became the resident expert in the groundwater monitoring requirements of the hazardous waste disposal act. I also began the continuing process of exposing and investigating the full extent of the deliberate releases of radiation made over decades by the Department of Energy in Washington State.

All of these issues were complex and technological and very political, and they involved diverse constituencies and opponents inside and outside Congress. The important point in all this was that these issues were going to move forward, decisions were going to be made, with or without the involvement of scientists. When my fellowship year was over, I was asked to stay on, and for 7 years I worked on health policy and biotechnology issues for the Committee on Energy and Commerce.

During my fellowship year and the years that have followed, I have spent a lot of time talking to informal and formal groups of scientists. In this sense I am able to act as a bridge from the world of politics, policy and business to the world of science. These bridges need to be strengthened.

All too often the scientists I talk to have a complaint, often real, sometimes imaginary, about how politicians are making decisions about issues that are important to them, such as AIDS, allocation of research funds, regulation of biotechnology, or use of animals in research. Yes, they are anxious, yes, they are concerned, but no, they don't want to be involved. The excuses range from 'too busy' to 'no one is listening anyway'. The expectation is that the government should simply understand their case and act in support of it.

Even on those issues of crucial importance to science-- for example, fraud and misconduct in scientific research --the scientific community was not just ineffectual but plainly obstructionist. It made little sense to tell the members of Congress responsible for the NIH and NSF research budgets that science was not something they could comprehend. These same members regularly scrutinised and sat in judgement on Medicare doctors, Department of Defence contractors and the Wall Street stockmarket.

The level of scientific education and understanding in the Congress approximates that in the community, but that was not going to stop the issue being considered. As David Baltimore discovered, not even a Nobel prize winner was safe. On this particular issue, the scientific community distinguished itself only by its inability to communicate effectively, its lack of a cohesive approach to the issues, and a general 'head in the sand mentality'--if we don't think about this it will go away.

In 1991 I left the exhilaration and madness and exhaustion of Capitol Hill to return to Australia, and I am quite recovered from my bout with Potomac fever. I went to work for the pharmaceutical industry, building new bridges. The pharmaceutical industry confronts us with a fascinating mix of

issues: it’s the intersection of science and health care, public policy and capitalism, profits and altruism. You have to deal with government, shareholders, researchers, the health care community, patients and consumers and the media. There is no possibility of retreat into an ivory tower.

My science skills served me well in public affairs. The company I worked for had scientists in regulatory affairs, marketing, sales, quality assurance, manufacturing and business development; they also used scientists in the traditional way--at the lab bench, in research and development. My science education taught me about solving problems, analysing the situation, using your resources effectively and that hard work pays off. My political education taught me about allies and building constituencies, communicating effectively and the art of compromise. My business education taught me about setting goals, evaluating outcomes, managing people and budgets and balancing priorities.

My reasoning is that from public affairs it was then only a short step to the Olympics. My appointment to SOCOG was a surprise. 'Dr Who?' the headlines screamed. If my appointment was unusual, it may be because we have all done a miserable job of selling the value of a science education to the world. We should take a leaf out of the lawyers’ books; they see their training as applicable to everything. It is interesting to speculate on the media reaction to my appointment had I chosen to present myself, accurately but incompletely, as an arts graduate who had worked in politics and public relations.

After leaving the Olympics, I spent some 5 months working as a public affairs consultant. It is interesting work, and offers many possibilities for someone who enjoys adrenalin, variety, hard work and solving problems. Increasingly, companies need help with environmental issues, media, government and community relations, crisis management and product launches.

The real growth area is not what has traditionally been thought of as PR--the glitzy event stuff--but strategic management issues. Increasingly businesses are realising that it is not enough to deal with their customers and keep their shareholders happy. They must also manage the total environment in which they operate to ensure their continued success and viability.

Now I have taken up a position with the Cancer Council as head of policy and planning. This is an arena where the ability to think as a business person, understand the science, explain it in terms that ordinary people can understand, know the marketing issues and work with the various constituencies are all necessary. In addition I must manage a diverse group of 14 people.

It’s a perfect job for me. It enables me to dabble in all sorts of areas. I read all the medical journals, go to scientific meetings, work with behaviourists and educators, develop public health programs, use my planning and coordination skills and interact with the media. All this and enough vacation time to ski in Colorado--what else does a scientist need?

With a good science education there can be an exciting future at the research bench. But you can also be on the cutting edge of science in so many other places-- politics, think tanks, the media. Scientists can work in policy development, crisis management, marketing and public relations. There are many opportunities if you choose to see those opportunities and are willing to take them.

Actually, to pick up on a point that I just made, what science and scientists really need are some good public relations. All those movies about mad scientists haven’t helped. If 'scientist' was a racial description and not a job description we could sue for discrimination. We need to be seen as the smart, interesting and attractive people that we are, with no more nerdiness or madness per capita than any other profession. You need to ask yourself this question: if I went to graduation day at the local school and presented yourself as an example of the scientific life, what would be the reaction? Would those young people want to be you or Poppy King or Lachlan Murdoch?

Scientists are not as lacking in the basic training for PR as they would like to believe. The skills that come from presenting and making the case for your research to colleagues and funding bodies can be refined and extended so that you can make your case to the broader community, in language they can understand. Scientists also have the basis from which to develop management skills. Most of you have had to juggle budgets and set priorities and help train other people. Did you do it well, and what lessons could you carry forward from these experiences?

The challenge I leave with you is to become, in your own different ways, the champions that science needs and deserves. We must all become effective advocates for science in general and our own work in particular. No one else will do this for us, and the luxury of assuming it is not necessary is long

gone. A good science education is a ticket to many worlds. It is up to you to be brave enough to use that ticket and to take some interesting journeys, and to cross your own bridges.

The Postindustrial PhD: Selection or Reincarnation?

(Meeting the demands of R&D leadership in a rapidly changing social and business environment)

Dr. Julian Clark
Group Director of Development and Operations, F.H. Faulding & Co. Ltd.

The question 'Is there life after a PhD?' must be answered in the context of the rapidly changing social, political and economic environment. The answer is and must be a resounding 'yes', provided we recognise and understand the demands of our global environment. Without appropriately skilled postgraduates, Australia will be rapidly doomed to the archives of intellectual, economic and industrial archaeology. There is a very positive future for good postgraduates in basic research, higher education and government and here we will examine the current situation and demands in the context of the commercial enterprise, often but erroneously classified as 'industry'.

The use of 'postindustrial' is deliberate. Firstly, to emphasise that our destiny is dramatically different from the traditional stereotypes of smokestacks, production lines and pickets. Many of today's high technology and service-based enterprises are the very antithesis of this image. Secondly, traditional industry is being forced to change and a broad range of alternatives to basic research, higher education and government have emerged in the enterprise sector as real alternatives for the postgraduate.

Figure 1: Duality and the industry stereotype!

The juxtaposition of industry against a yin/yang symbol (Fig.1) emphasises that the secret to our progress as individuals, organisations and as a nation will be our ability to handle duality and the balance of perceived opposites. Understanding duality is essential to appreciating the future roles of postgraduates and exploiting the synergies between higher education, government, enterprises and society. Examples of dualities and related roles and linkages relevant to the future of postgraduates include:

- higher education - enterprise
- higher education- government
- enterprise - government
- analysis - synthesis
- individual - group
- order - chaos
- change - status quo
- stakeholder - shareholder
- technology drive - market drive

The title of this discussion highlights three essential elements of the future of PhDs:

Postindustrial - The future for the PhD is in the context of an increasingly changing environment. Our world has changed dramatically from the times when the original systems were established for higher education and industry. New needs of society and the commercial enterprise have become

more clear and different approaches are needed if Australia is to achieve a strong, competitive position as a knowledge-based nation.

Selection - The current 'sink/ swim' approach for preparing postgraduates for their next career step is inefficient and leads to slower adaptation and a wastage few can afford. We do not have the time or resources to apply a 'Darwinian' approach. Smart and effective induction of the required skills is required.

Reincarnation - Due to the rapidly changing environment facing all organisations there must be a greater directed awareness of required skills and competencies. Science and technical skills alone will not guarantee survival of the postgraduate species. A rapid, directed transformation to a seamless set of applied skills, competencies and knowledge is required.

We will explore these issues starting from defining the broad context of our challenge and then focus on practical examples of current weaknesses and recommendations for improvement. The issues discussed here transcend the question of the 'needs of industry'; we are looking at a future set of skills generic to all leading individuals and organisations. In this discussion we will be highlighting three main areas:

• Rapid external forces and changes are driving the need for internal changes.
• There is a convergence of forces and issues for industry and academia, greater coordination is emerging.
• Simple solutions can rectify most of the key training gaps for current postgraduates.

Setting the scene

The future of the PhD graduate must be seen in the context of several factors, irrespective of whether a career is pursued in continued basic research and higher education or in a lateral transition to government or enterprise.

• Our environment is rapidly changing and increasingly less predictable. Certainty of linear tracks, tenure and status quo is no longer with us.

• Drivers of these changes include a greater demand from society for value and benefit, the realisation of time as a scarce and valued resource, and the impact of information technology. These drivers are superimposed on increasingly recognised but changing customer needs and the impact of changing demographics. The ageing of our population and related lifestyle and healthcare issues is having a profound effect.

• Society and markets have gained greater influence over implementation of knowledge and technologies.

• Emphasis on accountability is increasing. Whether we are measured by 'passive' stakeholders such as taxpayers and governments or by active shareholders, our contribution must take into account the demand for benefit in the broad context.

• Increasing global integration of research and enterprises, and recognition of the value of diversity are making traditional boundaries meaningless.

• The increasing task complexity brought about by the above factors requires development of additional skills and competencies.

These issues are converging for many previously different organisations. One point in common is that in order to prosper, all organisations will require high quality people--in this case PhD graduates who stand out because of their:

• Holistic view and understanding of context
• Foresight and ability to anticipate the unexpected
• Proaction - driving change rather than reacting to change
• Personal leadership

The Australian situation

Australia does not get the full benefit of its investment in science and research, including the investment in postgraduate degrees. The value of our knowledge falls far short of the value which

could be added in Australia. This situation has been well documented elsewhere and is described by some simple observations:

• There is strong basic science and research, but product development and commercialisation are weak.

• The relatively low private enterprise investment in R&D stems largely from an historical national reliance on primary and resource industries and tariff protection. The importance of investing in intellectual property and technology to generate true added value is recognised by too few Australian organisations.

• In relative terms other countries are investing more in development and commercialisation, and are adapting more rapidly than Australia to the changing environment.

• Training in product development and commercialisation in Australia is relatively weak.

• Becoming a knowledge-based nation remains elusive for Australia since we still find it difficult to link science and invention to an innovation process which creates real applied value from our knowledge.

Some key figures relating to Australian investment in R&D are shown in Figures 2-4. These reveal a significant growth in enterprise R&D in recent years, and a clear indication that there is an underlying demand for postgraduates in the expanding enterprise R&D sector. There is still a concentration of total enterprise R&D investment to the top 20 companies who account for 40% of total investment; however, greatest growth and probably potential is in the rapidly emerging SME sector.

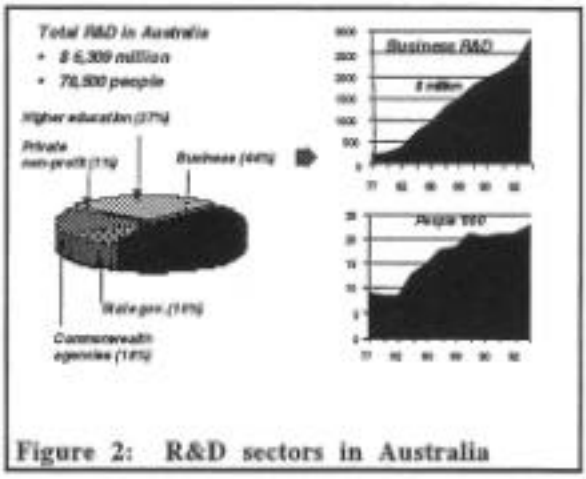


Figure 2: R&D sectors in Australia

Figure 3: Business R&D in Australia

The growth of Australian enterprise R&D, although promising, is from a relatively low base, and we lag far behind many other nations. In spite significant public investment in basic science this is not being matched by enterprise investment in product development and commercialisation. This leads to the real risk, and in some cases certainty, that valuable Australian intellectual property moves offshore to be commercialised and sold back to us at higher prices.

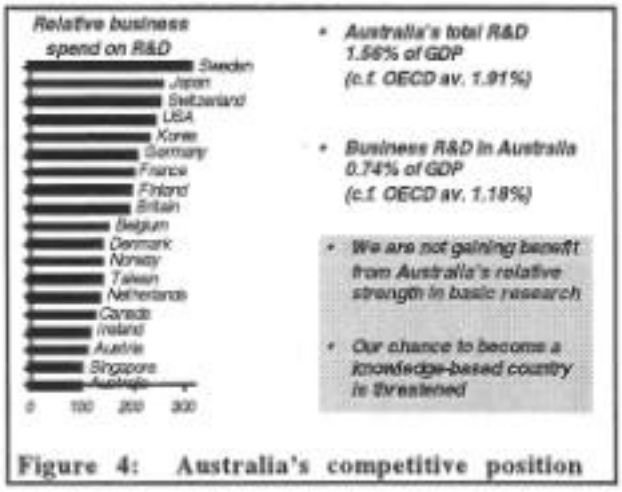


Figure 4: Australia's competitive position

While many postgraduates pursue careers in academic basic research a significant proportion move to government organisations and private enterprise (Table 1). Accurate statistics are remarkably difficult to find but we can expect that the proportion moving into non-academic sectors is increasing.

Employment destination: % Graduates	Government organisations	Private sector	Education sector	Other
Science postgraduate	41	17	39	3
Life Science	42	15	41	3
Chemistry	42	31	25	3
Science graduates	8	16	46	30
Engineering graduates	10	42	17	31

Table 1: Employment of Australian graduates

THE CONTEXT OF R&D

The R&D environment

The transformation of basic science and knowledge into genuine benefit improving quality of life is the quest of many individuals and organisations, both academic and commercial. The single most important factor in the industrial success of North America, Europe and Japan has been the systematic commercial exploitation of science. Nowhere is this more apparent than in the health care area where the academic and business sectors have developed strong global interdependencies.

The survival of Australian enterprises depends on a reliable supply of appropriately skilled graduates and postgraduates. Australia is particularly vulnerable due to the present rapid expansion of enterprise R&D from a relatively low level. The present training process does not guarantee a supply of high quality postgraduates capable of meeting the challenges of the future. It is recognised, however, that some promising initiatives are being taken in Australia by leaders in both the higher education and enterprise sectors. The issue is how to progress these initiatives on a broader, more coordinated front.

The R&D environment is experiencing radical change in many sectors. Rapid changes in internal and external forces mean that needs are constantly changing and new skills are required. Reaction and fragmentation are being replaced by proaction, integration and a holistic view as discriminators of success. Forces of change becoming common to higher education and enterprise R&D sectors are accountability, genuine benefit, value adding, and customer satisfaction. These pressures and rapidly

emerging linkages mean that higher education and enterprise are moving closer than is commonly understood. The closeness is often exemplified by the present mid-level collaborative links already in place and not representative of the divergence often described by upper management in both types of organisation!

These changes are set in the context of two rapidly changing relationships. Firstly, the relationship between higher education and enterprise R&D, and secondly, the relationship between enterprise R&D and the rest of the organisation. The fact that the role of R&D in enterprises is undergoing a major change is often overlooked in debates on the higher education/business interface. A better understanding of the changing relationship between R&D and the rest of the commercial enterprise is equally important as an understanding of the link between higher education and enterprises. Within enterprises there are major changes in the way in which R&D is managed, integrated into the total business, and how R&D is becoming central to strategic plans.

The pressures driving change are actually leading to a convergence of issues facing higher education and enterprise. The rapid increase in genuinely cooperative R&D is resulting in a 'globalism' which is rapidly replacing the parochial and ethnocentric tendencies of the past. The technology aspects of this globalism are waiting to be positively managed through effective R&D leadership.

All of these forces mean that postgraduates must be prepared for a changing world which is vastly different from that in which their teachers, mentors and supervisors were trained. The convergence of R&D leadership issues must again be emphasised, and traditional stereotyping of organisations in the training process amounts to no less than disinformation. It is clear that the issue of improving the quality and suitability of postgraduates is an issue which must be addressed jointly by higher education and enterprises.

R&D social system and culture

Comprehension of the underlying social system and culture for R&D is essential to understanding the future for a PhD.

• The predominant R&D system in both enterprise and higher education is still the individual social system, rather than related technical or management systems.

• The R&D system in enterprises was derived from higher education.

• A traditional focus on the individual hinders teamwork, deeper collaboration and synergy.

• There is little customer focus and emphasis on accountability to stakeholders and shareholders. R&D often functions in a vacuum where customers, either internal or external, are regarded as an after-thought or intruders.

• A fundamental issue faced by the R&D system is how to achieve sustainable creativity, invention and innovation. This is a clear meeting ground for the higher education and enterprise environments.

The R&D leadership challenge is to steer behaviour and implement systems that encourage leadership, reward cooperation and win-win teamwork, with consistent communication within and outside the teams and organisation. These issues are being addressed by leading R&D organisations.

R&D organisation trends

Emerging major changes in the way organisations are structured are having profound effects on the required skills and competencies. A new postgraduate may in fact be entering organisations where the existing people are also struggling to adapt to change.

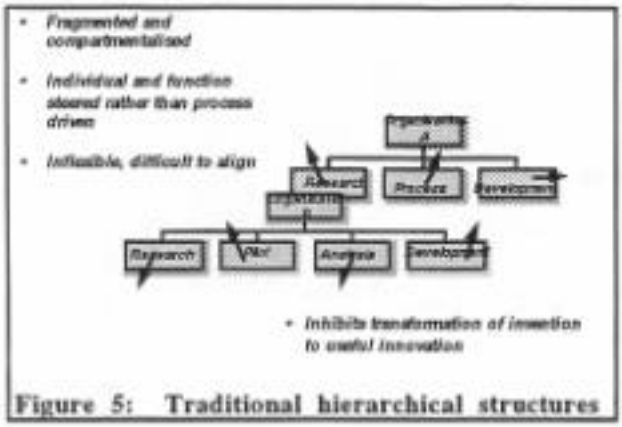


Figure 5: Traditional hierarchical structures

Organisation structures are being flattened to reduce the number of levels in the traditional hierarchy often regarded as a monument to the industrial revolution (Fig.5). However, simple flattening and downsizing are not sufficient to achieve the required improvements in effectiveness, flexibility and adaptability. Many leading organisations are moving to a value adding 'process flow' approach (Fig.6) where multidisciplinary and multifunctional teams are responsible for development and project delivery (Fig.7). The most striking aspect of the change depicted in Figs. 6 and 7 is the need for interaction and team skills over and above the traditionally valued technical skills.

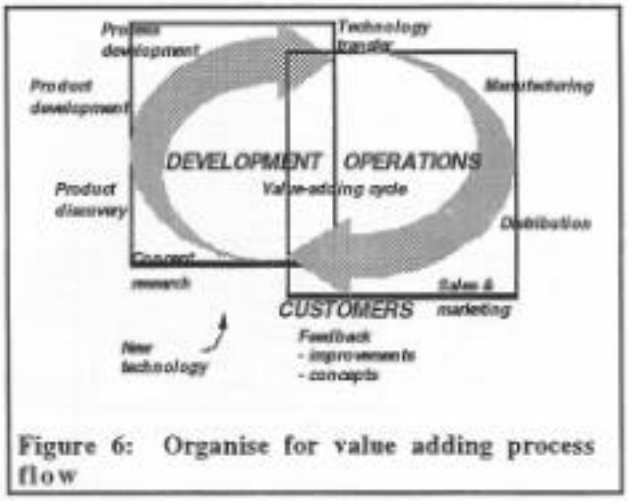


Figure 6: Organise for value adding process flow

Is induction and development of such skills being specifically addressed in our postgraduate training?

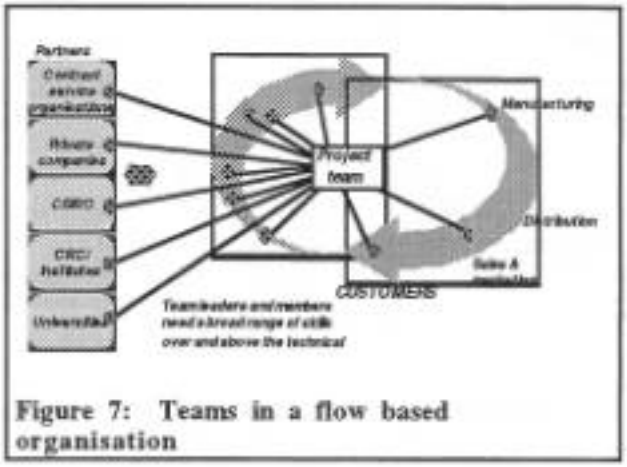


Figure 7: Teams in a flow based organisation

A specific example of complex linkages and interdependencies is provided by Kapanol/ Kadian, the first drug to be fully developed in Australia and approved as an NDA by the US Food and Drug

unmet clinical need: chronic pain in cancer sufferers. The development and commercialisation team required interaction with a wide variety of organisations and technology transfer to different cultures. The other important aspect of this example is the clear roles in innovation. The academic sector provided the clinical concept and research, and the enterprise sector provided technology, raw materials and commercialisation skills.

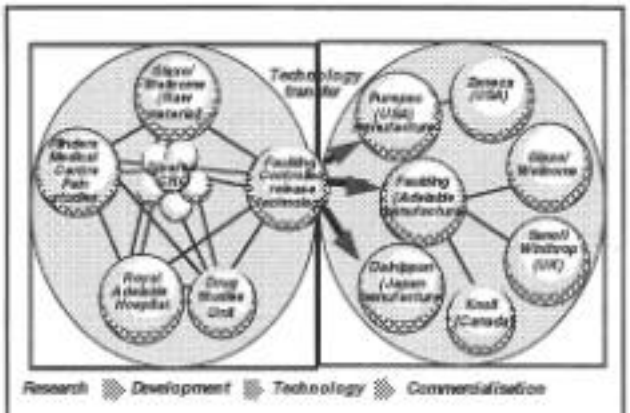


Figure 8: The development of Kapanol/Kadian

As a consequence of the above trends and examples we can see that the ability to understand cultural and organisational diversity has become essential for effective R&D. Leading enterprises have worked towards seamless multicultural and organisational interfaces. This diversity places very high demands on effective comprehension, communication and team skills. Flexibility is required and mobility within organisations and between cultures is increasing. Again, we ask the question --is the postgraduate being adequately prepared for these challenges?

THE CURRENT PHD GRADUATE

Input from Australian enterprises

This discussion is based on recent input from nine diverse commercial enterprises (BHP, Biota, Biotech Australia, CSL, Faulding, Gropep, J&J Research, Peptech, Sola Int) on the skill level, and ability of current postgraduate students to fulfil the contemporary needs of Australian enterprises. The intention of the input was to provide an update to the original report *Developing Leaders in R&D,* published by the Business/Higher Education Round Table (B/HERT 1994). Interestingly, many respondents employed overseas postgraduates because there was a shortage of comparably experienced local people.

The differentiators

The main focus of the current PhD is an original contribution to the body of knowledge of the discipline. However, it must be emphasised that knowledge, skills and competencies are completely different elements, and a good PhD student has a balance between knowledge, skills and competencies. Without certain competencies knowledge is essentially useless and cannot be applied to the value adding innovation process. Current PhD graduates are generally strong in a narrow area of knowledge, often have only limited development of some key skills and usually show poorly developed core competencies (Fig 9).

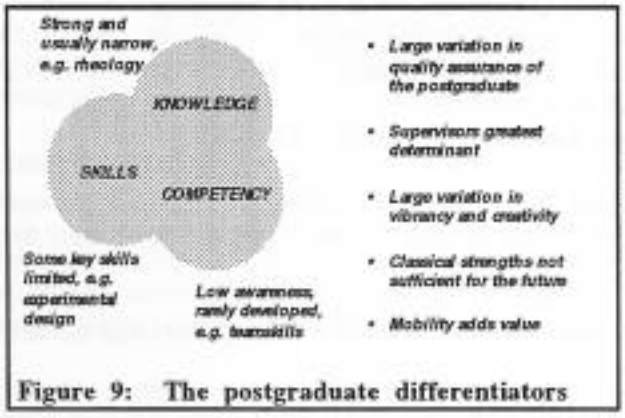


Figure 9: The postgraduate differentiators

There is enormous variation in the quality of postgraduates, and when viewed in product and customer terms it is clear that there are virtually no agreed quality assurance standards in the training organisations. The quality of postgraduate students depends very heavily on the quality of the supervisor and, to a lesser extent, on the quality of the department. One cannot escape the conclusion that due to the seriousness of the commitment and variability there is a need for a 'license to supervise', and a system for training and supervising the supervisor.

Quality comes from a clear understanding and experience of customer needs, environmental dynamics, purpose and success criteria. Therefore, the assumption that the philosophy of science in isolation drives development and assessment of postgraduate students must be seriously challenged.

The mobility of tenured university staff in Australia is exceptionally low. Furthermore, there is very low mobility between higher education and enterprise. Most supervisors are not in direct touch or up to date with other organisations' needs and have lessening contemporary experience of organisational diversity. This is exacerbated by an ageing of the Australian academic community. In itself ageing is not a problem, but in the absence of broader, direct updated experience in other R&D environments this ageing tends to develop postgraduates with limited understanding of the dynamics of the present global R&D environment. The value of mobility lies in the need for effective 'technology or knowledge transfer' and practical assimilation and synthesis of contemporary experience.

Among the classical Belbin teamskill roles the 'plant' (ideas, creativity, lateral thinking) is the type rarely found in present postgraduates. Although some recent students appear to have a greater awareness of industry, they seem less inventive, less adventurous and more 'tame' than 10-15 years ago. Several enterprises have noted a recent deterioration in the quality of PhD students for science and technology. This is partly due to the attraction of law and medicine for the best, and expansion of universities causing dilution of local talent A reduction in entry standards for PhD candidates is a problem, and assessment criteria do not address the stringency required to fulfil the demands of consistent quality.

Most enterprises prefer to employ postgraduates who have already had work experience. Furthermore, postgraduate recruits from the UK/USA currently seem to have better comprehension of diverse R&D environments. For this reason many current postgraduate appointments in enterprises come from the UK/USA. The demand is real; the possibility of better local supply must be addressed.

General strengths and skills

Key strengths and skills of the *best* postgraduates are:

• A good grasp of fundamental concepts in their discipline and knowledge in specific areas.
• Internationally competitive in their narrow field of expertise.
• Trained in the methods of 'academic research'.
• Well developed analytical thought processes.
• Ability to investigate an idea in depth.
• Ability to work as an individual, often in relative isolation.

Generally the skills developed in postgraduate training are those that are essential to the conduct of the project. In reality not all students take the full opportunity to develop these skills which include:

• Design of logical experiments (often dictated by supervisors and not the same as rational experimental design).
• Design of equipment/systems.
• Use of analytical equipment and development of methods.
• Use of computers, networks and data-bases.
• Technical presentation skills.
• Experimental techniques.
• Specific subject literature searches.

A serious reflection is that relatively few postgraduates can be classified as good according to all of the above criteria.

Main weaknesses

Although higher education provides many opportunities, it is only the proactive few postgraduates who get what they need out of the education. A harsh observation is that too many do the minimum necessary to get their PhD. The main strengths and weaknesses are obviously highly dependent on individual postgraduates and their supervisors. It could be argued that disciplines such as engineering are addressing many of these issues more successfully than 'individual based' disciplines such as chemistry and medicine.

Main weaknesses of current postgraduates include:

• Over-specialisation in intellectual scope. Many programs utilise well-established technologies and breed a student who is a highly qualified technologist, largely mechanistic in approach and not a frontier breaking scientist.

• Due to over-specialisation postgraduates rarely acquire the skills to view issues holistically and synthesise information from wide ranging sources.

• Postgraduates have little concept of international best practice or compliance standards, and safety awareness is usually poor and often a liability.

• A weakness in anticipating new developments is expressed through tunnel vision and multidisciplinary synergy is rare.

• Due to the limited knowledge in other fields postgraduates have difficulties when branching out into new areas or addressing practical problems.

• A major deficiency is weak appreciation of intellectual property issues. Most postgraduates struggle with the need for confidentiality and the concept of intellectual property as an asset which can be and should be traded.

• Postgraduates are typically underskilled in project management, and critical path project planning.

• Skills in verbal and written presentation are very uneven.

• Postgraduates are rarely pressured to develop and fine-tune lateral thinking and innovation skills. They are generally weak at using a range of approaches to solve problems; the limitations of conventional logic are evident and more 'out-of-the-box' thinking is required.

• Generally postgraduates do not have a broad picture of how their knowledge can be applied.

• Postgraduates tend to be individuals used to working alone and often find working in a multidisciplinary project team difficult. They tend to have poorly developed people, leadership, negotiation and communication skills.

• The increasing trend to continue into postgraduate studies in the same department or university is a major concern since it usually leads to narrowness and limited experience.

• Most postgraduates lack even a rudimentary understanding of financial systems.

As a consequence of the above, the key R&D leadership weaknesses of current PhD graduates can be summarised as a need to improve understanding or awareness of:

• Planning and time management

• Team skills

• Experimental design

• Context, social and business awareness

• Communication skills

• Compliance and safety

• Management principles

These issues are equally important for the higher education and enterprise sectors.

First contact with enterprises

The best postgraduate students are those who have already had broad work experience. Students who have only experienced the educational institution and academic environment usually have difficulties when first confronted with the realities of a new contemporary R&D environment. They usually show considerable initial anxiety about getting a job after graduation and need better preparation for seeking jobs.

Although culture shock is expected as a first experience in a new environment, most students have difficulty in applying their knowledge in the broader context usually required in the enterprise environment. One of the biggest areas of shock for the new postgraduate is the move into a multidisciplinary team environment from one where the pursuit of individual scholarship was paramount. A related shock is the greater emphasis on deadlines and parallel rather than sequential project planning.

Many postgraduates have unrealistic expectations of their position, worth, salary growth and career development when moving into enterprises. They often think they are above 'doing' the 'hands-on work' of the project, and have unrealistic expectations of rapid promotion into senior management. There is still an illusion encouraged by the system that a postgraduate qualification is a passport to fame and fortune!

If the research project the student is working on has a practical basis, or the supervisor is familiar with the needs of enterprises, transition is easier than if the research project is highly theoretical with the student having little understanding of future applications of their work. Having a supervisor with a genuine understanding of the global R&D environment is a clear advantage for an effective entry into enterprise industry and subsequent career progression.

Most enterprises report that integration of the PhD requires considerable extra effort and time, and while some postgraduates experience severe performance difficulties most eventually become successful. Simple and planned preparation of the postgraduate for this transition would be much more effective for both the individuals and the organisations.

Areas for improvement

Students who have a postgraduate degree should be better prepared to meet the needs of both enterprises and continued work in higher education. The PhD should be able to perform at a higher level and should not be just a more specialised version of an academically accredited undergraduate.

The knowledge, skills and competencies that students need to develop are related to the weaknesses mentioned above. Specific technical knowledge clearly needs to be of international standing. There are also common technical skills required by most enterprises:

• Experimental design, modelling, statistics and problem solving
• Information technology and computer literacy
• The ability to utilise fundamental and technical knowledge to applied systems
• Occupational health and safety
• Good manufacturing practice and good laboratory practice
• Intellectual property management
• Risk and hazard management

These technical skills must be supported by improved personal competencies including:

• Communication skills (oral, written, graphic and listening) to a wide range of audiences, including those that do not have the same body of knowledge or depth of knowledge.
• Negotiating skills

• Problem solving and decision making skills. Ability to tackle and solve a problem utilising a range of approaches, rather than being limited to a narrow range of techniques.
• Project planning, review and management.
• Team skills and good interpersonal skills to encourage teamwork and manage conflicts
• Better ability to network with external groups to maximise the outcomes of their research efforts.

Another way of describing these improvements is as follows:

Flexibility --willingness and ability to tackle a variety of small and large tasks, often outside the area of initial training.

Clear thinking--able to sort out the minimum path to a solution, not getting diverted by interesting side issues.

Rigorous experimental work--being able to distinguish the significant from the insignificant, and to utilise the scientific literature and other people's knowledge effectively.

A high degree of creativity and lateral thinking--being able to think 'outside-the-box', to add value to other ideas and to seek for synergy and synthesis.

How could postgraduates be improved?

Improvements should include:

• Better assessment of students entering the degree and design of an individual-based program. This program would focus on developing competencies (see below) other than the technical knowledge gained prior to the degree. Such a program would take up less than 10% of student time and should have regular progress reviews.

• Greater emphasis on encouraging students to participate in managing bodies (eg conference organising, learned associations, leisure activities, etc, to gain practical team skills).

• Assessment, selection and training of supervisors for greater consistency in mentoring to ensure higher quality and a broader context for the postgraduate. Concentrate on supervisors with working linkages. Give greater recognition to supervisors and make sure that adequate time is allotted for supervision.

• Demand a broader knowledge base than postgraduates are currently getting.

• Improved preparation and training for personal and career development. Include more formal consultation with other types of organisations during the degree.

• Make a serious attempt at providing relevant work experience. The best graduates are those from so called 'sandwich' courses, which incorporate theory, practical and 3-12 months experience in enterprise.

• Actively encourage mobility. Discourage postgraduate continuation in the same organisation. Overseas experience should be included whenever possible. Introduce collaborative elements of the research project which force mobility.

• Improve postgraduate degree assessment criteria. Examine students on how well they have been trained, not only on what they have achieved. The current specifications are too imprecise and lead to variability and generally lower quality.

• Nurture leadership and team skills in *both* staff and students.

• Encourage real inventiveness with focus on creativity and lateral thinking tools.

• Develop a better understanding of the requirement to protect intellectual property for the development of industry and investment in Australia. Replace the old 'publish or perish' objective with the three plus two new 'P's': 'perform, patent if pertinent then publish or perish'.

• Ensure that departments and individuals are all *outcome oriented* (rather than output driven) and the emerging general need for a ruthless focus to the problem under consideration is understood and emphasised.

Training recommendations

There are several major initiatives in training which must be considered. Training in specific areas and topics need not require a lot of time. Short sessions with regular follow-up are probably more effective. In most cases we are encouraging a short intensive awareness training and not expecting 'rolls royce' perfection. It is awareness and preparedness that count. Most enterprises highlighted the following areas as being central to better preparing postgraduates for life after the PhD:

• Supervisors must be adequately trained in the skills and techniques of supervision and mentoring.
• Whenever possible encourage greater work experience and mobility of both students and supervisors.
• Training in teamskills and teamwork is critical.
• Postgraduate students should receive training in critical path project planing and management.
• Training in problem solving/decision making should be provided early in the degree for development of these skills, and improving the quality and timeliness of research.
• Broader training in verbal and written communications, selling and negotiation with attention to diversity.
• There must be training on protecting intellectual property and managing the publication versus patent imperative.
• Occupational Health and Safety and Good Laboratory Practice (GLP) training must be provided. GLP should be incorporated into undergraduate courses and linked to current laboratory work.
• Diversity awareness sessions would prepare the postgraduate to better assimilate into a world dependent on functioning through inter- and multicultural linkages.
• More concentrated training is required for experimental design, statistics, interpretation of findings, modelling techniques and creativity.
• Simple grounding in finance, risk management and return on investment, which would demystify economics and business for postgraduates. This knowledge is important in both personal, higher education and enterprise environments.

In what way are the needs of enterprise/higher education similar or different?

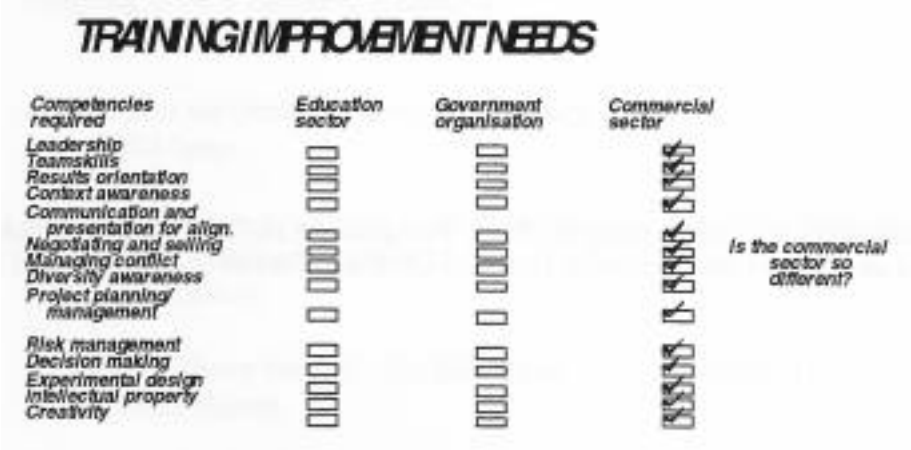
There are many similarities in the needs. The differences are more related to degree and priority rather than absolutes. Due to the pressures noted above-- increasing collaboration, funding patterns and mobility--we will see a greater degree of convergence.

There are two main types of research which fulfil different purposes:

• Applied projects, often instigated at the request of enterprises.
• Fundamental/theoretical projects which push back the boundaries of science.

The skill and competency base required to drive this research is similar, although the knowledge base is often different. Higher education must be at the forefront of new ideas and developments, and be pushing forward the frontiers of knowledge. Enterprises must be strong at converting these ideas into meaningful benefit. Both encounter the challenges and rewards of utilising diversity.

Thus, we see similar skills and competencies serving a value-adding 'organic system' with its roots in knowledge. Enterprises are clearly the customer of higher education and depend to a large extent on the output from higher education. Consequently, there is a strong future for the PhD graduate where the choice is to have a base in higher education, enterprise, or more excitingly, in both. A simple way of testing the thesis of convergence of competencies is to assess the following competencies consistently reported from enterprises as being important. Are enterprises unique in the required competencies? Definitely not.



Final thought

A recent Joint Business/University Workshop hosted by the Business-University Forum of Japan (Tokyo, October 1996) focused on graduates and postgraduates in Japan, US and Canada. The findings and observations on preparedness for careers and interaction between higher education and enterprise were remarkably similar to those discussed above for Australia. While it is interesting to discover that other nations have similar concerns about the quality of PhDs we must not get complacent. Because of our situation noted in the introduction it is imperative that we get more effective outcomes from our investment in the PhD; we are working from a weaker base if we are to become a knowledge-based nation.

It is essential for the future of Australia that our best talent moves into science and technology. Our future quality of life and economic success will depend on developing access to such talent in both the higher education and enterprise sectors. It is vital to stress that for a postgraduate student a career in enterprise is extraordinarily stimulating, offering great opportunity for working with cutting edge R&D, contact with global networks and diverse directions for personal development.

Examples of jobs currently part of the career development of PhDs in enterprise are shown in Fig 10. There is *definitely life after a PhD!*

Figure 10: Opportunities in enterprise

This discussion is partly extracted from ‘Postgraduate skills: a view from industry', presented by Julian Clark to the Australian Deans of Graduate Studies (Adelaide, April 17,1996).