ISSN 0028-8667

New Zealand Science Review
Vol 63 (2) 2006

Official Journal of the New Zealand Association of Scientists
P O Box 1874, Wellington
www.nzas.rsnz.org
A forum for the exchange of views on science and science policy.
Editor: Allen Petrey
Production Editor: Geoff Gregory

Contents

Cover photo: Promotional bookmark for Paul Callaghan and Bill Manhire (Eds) 2006. Are Angels OK? The Parallel Universes of New Zealand Writers and Scientists. Reproduced by permission of the publisher, Victoria University Press, Wellington

Foreword

In this issue of *New Zealand Science Review* we have a contribution to the policy debate on New Zealand science funding and two articles looking at factors affecting potential entrants into the science professions.

In *Finding the better way,* Geoff Chambers of Victoria University of Wellington points out that, for practising scientists, the result of recent science reforms has been a large-scale investment of energy and resources in chasing money rather than doing experiments. Morale in CRIs has been eroded because staff constantly fear losing their jobs and face a real or perceived risk when putting applications that might be seen as falling 'outside the square'. Morale in universities has been seriously eroded by poverty and compliance burdens. And, an altogether unnecessary tension has developed between CRIs and universities due to a real, or more often imaginary, competition for resources. In his paper Geoff identifies areas that our scientists might all be able to agree on and shows how these can lead to a relatively simple but compelling set of remedies.

In *Science as a career choice for the Y generation* by Jacqueline Rowarth and Virginia Goldblatt, the characteristics of the Y generation (born between 1981 and 1995) are discussed, and consideration is given to what the scientific community and research organisations might do in order to become a workplace of choice. In doing so, the authors build on the trilogy of papers on the role of science in New Zealand's innovative future published in *New Zealand Science Review* earlier this year. Jacqueline and Virginia remind us that the requirements of recruits will change as members of the Y generation come into the workforce. Only by continuing to meet these requirements will New Zealand research organisations be attractive.

While concerns are expressed that too few young New Zealanders are aspiring towards study and career pathways related to science, secondary school subject enrolment data gathered by the Ministry of Education indicates that a relatively high proportion of secondary students are still taking at least one science subject in Year 13.

The critical juncture is a student's transition to tertiary studies. This is pointed out in *Staying in science: Choices at the secondary/tertiary transition* by Rachel Bolstad, Josie Roberts and Rosemary Hipkins, of the New Zealand Council for Educational Research. Any endeavour to support students to widen their science interests and career horizons needs to engage both the affective *and* cognitive aspects of their decision-making. Additionally, as Rachel and her colleagues indicate, all students, even those who have a 'serious' interest in science, express a lack of knowledge about the range of science-related tertiary and career options available to them. More significantly, students do not know how they might access such choices.

In view of these findings the New Zealand science community has an important role to play in ensuring that students are aware of the current study and work opportunities in science, and that they have the skills, enthusiasm, and the right support to continue making good decisions about their careers.

Allen Petrey
Editor

Editorial

Marsden Fund allocation issues

The Council of the New Zealand Association of Scientists is a strong advocate for the adequate public funding of fundamental research in New Zealand and is of the opinion that the Marsden Fund Council has little to apologise for in the manner in which it allocates funding for this purpose. Criticism of the allocation process arises from time to time and NZAS notes that this seldom proves to be soundly based; it often arises from a misunderstanding of the nature of fundamental research and the process used to fund it. NZAS believes that the current level of funding needs to be increased substantially to a point where fundamental research claims about 10% of the research vote. The modest suggestion in the last paragraph of Dr Garth Carnaby's article (p. 51) that Marsden be resourced progressively to allow the funding of one in five qualifying researchers who apply (instead of the present abysmal rate of one in ten) is a suggestion that NZAS urges government to heed. Such an investment in excellent research will certainly bring national as well as international benefits.

The Marsden Fund was established in 1994 to support excellent research and researchers, and is distinguished by the fact that it is not subject to priorities set by government. The fund provides for long-term and sometimes serendipitous aspects of research which may lead to profound or unexpected discoveries. It may catalyse significant developments in previously unrelated and strategically important fields of knowledge. In the 2006/2007 financial year the Marsden Fund Council allocated $39.1 million to 78 new projects.

The specific objectives of the fund in the terms of reference are to:

- enhance the underpinning knowledge-base in New Zealand and contribute to the global advancement of knowledge;
- broaden and deepen the research skill-base in New Zealand; and
- enhance the quality of the research environment in New Zealand by creating increased opportunity to undertake excellent investigator-initiated research.

Marsden has been administered by the Royal Society of New Zealand since 1995, having been housed briefly with the Foundation for Research, Science and Technology. Sir Ian Axford was the inaugural Chair of the Fund Council (then Committee), followed by Dr Diana Hill and Dr Garth Carnaby.

Hamish Campbell
President, NZAS

Viewpoint

Finding the better way:

A contribution to the science policy debate stimulated by the May 2005 discussion document from the New Zealand Association of Scientists

Geoffrey K. Chambers

School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington

Last year the NZAS Council provided an influential analysis of the New Zealand science funding scene (Campbell et al.*, 2005), with a later update (Lillis, 2006). They presented a series of recommendations based on a large volume of contemporary public commentary in this area and invited feedback on their opinions. This article is written by a practising research scientist with extensive experience in chasing funds from diverse sources, and a long-term interest in domestic policy relating to the administration of science. It was originally prepared as a direct response to the above sources but has been widened to embrace subsequent developments in government policy. My approach is to identify areas that our scientists might all be able to agree on and show how these can lead to a relatively simple and compelling set of remedies along the lines suggested by NZAS and others. It is my view that these are only partly addressed by previous commentators and only partially remedied by the present round of policy reforms.*

Introduction

Concern surrounding the extent to which science is funded in New Zealand and the ways that these resources are distributed have been vexed issues for many years. For instance, in 2003 *New Zealand Science Review* devoted an entire double issue, Vol. 60 (2–3), to this topic, and members of the NZAS Council recently drew on this and other information to present eight recommendations in a discussion document (Campbell *et al.*, 2005). In my view, these authors did the New Zealand science community a great service with others by focusing attention on this topic once again at what would seem to be a critical moment. These opinions have certainly come to the attention of government, and policy changes have been signalled by the Ministry of Research, Science and Technology (MoRST) and the Foundation for Research, Science and Technology (FRST, see later). Thus, it seems essential that these recommendations and the associated policy changes, together with their associated supporting arguments, should be given all due consideration by scientists, administrators and legislators alike if New Zealand as a whole is to develop an effective 'knowledge economy'. It is my appraisal that the general thrust of the original NSAZ recommendations was well directed, but that they are not always clear (or perhaps not clearly achievable) and sometimes may not have gone quite far enough. The same may also be said for the newly proposed changes to the FRST funding scheme. Below, I present my reasons for arriving at this assessment. However, it is first necessary to lay out the platform on which these stand. In doing so, I hope to capture what I take to be received wisdom in the debate by presenting a set of frequently quoted facts and of commonly held opinions about them that I think many scientists might be willing to affirm.

The core issues seem clear to all

Private investment in RS&T is much too low for comfort, and the public science sector is so under-funded that it cannot hope to compensate. There are several good reasons for this situation including: historical lack of RS&T culture in some commercial sectors, scale of operation, inherent difficulties in capturing RS&T outputs, etc.—often termed *low absorptive capacity*. Many large multinational companies with extensive RS&T programmes do operate in New Zealand, but these ventures are largely focused on selling products to the New Zealand public and do almost all of their research overseas. A well-supported Government RS&T effort is not only essential to conduct projects for fragmented industries that cannot effectively do so on their own behalf, but also to collect long-term information in the national interest. The move to concentrate this effort in the Crown Research Institutes (CRIs) was part of the public sector reforms of the 1980s and intended to promote better links between users and providers. Their establishment was traumatic and CRI staff anxieties have been perpetuated by the FRST funding treadmill.

The perpetual dilemma of New Zealand's universities is perhaps best described as *Paradise Lost*. Ever since the reforms

Geoff Chambers is Reader in Cell and Molecular Biology in the School of Biological Sciences at Victoria University. Dr Chambers runs a set of extremely wide-ranging research projects across three programme areas: human evolution and health, conservation biology, and microsatellite biology. He has long-term interests in science policy in New Zealand and has previously contributed articles on this subject area for *New Zealand Science Review*. The present article is stimulated by recent events and draws on recommendations originally made by NZAS Council. He may be contacted at Geoff.Chambers@vuw.ac.nz

of the late 1980s, they have progressively moved even further away from the previously more favourable situation where salaries were index-linked to those of backbench MPs, most if not all deserving students got research scholarships, research work was funded internally (without the need for extensive grant applications), and large equipment was generously provided by the former University Grants Committee (a.k.a. *The Three Wise Men*). In addition, the NZ Lotteries Board could be depended upon to provide those vital small cash injections so necessary to get new initiatives going or to support students. Other more specialised agencies such as the Health Research Council (HRC) and philanthropic organisations such as World Wildlife Fund (WWF) catered for the more extensive needs of individual research sectors. For some unknown reason there were never anywhere near enough Postdoctoral Fellowships in the system, but this must seem a small blemish in a perhaps nostalgically idealised, but now long vanished, world (see Judd (2005) for an amusing encapsulation of the present challenges facing researchers).

Present solutions just seem to create new problems

Nobody doubts that the old DSIR was not sufficiently closely aligned with the interests of those who depended on the results of its work, nor that it hosted some notoriously inefficient elements. Equally, nobody can deny that external peer review of proposed work and accountability of outputs can be good means (within reason) for putting such things right. These services were supposedly provided by the FRST funding system. Regrettably, this otherwise well-intentioned institution seems to have produced a climate of chronic terror for CRI staff, whose salaries are regularly put at apparent risk with each round of applications. It may also have successfully excluded potentially valuable and legitimate players from significant pools of so-called Public Good Science Fund (PGSF) money, since it could not afford to do otherwise without actually making CRI staff redundant—a.k.a. *unintentional loss of capacity* (an intriguing euphemism). Many feel that the process encourages unimaginative low-risk proposals and results in outputs whose uptake by end-users cannot be reasonably assessed (all inflated claims, a.k.a. *aspirational statements*, to the contrary made in original proposals notwithstanding and with due recognition that this view is strongly disputed by applicants and funding agencies alike). In general, CRIs have tended to see universities as dangerous competitors who have the decidedly unfair dual advantage of relatively secure personal salaries paid through Vote Education and the opportunity to undercut on bids by using research students as a source of cheap labour. One reaction, arguably an over-reaction to this last concern, has seen some quite senior CRI managers make exaggerated suggestions that CRIs are the only places where MSc and PhD students should be trained, since it is only in their laboratories that the next generation of researchers can do work directed towards the national interest and where they will have access to the best resources and supervision. Nothing could be further from the truth.

As originally conceived, the Marsden Fund[1] was intended to bolster the public good investment portfolios by providing 5–10% of the budget for basic (a.k.a. *blue skies*) research in areas that supported the applied work of CRIs. In the event, it was almost entirely captured by the New Zealand universities which are particularly good at this sort of exercise and which are desperate for money. However, with a subscription rate around 5–7% investigators can only expect to get a Marsden Fund grant once every fifteen to twenty years or so. Continuity of research effort is difficult to maintain under such circumstances and is not encouraged. Resources have been lost since full-time equivalents (FTEs) and associated overheads for academic staff are double funded by Vote Education. Although overhead charges have become a fact of research life and may well be necessary, they were never part of the deal when plans for the Marsden Fund were first developed by Ian Axford. The correct allocation of these resources within universities is widely reported as a serious problem by grant recipients and one that the Royal Society of New Zealand, which administers the Marsden Fund, still does not seem to have to got to grips with effectively.

Fundamental research has recently been stimulated by the establishment of several new limited-term 'Centres of Research Excellence' (CoREs). In principle, these are an excellent idea, since their substantial resources supposedly free up some of our best minds to concentrate on what they do best—excellent and imaginative research, rather than wasting time on low-return grant applications. In practice, they can work well and promote co-operation between disparate organisations, as the outstanding example of the McDiarmid Institute CoRE illustrates. Unfortunately for those outside of CoREs, those inside them are still competing aggressively and very successfully in the Marsden Fund and other schemes (see Marsden Fund Update #33, Dec. 2005, for abundant evidence of this practice).

The situation in the New Zealand universities continues to deteriorate, salary levels erode in an atmosphere of industrial unrest stimulated by limits placed on equivalent full-time student (EFTS) funding and an anachronistic belief that they are in a situation of white-hot competition with one another. Hence, they continue to streamline their operations and to squander millions on needless glossy advertising in their efforts to recruit a greater share of students. There are some signs of improvements with increased salary offers (AUS, 2006a) and the recently announced changes to Tertiary Education Commission (TEC) policy (Cullen, 2006a, b). Although there is no clear evidence that the proportion of EFTS funding devoted to research has actually been shrinking, my own experience has seen a marked recent decline in available operational budgets. The new Performance Based Research Fund[2] (PBRF) would seem to be an ideal tool to identify and ring-fence this part of the EFTS budget. It is also intended to redistribute it to those whose track records suggest that they may be best placed to take advantage of the extra resources. The PBRF process itself is fundamentally illogical, since it is based on asking how well past behaviour conforms to a set of criteria that academics were not aware of at the time and allocates investigators to quality

[1] The Marsden Fund is one of 11 funds through which the Government funds research, science and technology. It is administered by the Royal Society of New Zealand (RSNZ) to support research in any field of science, including the physical, biomedical, ecological, engineering, social sciences and the humanities (see www.rsnz.org.nz).

[2] The PBRF is managed by the Tertiary Education Commission (TEC), and the new funding arrangements are being phased in between 2004 and 2007. It is progressively replacing the current EFTS (equivalent full-time student) 'top-up' funding for research (see www.tec.govt.nz).

categories according to arbitrary rules that were established before the data were collected (not a very scientific process). Direct inspection of the setup suggests that universities are big places containing many investigators and that the law of large number averages will apply. Fine-tuning may be the best that one can hope for and achievable only at great cost of time, effort and administrative expense.

The PBRF has also boldly decided to estimate 'research quality' via peer review as well as measuring quantity. The majority of nations with comparable schemes (such as the UK and Australia) limit their ambitions to compiling the latter statistic and find this task difficult enough to achieve well. Indeed, the UK Research Assessment Exercise (RAE) will be carried out for the last time in 2008, then moving to an even simpler metric-based system (AUS, 2006b). Many academics in New Zealand hold privately that the PBRF will not survive another round. The Australian Research Quality Framework did not even manage one round before being put on hold until 2008 and sent back to the drawing board, due to widespread confusion created by the original version (AUS, 2006c). In contrast, the scientists themselves are usually content to let history in the longer term be the judge of quality and regard continuity of recent output as being of greatest significance. I doubt if anyone can tell you if it is better to write ten papers each ten pages long than one of one hundred pages. I tend to favour the former, but not always. New Zealand university scientists are now locked into a sort of *prestige publication culture* by PBRF rules and must balance efficient submission of articles to 'best-fit' journals, following established trends and models v. the more risky route of going for 'high impact factor' journals. Academic managers and PBRF scores certainly seem to encourage the latter route, despite the costs associated with rejection and resubmission elsewhere.

In summary, for practising scientists the result of recent reforms is a large-scale investment of energy and resources in chasing money rather than doing experiments. Morale in CRIs has been eroded because staff constantly fear losing their jobs and face a real or perceived risk when putting in applications that might be seen as falling 'outside the square'. Morale in universities is seriously eroded by poverty and compliance burdens. An altogether unnecessary tension has developed between CRIs and universities due to a real, or more often imaginary, competition for resources. Everyone is worn down by a culture of excessive accountability and a particularly corrosive one where accountability equals compliance, rather than a simple record of performance; see Tallon (2005) for further commentary. These collective experiences have brought forth some admirably clear expressions of concern—which do in turn seem to have been heeded, at least in part, by our Government.

Picking the best and simplest remedies

The box below shows some suggestions for remedying these problems.

The better way—some suggestions

1. Increase the total national RS&T budget as a fraction of GDP well ahead of the competition, i.e. to take a predetermined place on the OECD continuum ahead of advanced nations of similar size and recognise that the private sector component may always be relatively low.
2. Combine residual PBRF, FRST, Marsden, and CoRE budgets into a single pool held by a single ministry (probably MoRST), but retain specialised agencies like the HRC and allow new ones to arise as later needs dictate.
3. Return a sufficient fraction of this pool to institutions as *research capability funding* to cover salaries and a small proportion of running costs—sufficient to keep minimal efforts of all individual employees ticking over and to ensure that existing data get analysed and reports get written (a.k.a. *the science backbone* concept).
4. Create a single new agency to distribute the remaining funds (two rounds per year) to small-scale, short-duration (1–2 years) and medium-scale, medium-duration (2–3 years) projects plus large-scale, long-duration (3–5 years) integrated programmes (e.g. as at present with CoREs). The application procedures associated with these awards should be minimal, but commensurate with the resources requested. A record of past productivity under the funding scheme is the essential prerequisite for entry with the exception of young researchers and/or other new entrants.
5. Include full overheads in awards and allow for these costs in the national RS&T budget. Staff FTE time should not be charged by any currently employed CRI staff under any circumstances (since they are now by re-definition 100% FTE research committed), nor by university staff unless they can show that the 30% or greater of their time originally paid for by Vote Education (and henceforward by PBRF funding) is already devoted to funded research projects. Independent researchers without other visible means of support should be allowed to claim up to 100% FTE and overheads from their awards.

   Some simple individual-based prescriptive limits will need to be set in place to guard against oversubscription. These types of rules are most effective when they employ a combination of quotas (as the Marsden Fund presently does) and take full account of the time invested by applicant investigators in all externally and internally supported projects (as the Marsden Fund does not do).
6. Make applications for large and expensive pieces of equipment part of, or associate them with, any of the above awards.
7. Encourage commercial interests to invest in RS&T by means of tax incentives (higher if undertaken in collaboration with CRIs and universities).

Why these ideas will work

Recommendation 1

The case for an increased fraction of GDP to be allocated to RS&T (NZAS 1) to promote growth of the knowledge economy is overwhelming, well-recognised and well-supported (Campbell *et al.*, 2005; Tallon, 2005). The advice to *simply throw money at the problem* is rarely popular with governments, but one must recognise that situations can and do sometimes reach the point where this solution becomes compelling. Here we have one such example and there is already sufficient evidence that this reality is acknowledged by Government.

Recommendation 2

This streamlines the process under a single set of decision rules on a level playing field. It retains specialised agencies like the HRC which play a niche role (albeit a substantial one in this particular example) and which seem to be functioning more or less effectively (other public comments and criticisms to the contrary notwithstanding). The philanthropic organisations lie outside this proposed structure and may be expected to continue to play an important role in supporting research areas within the declared limits of their interests.

Recommendation 3

This creates a genuinely level playing field. The CRI staff will once again become secure investigators free to exercise imagination and enter external co-operations. This should automatically promote rationalisation and more efficient use of infrastructure, services and equipment resources (NZAS 3 and 4). This concept is more or less equivalent to that first advanced by NZAS (2006) in response to MoRST (2005a).

It is important that a realistic view of CRIs and the activities of their staff be incorporated into this recommendation. For instance, it should be recognised that many parts of the various CRIs have grown in size since their foundation, reflecting their success in obtaining external contract revenue. The New Zealand Government cannot be expected to foot the entire bill, just to keep up, or better still, improve their own present level of investment. Thus some CRI staff can expect to enjoy only partial research capability funding since the remainder of their salary comes from contracts. This is equivalent to the situation in the universities where their staff effectively contract 50% or greater of their time as teachers for TEC. Thus, under the present recommendation, the CRI managers would be ones responsible for moving their staff between contract and capability funding.

Recommendation 4

This is required following adoption of Recommendation 2, and sets in place a new set of funding schemes matching a range of needs (NZAS 6, 7 and 8). This is similar to FRST's new proposals (see later), but theirs also include provision to negotiate very long-term support. There should be no need for a two-stage application process since the checks and balances contained within the present set of recommendations guard against serious oversubscription.

Recommendation 5

This ensures that the benefits of Recommendations 3 and 4 are realised and removes existing abuses and distortions. It is recognised that some extra degree of accountability will be required to assure that these goals are achieved. For instance, universities need to present a clear accounting trail showing that: (1) the retained salary and basal operating components of PBRF income have actually been spent on research, rather than simply entering consolidated funds, and (2) if staff time has been covered by grants, these funds have been spent on relief staff who can take over duties, such as by providing teaching replacement.

Recommendation 6

This meets a well-recognised need (Tallon, 2005).

Recommendation 7

This seems to be the only practical and realistic way available to encourage the private sector to embrace this very necessary shift in corporate culture (see Lillis, 2006).

A final word with notes on recent developments

My contribution to the science policy debate presented here has been made from the standpoint of a practitioner, and largely supports the NZAS recommendations in Campbell *et al.* (2005), but goes further in some respects, particularly regarding the prescription of detailed remedial mechanisms. I have not considered the way that high-level strategic overview should be exercised by MoRST (NZAS 5), nor how national research priorities should be set and balanced, nor how they might best be directed with respect to more efficient production of commodities v. development of new 'value added' export products. These are complex topics outside the present scope, but I certainly do agree with Campbell *et al.* (2005) in that clear signals need to be given to the research community regarding allocation and re-allocation of resources. One means of achieving this is via a scoring system for grants, with weighting of sections for project quality, fit to strategic objectives, track record of applicants, etc.

In fairness to government, one must recognise that they have devoted a great deal of resources to reform of the science policy area over recent months and years. Many of the problems noted here are well recognised (MoRST, 2005a,b) as are the expressed concerns of professional organisations. MoRST engaged three sets of consultants to review these claims and to further develop strategic options. This resulted in a policy initiative called *Picking up the Pace* which was circulated to selected sector representatives for comment (MoRST, 2005b) and subsequently released as policy in May 2006 under the title *A More Stable Funding Environment*. Key elements include streamlining the FRST application process by pre-screening 'concept documents' and funding very long-term projects (6 or more years) via negotiation together with some medium-term projects (up to 6 years), a reflection of increasing trust in the now mature CRI administrative systems. These were released for consultation by FRST in May 2006 under the title *New Investment Pathways,* a heavily engineered document that has clearly enjoyed an extended gestation period.

The proposed new form of FRST application will be similar to that employed by the Marsden Fund and should be welcomed if it does actually reduce the burden of paperwork. This is not guaranteed, and there are two other potential pitfalls. First, a lack of adequate feedback on concept documents seems almost inevitable, if the Marsden Fund experience is any guide. Secondly, oversubscription seems destined to be managed by a set of complex organisation-based rules rather than a simple individual-based quota system. The mixture of competitive bids with negotiated contracts is novel and the latter seem eminently suited for funding national databases and collections. However, care must be exercised not to re-create the old DSIR Head Office in the process and ensure that CRI staff are not weighed down with a whole new set of reporting requirements—as seems to be implied in the FRST document. Information about the developments is readily accessible from the MoRST and FRST websites (www.morst.govt.nz and www.frst.govt.nz.). An excellent detailed commentary on this period of policy history has already been provided by Johnson (2006).

The initial impact of these announcements has been disappointment followed by further division along traditional lines. Strong claims were advanced that science had been short-changed (Gardiner & Ballagh, 2006) and these were countered with prompt damage control statements from MoRST's chief executive (Anderson, 2006). The early dialogue between the universities and CRIs was arguably entirely predictable from the behavioural history suggested her—a polarised response reflecting entrenched positions. West (2006) opened with the radical suggestion that the CRIs should get a crack at the PBRF funds. Quigley (2006) countered with a claim that the policy was protectionist and effectively locked the universities out of the larger part of the formerly contestable PGSF resources and now tied up in long-term negotiated contracts exclusively with CRIs. It should be apparent from the preceding arguments that the present author sympathises with all of the above assertions, but does not find them contradictory. Indeed, it is one leading intention of this article to point out that some fraction of the PGSF really should be permanently ring-fenced for retention and support of CRI research talent.

It is my closing position that the set of recommendations above deal most effectively with long-standing and widely-shared concerns of professional scientists currently practising in New Zealand and many of those talented people presently wishing to return home from overseas. I look forward to continued outcomes from the Universities Tripartite Forum, which brings staff unions, university employers and government together. New funding of $26M to improve university sector salaries is now assured, but many would have felt more secure along the way to have seen this appear as line item in Hon. Dr Cullen's 2006 budget. Those of us in the university sector also wait to see the wider implications of the new decisions which herald the next steps in tertiary reform (Cullen, 2006a,b).

Acknowledgements

I am grateful to David Lillis, Mike Berridge, Janet Greive and other members of NZAS Council for excellent constructive criticism and directions to valuable information resources during the drafting and revision phases in the production of this paper.

References

Anderson, H. 2006. Getting the best out of science. *The Dominion Post*. Wellington, 2 June 2006.

AUS 2006a. New funding welcomed by university staff. *Tertiary Update 9(22)*; 29 June 2006.

AUS 2006b. Statistics dominate research assessment. Reprinted from the Education Guardian in *Tertiary Update 9(20)*; 15 June 2006.

AUS 2006c. RQF deadlines hamper project. Reprinted from *The Australian* in *Tertiary Update 9(19)*; 15 June 2006.

Campbell, H.; Lillis, D.; Grieve, J. 2005. There is a better way: Eight recommendations on the science system in New Zealand. *New Zealand Science Review 62*: 80–86.

Cullen, M. 2006a. Key decisions to improve tertiary performance. Media statement from Ministry of Tertiary Education 27 July 2006.

Cullen, M. 2006b. Tertiary reform next steps. Speech notes from address to the ITF Annual Conference, Wellington , 27 July 2006.

Gardiner, C.; Ballagh, R. 2006. Science short-changed. *The Dominion Post*. Wellington, 31 May 2006

Johnson, R. 2006. With the Crown Research Institutes? Funding Issues. A paper presented at the Annual Conference of new Zealand Agricultural and Resource Economics Society, Wellington, August 2006.

Judd, W. 2005. The haemorrhaging knowledge economy. *New Zealand Geographic 72*: 2–3.

Lillis, D. 2005. Update on the NZAS Science Policy Paper of May 2005. *New Zealand Science Review 62*: 139–140.

Lillis, D. 2006. The role of government R&D for economic performance. *New Zealand Science Review 63*: 22–27.

Marsden Fund 2005. Marsden celebrates ten years. *Marsden Fund Update #33*.

MoRST (Ministry of Research, Science and Technology). 2005a. A more stable funding environment. A sector engagement paper.

MoRST (Ministry of Research, Science and Technology). 2005b. Opportunities and issues in the research science and technology portfolio: Briefing to the incoming minister.

NZAS 2006. NZAS response to MoRST's sector engagement paper 'A more stable funding environment'. February 2006.

Quigley, N. 2006. Competition vital for science funding. *The Dominion Post*. Wellington, 16 June 2006.

Tallon, J. 2005. How can we improve the performance of New Zealand's science system? *New Zealand Geographic 72*: 8–10.

West, A. 2006. Science funding needs overhaul. *The Dominion Post*. Wellington, 12 June 2006.

Article

Science as the career of choice for the Y generation

Jacqueline S. Rowarth [1] and Virginia Goldblatt [2]
[1]University of Melbourne, Victoria 3010, Australia, and
[2]Massey University, Private Bag 11-222, Palmerston North

Attracting students into science careers in New Zealand could become increasingly difficult in a global environment. Only by meeting the requirements of potential recruits will New Zealand research organisations be attractive, and the requirements of those recruits are changing as members of the Generation Y come into the workforce. This paper presents information on the apparent employment requirements of the Generation Y, and suggests how the research organisations can present employment opportunities in order to become known as good employers. The importance of culture and leadership is emphasised, as well as living up to the statements made.

Introduction

As the present workforce ages, attracting vibrant, energetic, passionate, motivated, creative and able youths as replacements will be vital for business, industry, and nation. Members of the Y generation (born between approximately 1981 and 1995, but dates vary slightly according to authors in different countries) fit this description—by their own admission. While Baby Boomers, the employers, might look for evidence to justify this statement, they show their age in so doing. The Y generation is one to which we will increasingly need to be adjusted, and census data suggest that, by 2010, they will be coming into the workforce at half the rate that the Baby Boomers are leaving it.

Those currently employed in scientific research know that to be successful one has to be vibrant, energetic, passionate, motivated, creative and able. Scientists create new knowledge, and in so doing change the behaviour of society: change in behaviour is the litmus test of creativity (Robinson & Hackett, 1997). Scientists need flair and imagination in order to be creative, and to combine that with a knowledge of how things work. This ability has been gained through years of education—school, a degree and ultimately a doctorate—during which the cynic might say that more and more is learned about less and less. In fact, during the process, the researcher gains not only the knowledge, but also the skills which enable future 'eureka moments' (Rowarth, 1998).

It is the latter aspect that has not been explained to Generation Y appropriately and presents science organisations with the challenge of recruitment.

This paper discusses the characteristics of Generation Y and considers what the scientific community and research organisations might do in order to become their workplace of choice. In doing so, it builds on the trilogy of papers on the role of science in New Zealand's innovative future published in *New Zealand Science Review* earlier this year (Rowarth *et al*., 2006 a,b,c).

Generation Y characteristics

Generation Y members want a good income without working long hours: they believe in work-life balance. In a survey of more than 37 000 graduates in the USA, Universum Communications (an employer-branding specialist consulting firm) reported that the number one career goal was to 'balance personal and professional life' (Gerdes, 2006). Members of both the Baby Boomer generation and Generation Y have what they consider to be a strong work ethic (Levy *et al*., 2005), but there appears to be a 30 hour per week difference in what that work ethic means to them (Sheahan, 2005). In fact, according to Sheahan (2004), members of Generation Y do not believe they need to choose between having a balanced lifestyle and professional success: they want, and expect, to be able to have both.

Jacqueline Rowarth is Director, Office for Environmental Programs, at the University of Melbourne, Australia. She is also a member of the Board of Directors for Crop and Food Research, and on the Advisory Board for the Australian Centre of Excellence for Risk Analysis. Jacqueline was President of the New Zealand Institute of Agricultural Science from 1999 to 2003 and is a Companion of the Royal Society of New Zealand and a Fellow of the New Zealand Institute of Agricultural and Horticultural Science. From 2007 she will hold the Foundation Chair in Pastoral Agriculture at Massey University. Currently she may be contacted at jrowarth@unimelb.edu.au

Virginia Goldblatt is a senior lecturer in Dispute Resolution in the Graduate School of Business at Massey University, New Zealand. She has also been practising as a professional mediator since 1994 and was Vice-President (mediation) of the Arbitrators' and Mediators' Institute of New Zealand (AMINZ) from 1997 to 1999. She is an accredited member of the AMINZ panel of mediators, a Fellow of the Institute, and a committee member of the New Zealand Chapter of the Australian and New Zealand Education Law Association.

Generation Y members also want responsibility before they have experience; they want challenge but expect the rewards to be immediate (Sheahan, 2005). Eighty-three per cent of graduates in Generation Y expect to receive promotion within two years of starting the job: 63% expect promotion within one year of starting (Fairfax, 2006). If expectations are not achieved, they will leave. Australian data suggest that 63% of Generation Y members stay with an employer for less than two years (whether this ties in to the 63% who expect promotion, and perhaps don't get it, has not been explored).

Further points to consider are that members of Generation Y do not like being managed, but complain if 'they don't get to learn enough' (Sheahan, 2005). They do want personal career development (indicated by 63% of respondents in a Fairfax survey this year), and are used to the concept of a mentor (they have grown up with TV programmes such as Teenage Mutant Ninja Turtles and Morphin' Power Rangers, where mentors played a significant role). They don't, however, necessarily want to hear about somebody else's past experiences (Heath, 2006). A Linkme.com.au workplace survey, reported in the media in May 2006, indicated that two-thirds of Generation Y employees believe that they don't receive enough attention in the workplace. In contrast, two-thirds of Baby Boomers think that the Y generation receives quite enough. Members are, according to the Robert Half Finance and Accounting white paper, motivated by personal fulfilment. 'What's in it for me?' is a repeated question, and they would rather not have to work out the answer to that question for themselves.

Although work-life balance rates above salary in their desires, salary expectations are high (as are regularity and frequency of promotion). They want feedback, but regard critique as criticism. They want independence, but three-quarters of 20- to 24-year-olds still live at home, even though only 35% are participating in education (Sheahan, 2005). AustraliaSCAN (the annual monitor of cultural and social change in Australia) reports that half of those Australians between 18 and 30 are uncommitted to a mortgage, and two-thirds live at home.

It is easy to over-generalise, but the literature supports a change in employee behaviour with Generation Y. The Y generation has no clear understanding of the differences between 'need, want and desire', they are inclined to divorce effort from reward, and the concept of short-term pain for long-term gain is foreign to them (Sheahan, 2005). At present, Generation Y constitutes 20% of the population, but only about 5% of the workforce. With 95% of the workforce thinking that rewards come after hard work, the old ways of considering people still have a place, but as the employee mentality changes, employers will need to adapt. A survey from the Society for Human Resource Management found that 76% of America's workers are thinking about looking for another job (Seitel, 2005). HR Consultancy Hewitt's study of Best Employers in Australia and New Zealand in 2005 found that 75% of organisations were experiencing a talent shortage, with 52% of employees thinking about leaving their current organisations. Already 70% of HR managers state that employee retention is a primary business concern (Monster Inc., 2006) and 40% report an increase in employee turnover during the past 18 months. SEEKNZ reported this year that 26% of respondents in an online survey would 'change jobs at the drop of a hat'. Although HR managers currently find employee retention a business challenge, long-term demographic changes, which include Baby Boomer retirement, have the potential to aggravate the situation.

In addition to the different norms, beliefs, and values of those now entering the workplace, there is the current level of employment in New Zealand and Australia. This means that the war for 'talent' is global (Rowarth *et al.*, 2006c). New Zealand already has one of the lowest rates of unemployment in the world (now 3.6%) and an OECD report in 2005 indicated that New Zealand has greater than 20% of its tertiary educated workforce overseas. Of further concern is that, according to a World Economic Forum Executive Opinion Survey in 2000, New Zealand has been ranked 45th in ability to retain talent: perception becomes reality.

Recruiting and retaining talent requires tolerance, technology ... and other talent (Florida, 2005). Australia ranks 12th on Florida's Global Creativity Index, and New Zealand 18th. Sweden, Japan, Finland and the USA top the index, and are described as 'global talent magnets'.

In a period of low-single-digit unemployment, almost the only people unemployed are either unemployable or those unable or unwilling to work. In this environment, Generation Y members who are bright, able, talented and equipped with a university degree will have their pick of jobs in any country. In Australia, 81% of graduates in 2005 gained full-time employment within four months of graduating, according to Alexander Mann Solutions, and global skill shortages mean that Australian organisations are being urged to expand their recruitment programmes to ensure that they remain competitive (Coakley, Alexander Mann Solutions, pers. comm. 2006). The challenge for New Zealand research organisations is to ensure that they become talent magnets—that they have the right culture to ensure that students aim for a science career right from school. This will mean ensuring that the Generation Y members **know** that the research organisations have the right culture.

Decision making in school

Participation in school science subjects in New Zealand is at the European Union norm: just over 50% of all students do at least one science subject. However, the numbers taking two or more subjects are much lower—less than a quarter of the cohort in New Zealand in 2003 (Hipkins & Beals, 2004). The prerequisites for a science degree in the 1970s were 'biology, physics and chemistry'. Developments in the curriculum in the last few decades mean that (a) there is more choice and competition between school subjects and (b) that it is possible to complete a BSc (at least at some universities) without taking chemistry or physics.

A study in 2005 for the New Zealand Universities Science Council reported that students choose to study science at university because they are genuinely interested in the discipline – they have internal motivation to become involved in a science-based career (Koslow, 2005). External motivators, such as salaries and prizes, did not rate highly in choice, yet the highest motivator for deciding to work overseas was reported to be 'higher salary' (linked both to earning enough to pay back the student loan, and to avoiding it).

Recent research commissioned by the Ministry of Research, Science and Technology (Hipkins *et al.*, 2006) supports the Science Council research in that factors influencing students to stay in science can include personal interests, broad decision-making orientation, family background, positive learning experiences (both inside and outside the school environment), type of school attended, and knowledge of potential science careers. Of the 546 students surveyed at school, 33% were considered to be serious science students (planning to take science subjects at university and have a traditional science-related career), 23% were taking science and business (usually a combination of physics, calculus and computer science as well as commerce subjects), and 44% were studying a mixture of subjects which tended to include biology/agriculture with other subjects but not mathematics.

Perhaps of greater importance are the reasons students choose **not** to do science at university. Reports on this have not yet appeared in the research literature, but press comments abound (e.g. from Universities' Students' Associations, the *Guardian Education Supplement, Education Review,* and *Campus Review*). The issues boil down to the fact that many bright school leavers are doing the calculation of time and cost of **any** degree against eventual salary: science does not stack up well. A further factor against science is that it is a laboratory-based programme. For the average student, working over 17 hours a week in paid employment is normal (data from University of Melbourne surveys)—and it becomes difficult to fit laboratory classes into the schedule. British research by the Training and Development Agency for Schools (TDA, 2005) has shown that 40% of graduates aged between 21 and 27 will change their chosen career within 5 years, and 71% within 10 years. Furthermore, 38% of Generation Y are opting for a portfolio career, made up of part-time and entrepreneurial ventures (Paul Stevens, WorkLife, pers. comm. 2006); in North America, 51% of the workforce does not work full-time for any single employer. The comparable figure in Australia is 28%.

Governments on both sides of the Tasman are considering reducing fees in 'areas of national importance'. They have not yet come to grips with the fact that today's students have lifestyles to support, and so most are in paid employment. According to Teenage Research Unlimited, American teenagers have more than $100 a week in discretionary income, and media comments suggest that Trans-Tasman teenagers are not far behind. This being the case, it will take more than 'no fees' to attract the student who is not already determined on a career in science—it will take a 'living' bursary.

Of even more importance, however, is the perception of careers in science, and opportunities from a science degree. Cornell research in 1995 (Motluk, 1996) indicated that over 80% of managing directors in the top 500 companies in the USA regarded 'gold collar workers' as those with a science degree and a postgraduate qualification in business. If this mentality becomes apparent in New Zealand, science enrolments will increase.

Best practice in recruitment

BusinessWeek (Gerdes, 2006) reported that companies from different industries are competing for the brightest and best. Generation Y members are far more open to career experimentation than previous generations, and, recognising that a good student can do anything, top companies are no longer restricting themselves to recruiting from their traditional degree qualifications. Almost half the new-entrants in financial services companies Lehman Brothers and JPMorgan, and almost a third of those at Goldman Sachs, are liberal arts students.

To assist with encouraging students into science at university, research organisations need to become known as good employers, and to be active in recruitment. In the Universum Communications survey of over 37 000 graduates in America (Gerdes, 2006), successful recruitment was reported to be increasingly achieved through internships. More than 50% of new recruits to Goldman Sachs in 2006 were former interns, for instance, in comparison with almost 40% in 2004.

Identifying promising recruits early has been the strategy of many industries for some time, but often through the form of fees bursaries. Holiday and academically credit-bearing internships are becoming popular with students, industries and universities, as a way of gaining work experience and, eventually, a position. Research organisations can build profile by creating more summer short-term research positions, and ensuring that the 'interns' are treated appropriately. This will mean more than harvesting trials and sorting the mail—they will need to be able to be involved in research over which they feel some creative power. They should also be given responsibility for an experiment or trial from beginning to end so that they feel they have contributed to an understanding of the whole project.

BusinessWeek also reported that the top companies for graduates paid well (starting salary is still the most important factor for 44% of graduates in the UK (UK Graduate Survey, 2006), rating equally with job content), had superior perquisites, gave new employees opportunities early and often, and had extensive training programmes (estimated at nearly US$10,000 per recruit). They also had flexible and 'not long' working hours. These aspects are advertised in advance (using, for instance, space on coffee-sleeves; raffles via text messages which publicise career opportunities; and ' pizza ambassadors' – undergraduates hired to provide classmates with pizza served on the advertising material during exam time). The companies make sure that they deliver on their advertising promises. This is extremely important to Generation Y members: if the brand promise and the brand delivery don't add up, they move on (Sheahan, 2005).

Current theories in retention

Human Resource specialists, Retention Solutions, suggest that employees can be considered as Explorers, Professionals, Experts, or Passionate (Retention Solutions, 2005).

Explorers have not decided on their professional orientation and are ready to change jobs frequently in order to find a job in which they are happy. Most of the Generation Y members are in this category, resulting in predictions that they will have approximately 22 'careers' (Sheahan, 2005).

Explorers are those who need constant stimulation and challenge. The requirement for external stimulation (and responsibility) is already becoming apparent in advertising—a company or product being the answer to the 'who will inspire me, who will challenge me, and give me the confidence to be what I want to be…' questions. It is also apparent in the factors which make graduates rate some workplaces more highly than others (Gerdes, 2006). For instance, surveys of good working places by Hewitt Associates Surveys from 2000 to 2004, have identified several common features in top workplaces (Thompson, 2006). The features include excellence in leadership, focus on performance and results (including performance-based rewards, recognition systems and formal management structures). This allows employees to feel they are making a difference, and ensures that they are acknowledged for their contribution. Investment in the accelerated development of workers, open lines of communication, high levels of employee engagement, competitive remuneration and a strong push for work-life balance are also important.

Leadership is key in employment culture, and the suggestion has been made that employers must move from 'effective' leadership (considered appropriate for members of the X generation) to 'inspiring' leadership for Generation Y (Henry, 2006). Generation Y members need constant stimulation, reassurance and praise in order to perform. In fact, they need what Lester Levy, the Chief Executive of the Auckland University-based Leadership Institute Excelerator, terms transformational leadership—where bosses treat people 'like hearts and souls rather than heads and hands'. The alternative is transactional leadership and this is common in New Zealand. It focuses on goals and objectives and on telling employees when something has gone well or wrong. It usually results in disengagement, and a disengaged workforce is not happy or productive. Levy refers to an international study of 90 000 workers and 235 companies that shows that regular informal and meaningful feedback is associated with a nearly 40% increase in performance and a 20% rise in discretionary effort. In comparison with this, there was a negative impact of almost 30% in people who had had their weaknesses highlighted in an annual performance review.

The attractive science workplace

Making science organisations attractive to the Generation Y employees is a matter of matching their perceived requirements with what can be offered. The starting point is that research is of benefit to society—and 27% of the 37 000 graduates surveyed by Universum Communications said that their main career goal was to make a contribution to society (Gerdes, 2006). In the USA, the 'doing good' is regarded positively for government agencies, such as universities and research organisations, where jobs are associated with 'reasonable hours and solid benefits'. This is not, however, perceived to be the case in New Zealand (e.g. Sommer & Sommer, 1997; Hay, 2002). The Science, Technology and Industry Outlook (OECD, 2004) indicated that OECD countries needed to address a number of challenges. These include reforming public research systems and ensuring adequate human capital. Fixing the former will assist with the latter—public research systems must offer careers associated with status, security and salary (discussed in Rowarth *et al.,* 2006a,b,c).

Building on the worth of the work to society, research organisations must ensure that they have the six dimensions of high-performance work systems described by Keith Macky, Massey University, from a sample size of over 10 000 workers. The 'dimensions' were identified as a fair promotion process, few status differences, accurate performance appraisals, regular constructive feedback on performance, information sharing, and inclusion in decision-making. Creating such a system lifts job satisfaction, commitment, trust in leadership, and ultimately performance, for everyone.

The biggest need in a job, indicated by 63% of respondents, was on career development. Furthermore, in the August 2006 Fairfax survey on what reward would be most valued for a job well done, 38% of respondents listed 'extra training for further career development (with 28% wanting time off work). Generation Y is focused on career as well as personal development, while valuing independent thinking, freedom to choose, and mentoring. Members respond well to personal attention, and so are good candidates for postgraduate education. They are, according to the Robert Half Finance and Accounting white paper, motivated by personal fulfilment: this means that employers will need to provide reward programmes rather than just salary in order to retain staff. In research, this may well mean building on the summer employment positions to put people through honours degrees, and then PhDs, the latter on full salary. Following the degree, further development can be through conferences (which should be regarded as professional development) and short courses (again professional, and possibly personal, development). Treating these as a formal process will assist with the development requirements of the Y generation.

Management training

To ensure the culture in which Generation Y members will thrive, employers need to be investing time and money in current and future managers—creating open cultures which can enable development of management and leadership. This means helping them to listen more and talk less, encouraging them to learn how to give constructive feedback on both good and poor performance, creating positive working environments, where employees are encouraged to be the best they can be, without fear of 'tall poppy' pot-shots or retaliation. Inclusive approaches to problem-solving by involving employees across the organization must be the norm. There must also be a move from command and control leadership to more inclusive leadership, engaging employees at all levels (Thompson, 2006).

This enlightened and flexible approach to leadership will also play a crucial role in the retention of staff. It is commonly said that people come to jobs but that they leave managers and this will only be more likely over the next decade.

Conflict is inevitable in the workplace, and if Generation Y members are to be restrained from simply walking out when they strike difficulties, negotiation and mediation should be developed as core competencies in the environment in which this generation of scientists will work (Ertel, 1999).

As Peter Sheahan (2005) says, 'Generation Y will thrive in the team environment that is genuinely inclusive and open to their ideas and viewpoints. It is going to be a scary challenge for managers to provide a forum for genuine expression of employees' points of view, especially from people half their age. But they will have to. Generation Y will demand it. If you don't give it, they will either march into your office and just do it, or they will begin looking on www.seek.com.au for a company that will.'

Conclusions

Motivators for Generation Y employees have been identified (Sheahan, 2005) as culture, team, management style, flexibility, conditions, and salary. Given the basic statement that a significant proportion of Generation Y want to do good for society, research organisations can build on this foundation to create a workplace culture that acts as a magnet for talent. In the CRIs there has already been a move away from hierarchical age-based structure. It is also the case that staff have been funded through PhDs and into professional development, and that some of the CEOs have inspiration rather than management as their style. As a group they now need to be shaking off the legacy of the 1990s and promoting science as a vibrant career with a myriad of opportunities ahead. Some have already embraced the challenge.

References

Ertel, D. 1999. Turning negotiation into a corporate capacity. *Harvard Business Review, May-June*. 10 p.

Fairfax 2006. MyCareer monthly surveys. www.fairfax.com.au

Florida, R. 2005. *The Flight of the Creative Class*. Harper Collins, New York.

Gerdes, L. 2006. The best places to launch a career. *BusinessWeek online 18 Sep*. www.businessweek.com accessed September 2006.

Hay, J. 2002. The career challenge for employers in science: the current situation in Crown Research Institutes. *In*: Rowarth, J.S.; Sutherland, G.P. (Eds): Preserving New Zealand's wealth-generating capacity. *Royal Society of New Zealand Miscellaneous Series 62*: 47–50.

Heath, R. 2006. Please just F* off it's our turn now. Pluto Press, London.

Henry, A. 2006. The changing face of the workforce and intergenerational impacts. A thinkpiece prepared for ICVET (TAFE NSW International Centre for Vocational Education and Training Teaching and Learning). 8 p. www.icvet.tafensw.edu.au Accessed 12 September 2006.

Hipkins, R.; Beals, F. 2004. *Students' choices of Year 12 science disciplines: what do we know?* New Zealand Council for Educational Research, Wellington.

Hipkins, R.; Roberts, J.; Bolstad, R.; Ferral, H. 2006. *Staying in Science 2: Transition to tertiary study from the perspectives of New Zealand year 13 science students*. Ministry of Research, Science and Technology, Wellington. 92 p.

Koslow, S. 2005. If creative scientists sustain New Zealand's knowledge economy, how is science education doing? Waikato: Report prepared for the New Zealand Universities Science Council.

Levy, L.; Carroll, B.; Francoeur, J.; Logue, M. 2005. The generational mirage? A pilot study into the perceptions of leadership by generation X and Y. *Hudson 20:20 series*. 37 p.

Monster Inc. 2006. Retention strategies for 2006 and beyond. Monster Intelligence. http://Intelligencemonster.com Accessed 1 September 2006.

Motluk A. 1996. If you want to get ahead get a science degree. *New Scientist 30 March*: 10.

OECD (Organisation for Economic Co-operation and Development) 2004. Science, Technology and Industry Outlook 2004. 15 p. www.oecd.org Accessed 15 July 2005.

Retention Solutions 2005. Generation Retention. www.retentionsolutions.com.au Accessed 29 August 2006

Robinson, R.; Hackett, J. 1997. Creating the conditions of creativity. *Design Management Journal Fall*: 10–16.

Rowarth, J.S. 1998. Passionate minds. *New Scientist* 2142: 54

Rowarth, J.S.; Goldson, S.L.; Lambie, T.C. 2006a. The role of science in New Zealand's innovative future. I. Economic development. *New Zealand Science Review* 63: 5–9.

Rowarth, J.S.; Goldson, S.L.; Lambie, T.C. 2006b. The role of science in New Zealand's innovative future. II. Innovation, research and development. *New Zealand Science Review* 63: 9–11.

Rowarth, J.S.; Goldson, S.L.; Lambie, T.C. 2006c. The role of science in New Zealand's innovative future. III. Recruitment and retention of talent. *New Zealand Science Review* 63: 12–16.

Seitel, S. 2005. Generational Competence. Work and Family Update, Essay, December. 2p. www.workfamily.com Accessed 3 March 2006.

Sheahan, P. 2004. Gen Y is about more than just supply & demand. www.petersheahan.com Accessed 1 September 2006.

Sheahan, P. 2005. *Generation Y: Thriving and Surviving with Generation Y at Work.* Hardie Grant Books, South Yarra.

Sommer, J; Sommer, D. 1997. Profiles: a survey of New Zealand Scientists and technologists. *Royal Society of New Zealand miscellaneous series 43*. 60 p.

TDA (Training and Development Agency for Schools). 2005. Career moves lead to the classroom. www.tda.gov.uk Accessed 18 September 2006.

Thompson, J. 2006. Employers of choice need good leaders. Department of Employment and Workplace Relations www.DEWR.govt.au Accessed 28 August 2006.

Article

Staying in science:

Choices at the secondary/tertiary transition

Rachel Bolstad, Josie Roberts and Rosemary Hipkins
New Zealand Council for Educational Research, P O Box 3237, Wellington

Science policy-makers and the science community sometimes express concerns that too few young New Zealanders are aspiring towards study and career pathways related to science. However, secondary school subject enrolment data gathered each year by the Ministry of Education indicate that a relatively high proportion of secondary students are still taking at least one science subject in Year 13. This information led the Ministry of Research, Science, and Technology (MoRST) to identify the transition point between Year 13 and the first year of tertiary studies as an important point of decline in participation in science education. In 2005, MoRST commissioned us to undertake research to investigate two key questions:

- Why do students choose to continue with sciences in Year 13 of their school studies?
- Why do students plan to take up (or not take up) sciences in their tertiary level studies?

Underlying MoRST's commissioning of this research was an implicit policy question: Are there ways to support or influence young peoples' choices and pathways so that they continue to participate in science at least to tertiary level education, and perhaps into their careers? This article outlines some key findings from the research NZCER undertook to address these questions.

Methodology and framing

To investigate the decision-making of New Zealand Year 13 science students, we designed a national survey which was completed by 496 students from 20 randomly selected New Zealand secondary schools. In addition, we convened ten focus group conversations with Year 13 science students in five purposively selected secondary schools around the country (involving 45 students in total). All the students who participated in the research were taking at least one science subject in Year 13 and were very near the end of their secondary schooling (Hipkins *et al.*, 2006).

Our study was preceded by a review of existing research on young peoples' decision-making with respect to both secondary science, and tertiary studies (Hipkins & Bolstad, 2005). Overall, the literature suggests a complex interplay of factors influence students' attraction to science, or to particular branches of science, including: how relevant or interesting these subjects are in relation to the students' current lives and interests; how much encouragement students have had to continue with those subjects; whether students feel they are able to succeed in learning in the sciences; how relevant sciences are to students future study and career interests; and students' (or their families') perceptions about whether science subjects are 'stra-

Rachel Bolstad is a research project leader at New Zealand Council for Educational Research (NZCER). Her research interests include: environmental educational, school-based curriculum development, science education and the role and potential of ICT, multimedia and e-learning in education. Rachel may be contacted at rachel.bolstad@nzcer.org.nz

Josie Roberts commenced with NZCER in July 2005. Most recently she was a Research Fellow at Victoria University of Wellington, and further back combined tertiary study with a variety of research positions across government and non-government organisations.

Rosemary Hipkins is a senior researcher at NZCER. Her research interest include: curriculum and assessment, secondary and science education, and public involvement in science and technology.

tegically useful', for example, as a gateway into 'high status' or restricted-entry tertiary pathways (e.g. Brown *et al.*, 2005; Koslow, 2005; Lyons, 2004; Stewart, 1998; Worthley, 1992). As well as the variety of more-or-less explicitly considered factors that contribute to students choosing to continue to learn science, research suggests it is also important not to overlook less visible, more subtle influences (e.g. cultural or socioeconomic) that shape, constrain, or encourage certain kinds of choices and make particular pathways more available to certain types of students. These factors may act to subtly dissuade young people from seeing themselves as people who *could* have a pathway in science.

Whether conscious or unconscious, students' ideas about who they could be in the future, including what kinds of job they might want to have, seem to be important in shaping their decisions in senior secondary and tertiary level study. One recent longitudinal study proposed a variety of different 'choice trajectories' among students as they move through the final few years of secondary school. Cleaves (2005) found that some students had identified a career goal early in secondary school, and tended to funnel their subject choices through senior secondary school to lead them towards this career. If science was not the focus of this early career goal, the students did not pursue it at senior secondary level. Other students kept their subject options broad, gradually gravitating towards particular subject areas as they became aware of their own strengths, interests, and breadth of choices. These students often eventually dropped science because they found it boring, or irrelevant, or lacked confidence in their science abilities. Other students juggled images of themselves in a variety of career roles, including science, and often chose an area other than science not because they no longer liked science, but because they had developed a stronger taste in other directions.

Overall, the existing research suggests that there are no simple 'models' for understanding students' decision-making with respect to secondary and tertiary studies. As outlined next, our research endorses this picture of complexity, suggesting no one policy initiative will be sufficient to address issues of ongoing recruitment of young scientists.

Patterns in New Zealand students' subject choice combinations

Even at secondary school, 'science education' actually encompasses a broad range of learning areas. In Years 11–13, these include: science, biology, chemistry, physics, earth sciences, astronomy, agriculture, and horticulture; as well as other subjects classified in the 'technology' domain, such as biotechnology, computer science/ICT, structures and mechanisms, or electronics and control. The choices students make about *which* sciences to study in senior secondary school have implications for the branches of science that students can easily move into in their tertiary study. Similarly, mathematics choices made in Year 13 potentially impact on tertiary choices. (Students can choose either or both of mathematics with statistics and mathematics with calculus, or, if their school has taken advantage of new flexibilities offered by the NCEA, they may do some combination of these or another type of a school-designed course.) The ways students combine sciences with *other* subjects also provide some insight into students' tertiary study or career intentions, as we found in an earlier evaluation of MoRST's Business of Science pilot initiative (Bolstad, 2003).

A statistical analysis of our survey data revealed some very interesting patterns in the way New Zealand students were choosing to combine sciences and other subjects at Year 13.[1] Students' subject combinations tended to fall into one of four cluster patterns, and these were associated with interesting differences in students' attitudes to science careers, their future study plans, and some demographic differences.

We called one cluster the **'serious science'** students. They represented 33% of those surveyed, and 57% of them were female. As the name suggests, these students tended to be taking more than one traditional science subject, and at least one mathematics subject in their final year of school. They enjoyed sciences, thought they did well in them, and had a committed intention to study science at university, often with encouragement from parents and teachers. They tended to see their science as leading to somewhat traditional careers, for example in medicine, dentistry, or veterinary science.

The **'science/business'** students (23% of those surveyed, 86% male) tended to choose physics and calculus in combination with some form of computer science/ICT as well as the business-oriented subjects in Year 13. Clearly they were also very able students, arguably potential future entrepreneurs. But they were much more likely to be neutral about their interest in science and science learning, and less likely to see science as a worthwhile career to pursue.

The situation is even more fluid for the other two clusters, which showed different variations on the theme of '**keeping options open'.** Almost half the survey sample had chosen a more 'mixed bag' of subjects and said that sciences were not among their 'top choices'. The 'keeping options open (1)' cluster (predominantly female), tended to combine one or more, often alternative, types of science course with other Year 13 subjects that were likely to include English but not mathematics. In the 'keeping options open (2)' cluster (predominantly male), ESOL[2] replaced English and there was a stronger combination of IT/business subjects with alternative versions of science. Students in these two clusters were likely to be less confident than the other students of their academic ability in sciences, or to be enjoying their science learning. They were also less likely to be encouraged to persevere with science studies by their families, and many of them seemed poised to drop sciences on transition to tertiary, despite the fact that a number of them agreed that science may be needed for their future career plans.

[1] Students were asked to indicate their subject choices across the final three years of their secondary education, from provided lists. Our research experience has demonstrated the advisability of a checklist approach because similar subjects often have different names in different schools (Boyd *et al.*, 2005). Because there are dozens of subjects available in Years 11-13, we limited the tick-box options to core subjects (English, mathematics, and science) and to two other subject areas (ICT and business-type subjects) likely to be of policy interest to MoRST. Accordingly, the responses did not capture the extent to which students were combining science with other subject areas such as arts or languages, for example.

[2] ESOL is an acronym for English for speakers of other languages (see www.cambridgeesol.org).

Implications emerging from the cluster findings

The picture is one of considerable complexity. Overall participation in science at Year 13 may not have declined as much as seems to be the case in some other countries but this is not grounds for complacency. Our findings suggest that a considerable drop in participation rates on transition to tertiary studies is likely. An important policy challenge thus seems to lie in assisting students who are 'keeping their options open' to continue with at least some science as they begin their tertiary studies. But the nature of the options that are actually open will depend at least in part on the specific combination of subjects they have taken at Year 13. With so many subject choices potentially available, access to good advice and ongoing support are vital.

We began our research by asking why students choose science subjects in the final year of secondary schooling and what influences their decisions about whether to take up science at tertiary level. We found that the same kinds of factors impact on decisions about secondary and tertiary studies, with some changes in the sources of information accessed to inform the school-to-tertiary transition.

Figure 1 documents students' perceptions of the extent to which the various sources they accessed had been helpful in making their decisions about tertiary study. Information from universities was rated most positively, followed by students' families, and school careers advisers third. This suggests that policies and practices that aim to increase science participation might benefit from seriously considering the influence that families, not just schools, have in students' decision-making.

Personal interests and experiences, decision-making orientations, family background, schools attended, learning experiences—both curricular and extra curricular—all play a part in the decision-making journey, which often starts much earlier than Year 13. Many are still undecided at the stage of leaving school—some who believe that they are strategically poised to take advantage of opportunities presented to them, and others who feel overwhelmed, unconfident, or restricted in negotiating a pathway beyond school. Figure 2 shows how surveyed students felt about the tertiary study decisions they were facing. It is a powerful reminder that choosing science involves the emotions, not just rational information processing.

Concluding comments

Any endeavours to support students to widen their science interests and career horizons will need to equally engage the affective *and* cognitive aspects of their decision-making. It is food for thought that, whether students knew what they wanted to do or were not sure, many of them—even those in the 'serious science' cluster—expressed a lack of knowledge about the range of science-related tertiary and career options that might be available to them, and more significantly, how they might access such choices. In view of these findings it would seem important to find ways to raise students' awareness of science-related tertiary and career options, and provide them with helpful advice on ways to access such opportunities.

Given the rapidly changing fields of science practice with the emphasis on interdisciplinary research, and the related unpredictability of emerging science and 'hybrid' work possibilities, students and scientists not only need high science-career awareness, but also a good dose of flexibility, adaptability and ingenuity. The New Zealand science community has an important role to play in ensuring that students are aware of the current study and work opportunities in science, and that they have the skills, enthusiasm, and the right support to continue making good decisions about their careers over time.

References

Bolstad, R. 2003. *Evaluation of the Business of Science initiative.* New Zealand Council for Educational Research, Wellington.

Boyd, S.; Bolstad, R.; Cameron, M.; Ferral, H.; Hipkins, R.; McDowall, S.; Waiti, P. 2005. *Planning and managing change: Messages from the Curriculum Innovation Projects.* Ministry of Education, Wellington.

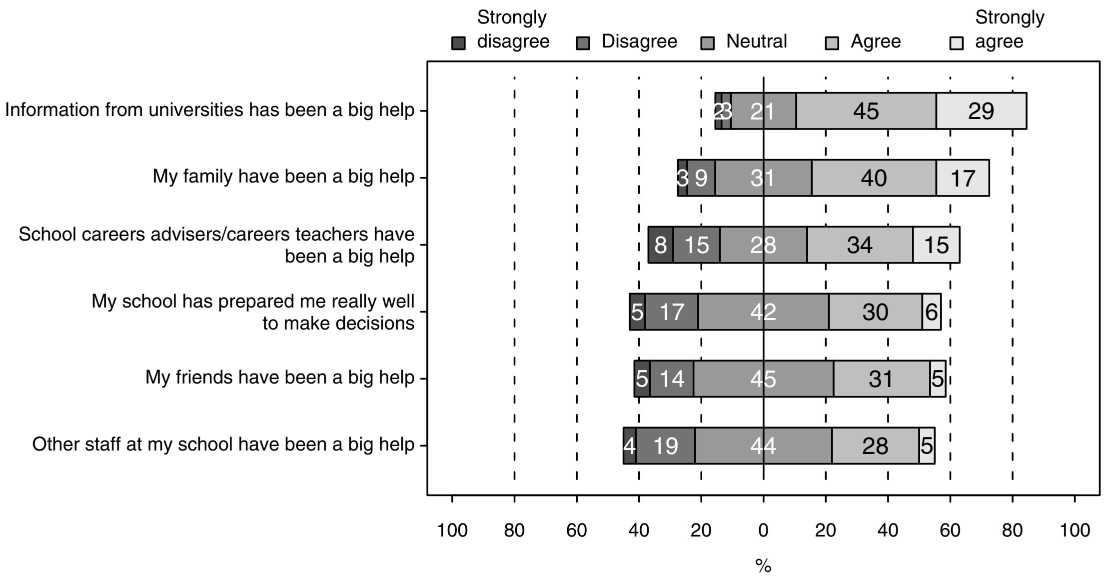

Figure 1. Helpfulness of sources of information concerning tertiary study options

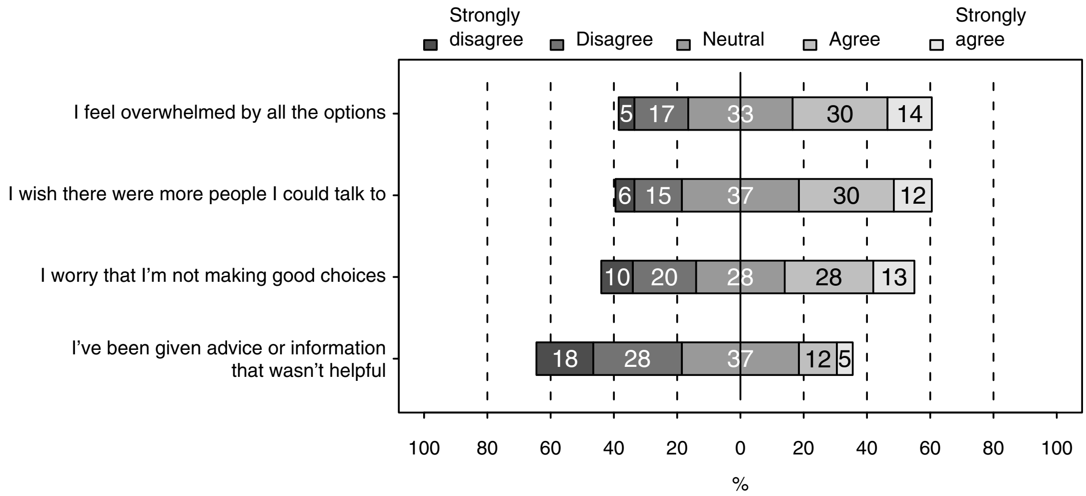

Figure 2. Students' feelings about making tertiary study decisions.

Brown, N.; Koutoulis, A.; Jones, S. 2005. Pre-tertiary science: A critical influence on choice of tertiary course. Paper presented at 36th annual Australasian Science Education Research Association (ASERA) conference, Hamilton, 6–9 July 2005.

Cleaves, A. 2005. The formation of science choices at secondary school. *International Journal of Science Education 27(4)*: 471–486.

Hipkins, R.; Bolstad, R. 2005. *Staying in Science: Students' participation in secondary education and on transition to tertiary studies. Report prepared for Ministry of Research, Science and Technology*. New Zealand Council for Educational Research, Wellington. Available from http://www.nzcer.org.nz/pdfs/14606.pdf.

Hipkins, R.; Roberts, J.; Bolstad, R.; Ferral, H. 2006. *Staying in Science 2: Transition to tertiary study from the perspectives of New Zealand Year 13 science students. Report prepared for Ministry of Research, Science and Technology*. New Zealand Council for Educational Research, Wellington. Available from http://www.nzcer.org.nz/pdfs/14605.pdf.

Koslow, S. 2005. *If creative scientists sustain New Zealand's knowledge economy, how is science education doing?* Royal Society of New Zealand, Wellington.

Lyons, T. 2004. Choosing physical science courses: the importance of cultural and social capital in the enrolment decisions of high achieving students. Paper presented at the International Organisation for Science and Technology Education IOSTE XI Symposium, Lublin, Poland, 25–30 July 2004.

Stewart, M. 1998. Gender issues in physics education. *Educational Research 40*(3): 283–293.

Worthley, J. 1992. Is science persistence a matter of values? *Psychology of Women Quarterly 16*: 57–68.

James D. Watson (Ed.)

Darwin: The Indelible Stamp

Book review by David Penny, Massey University, Palmerston North

This compendium contains four of Darwin's most important books together with a brief introduction by Jim Watson of DNA double helix fame. At one level it is a marketing gimmick to bring together four science classics and a Nobel Prize winner. At a deeper level it brings together four of the most profound and influential books in intellectual history. A continuous theme running through the book is the evolution of Darwin's intellectual journey from geology into biology and into human physical and cultural origins. Could there be a better choice of four books of Darwin? Possibly, but I would only add to the list and not take any away.

The first book is the '*The Voyage of the Beagle*' (2nd edition) published in 1845. This records the almost four-year voyage, from 1831 to 1835, through most of the southern hemisphere. The purpose of the voyage was surveying by the Royal Navy to produce the best possible charts, and Darwin was invited to join the voyage as a naturalist. The Captain of the *Beagle* was Robert Fitzroy, later Governor of New Zealand, and having a naturalist on board gave the captain a fellow gentleman to dine with!

The four years were mostly spent in South America including the Falklands and Galapagos, but then the ship completed the voyage around the world by going to Tahiti, New Zealand, Australia (including Keeling Island where Darwin checked his theory of coral reefs), Mauritius and South Africa. Thence they returned to Brazil and back to England.

At one level this is an interesting travelogue including Darwin's frequent overland expeditions, particularly in South America and including crossing the Andes. Before he left, Darwin had been given the first volume of Charles Lyell's *Principles of Geology*, and told that although there was useful information in it, not to believe the ideas. Lyell's claim that the geological mechanisms studied in the present could explain the past had not been well received by geologists. It was largely based on research in Europe, but Darwin showed that Lyell's highly mechanistic approach was applicable in the Southern Hemisphere and Americas.

February 20th 1835 was as important for the history of science as it was terrible for Concepcion and its port Talcahuano in Chile. A great earthquake, followed by tidal waves, destroyed nearly every house in 70 villages. Disastrous as it was locally, it was an important event for science. Locals pointed out a rocky shore, still with living mussels attached, that previously they had had to dive down to at low tide. Darwin then found a series of raised beaches going several hundred feet above sea level. Later when crossing the Andes he found several examples of sea shells of relatively young geological age right up near the high passes. His guide recommended garlic to help overcome the effects of altitude sickness, but Darwin said he found the exhilaration of finding marine fossils at up to 12 000 feet more then sufficient! These finds were of immense geological importance, they proved beyond doubt the power of Charles Lyell's theory that you could explain past geological events by 'causes now in operation'. Prior to this time the formation processes of the earth were considered unexplainable or catastrophic, but now the same causes Lyell and Hutton found in Europe were seen in all the hemispheres: to the north, south, east and west. At that time Darwin was a geologist, and on his return joined the Geological Society of London and published three books—on the geology of South America, of coral islands, and volcanic islands.

Darwin: The Indelible Stamp; The Evolution Of An Idea. 2005. Edited, with commentary, by James D. Watson. Running Press, Philadelphia, PA. 1260 pp. ISBN 0 7624-2136-3. Hardback Price USD 29.95

While the book describes a voyage that had immediate scientific importance, it also shows the foundations to Darwin's later work. He was surprised by the social structures he saw while exploring the lands he visited and preferred the order and structure he knew from England. On finally leaving South America for home, instead of looking forward to getting home, he launches into a diatribe against slavery, perhaps one of the most brilliant pieces of writing in English.

> *On the 19th of August we finally left the shores of Brazil. I thank God, I shall never again visit a slave-country. To this day, if I hear a distant scream, it recalls with painful vividness my feelings, when passing a house near Pernambuco, I heard the most pitiable moans, and could not but suspect that some poor slave was being tortured, yet knew that I was as powerless as a child even to remonstrate… Picture to yourself the chance, ever hanging over you, of your wife and your little children… being torn from you and sold like beasts to the first bidder! And these deeds are done and palliated by men, who profess to love their neighbours as themselves, who believe in God, and pray his Will be done on earth! It makes one's blood boil, yet heart tremble, to think that we Englishmen and our American descendents, with their boastful cry of liberty, have been and are so guilty:* … (pp. 333–334).

In summary, *The Voyage of the Beagle* is an extremely interesting travel journal, outlines extremely important geological research, and shows the foundations for Darwin's later work on biological and human evolution.

The second book is '*On the Origin of the Species*' (1st edition, 1859). Here Darwin transfers the mechanistic explanations from geology into biology. The two most important are that the mechanisms that can be studied in the present can explain events in the past, and that there are a continuous series of intermediate forms. On the continuity side Darwin six times uses the phrase *natura non facit saltu* (nature does not make jumps). Although used even earlier, the phrase was most often associated with Leibniz, the co-founder of calculus in the 17th century. Biology was now coming in line with mainstream science that had already accepted continuity.

It is useful to think of evolution in three categories: firstly that evolution has occurred, that is *macroevolution*; secondly that the mechanisms of population growth, ecological principles and inheritance are*necessary*; and thirdly that they are *sufficient* to explain past events. Although the first and second points are generally accepted in biology, Darwin's third point, sufficiency of microevolutionary process, is still hotly debated.

Perhaps one of the most striking features of this book is the very large number of biologists whose work is quoted—every page refers to several books and to correspondence with people from all around the world. Although Darwin started as a geologist, following in the tradition of, and following the principles of, James Hutton (late 18th century) and Charles Lyell (1830s) he became one of the widest read biologists. Today with our ultra-specialisation it would be unusual for an individual to understand all of the areas involved. To take an example, a palaeontologist would not usually become fully conversant with ecological principles and population and molecular genetics, before claiming that microevolutionary processes could not explain some feature of the fossil record.

Another notable feature was that Darwin looked for difficult areas that were not easily explained. He continually refers to small experiments where he tests some aspect of evolution. These range from floating seeds on sea water to see how many days they remain viable, to observing the development of muscles in his young children and recording and comparing muscle structure of the human face to that of the great apes. It is not surprising that he could boast that virtually nobody had thought up an objection to his theory that he had not already considered. This is real science in a Popperian sense. In this book, virtually nothing was said about human evolution; this comes in the later books.

The third book is the combined '*The Descent of Man*' and '*Selection in Relation to Sex*' (Second edition, 1882). This book is a monster at 450 pages—definitely too long, but it covers vitally important issues that are still being worked on today. Again Darwin seeks out observations his theory does not appear to explain and then starts his analysis in more detail. For humans it was important to show 'continuity', for example that the great apes muscles, nerves, bones, sense of taste and stages of development could be mapped to those of humans. He was very interested in behavioural traits in animals, and observed his young children very carefully (he worked at home). He noted the development of different behaviours, smile, clutch instinct, 'mental' and emotional states, using sounds for commands, and reflex reactions in young humans, some of which could be seen in other animals. In addition he refers to many studies in animal instincts and behaviour showing that they have many attributes in common, although to a lesser extent, with humans. Interestingly tool use in the great apes was known at that time although the knowledge was lost and 'rediscovered' by Jane Goodall 80 years later. At that time he thought that animals were not 'self-conscious', and that is one area where we *have* managed to progress beyond Darwin.

His conclusion was that animals must have some sense of beauty, for example with the peacock 'preening' and 'showing off' to the peahen. Dogs possess something very like a conscience, knowing they have done wrong and acting accordingly. He considers the evolution of religion and also the evolutionary role of celibacy, which from a biological point of view is meaningless. He ponders:

> *How so many absurd rules of conduct, as well as so many absurd religious beliefs, have originated, we do not know; nor how it is that they have become, in all quarters of the world, so deeply impressed on the mind of men; but it is worthy of remark that a belief so constantly inculcated during the early years of life, whilst the brain is impressible, appears to acquire almost the nature of an instinct; and the very essence of a instinct is that it is followed independently of reason* (p. 699).

Another discovery from this book is the tragedy of classical botany and zoology education. Zoology was extremely badly taught for a century as the comparative anatomy of dead animals, with only occasional forays to living organisms. Perhaps comparative anatomy was Thomas Huxley's 'contribution' to mis-education as it is clear from this book that there was vibrant research activity with living animals in the last half of the 19th century. However, this did not seem to make its way into zoological education until the 1970s.

I had long been aware that the same problem occurred in botanical education, which was dominated by descriptive morphology and life cycles. Darwin's experiments on breeding systems and functional morphology (the physiological significance of different leaf sizes and movements) was simply omitted. There was a brilliant textbook by Lord Avebury (Darwin's neighbour, originally Sir John Lubbock), *Flowers, Fruits and Leaves* (1886), that offered a fully experimental evolutionary understanding of plant morphology. Botanical mis-education was not quite as extreme as the comparative anatomy of zoology that simply omitted functional evolutionary biology. One hundred years of lost opportunity in biological education! Perhaps this still goes on. In biochemistry, evolutionary ideas on origin are still largely untaught.

Yes, in *The Descent of Man* and *Selection in Relation to Sex*, Darwin has written too much. However, there is a huge amount of information, ideas and experiments contained within.

Fourthly there is '*The Expression of Emotions in Man and Animals*' (1st edition, 1872, with ideas since 1838). The continuity between human and animal worlds, starting from the similarities of structure of muscles in the faces of apes and human and how they are used in expressions and emotional states, is further explored and developed:

> *No doubt as long as man and all other animals are viewed as independent creations, an effectual stop is put to our natural desire to investigate as far as possible the causes of Expression. By this doctrine, anything and everything can be equally well explained: and it has proved as pernicious with respect to Expression as to every other branch of natural history* (p. 1073).

Again there are lots of ideas here, many of which are not picked up again until the late 20th century, and although they still may not be solved, are at least now recognised as important and fundamental questions. The following example indicates some of the extensive examples considered around the physical expression of emotion:

> *I took a stuffed snake into the monkey-house, and the hair on several of the species instantly became erect; especially on their tails, as I particularly noticed with the Cercopithecus …*
>
> *I have been assured by a veterinary surgeon that he has often seen the hair erected on horses and cattle, on which he had operated and was again going to operate. When I showed a stuffed snake to a Peccary, the hair rose in a wonderful manner along its back; and so it does with the boar when enraged* (pp. 1114–1115).

The book is a strong beginning to the field of comparative psychology, which is now well established in considering the continuity between the animal and human minds.

The shear number of examples is amazing, highlighting the extensive research in these areas at the time, and marking the start of the breakdown of Descartian dualism. Descartes' division of the world into mind matter and physical matter was important in the 17th century in allowing fledgling scientists freedom from persecution by theologians, although Descartes' ideas were without scientific justification. It is only in the last 20 to 30 years that academia has moved past the Descartian position that human minds are completely distinct from those of animals, and conversely animals are comparable to machines without emotion. This continuity of mind and emotions between animals and humans in no way denigrates humans, but instead makes us look at animals with more respect and appreciation. The book was one of the very first to use photographs, which may have contributed to its popularity at the time of publication.

What we can say about the utility of reproducing the four books? It is certainly a build up to the 150th anniversary in 2009 of publication of *On the Origin of the Species*—expect more! It emphasises again the originality and depth of Darwin's thinking. The book is full of little experiments Darwin did, from the number of young seedlings eaten by slugs, the extent of hybridisation between varieties of cabbage and onion and radish, and thought experiments to imagine the purpose of attributes such as fast running in wolves. One interesting aspect is the hundreds of references to New Zealand throughout the books ranging from evidence that bees are required for pollination, and evidence of an ice age occurring in the southern hemisphere as well as the northern, to the consideration of facial expressions in the Māori.

The four books are a living legacy of ideas, still being developed today. We still need Darwin's emphasis on the unity of humankind, and the need to test ideas to get away from extremist beliefs. We can end with part of the concluding paragraph of the final book:

> *We have seen that the study of the theory of expression confirms to a certain limited extent the conclusion that man is derived from some lower animal form, and supports the belief of the specific or subspecific unity of several races; but as far as my judgement serves, such confirmation was hardly needed. We have also seen that expression in itself, or the language of the emotions, as it has sometimes been called, is certainly of importance for the welfare of mankind. To understand, as far as possible, the source or origin of the various expressions which may be hourly seen on the faces of men around us, not to mention our domesticated animals, ought to possess much interest for us (*p. 1257).

Paul Callaghan and Bill Manhire (Eds)

Are Angels OK? The Parallel Universes of New Zealand Writers and Scientists

Book review by Mike Berridge, Malaghan Institute of Medical Research, Wellington

In this book, ten leading New Zealand writers, helped by a similar number of physicists and mathematicians, explore a range of topics with a common scientific thread. The result is a diverse collection of short stories and poems, informed by science, that not only challenge the imagination, but also generate a sense of fun and mystery.

The brainchild of Glenda Lewis, one of the Royal Societyof NZ's most passionate science advocates, the 'Are Angels OK?' project arose from the 2005 International Year of Physics, which celebrated the centenary of seminal publications by Albert Einstein. These publications changed the way we view 'space-time' and matter. The project was supported by the Smash Palace Fund, an initiative of Creative NZ and the Ministry of Research, Science and Technology, aimed at encouraging convergence between the arts and sciences through creative and innovative endeavours.

There is a certain irony in the way in which Government investment in both the arts and science has paid rich dividends in a relatively short time in the film industry, whereas economic returns from targeted investment in science is proving to have a much longer haul. A closer look reveals that innovative computer technology has played a large part in the success of the creative film industry, pointing to convergence and synergies in the dual investment strategy.

Each different sphere of creative expression is constrained by its own boundaries: the writer of prose by language, the poet by constraints on the use of language, the cartoonist by the requirement to visualise a concept, the scientist by scientific rigour of the concept under consideration, and the mathematician by formulaic constraints of fundamental processes. The struggle to find common ground between these creative endeavours has succeeded in a way that could not have been perceived at the outset of this project. A dialogue first carried out in the public arena here in New Zealand gave rise to the book, and the 'Are Angels OK?' project has recently been on tour in the UK. A planned postscript will expose the project to a secondary schools essay competition.

Although the scientists involved in the project were physicists and mathematicians, in line with the celebration of Einstein's publications, creativity in science has no boundaries and a different masterpiece would have resulted if biology or the human condition had been chosen, albeit with exotic particle names replaced by evocative gene nomenclature or human traits.

It is interesting to speculate about the outcome if the scientist had been the writer exploring creativity and innovation in science, with the artist pushing the boundaries. In some cases, the result could have been rather similar, while in others a very different prose would have emerged. I must admit that at times I felt a little short-changed on scientific creativity.

Paul Callaghan and Bill Manhire (Eds) 2006. Are Angels OK? The Parallel Universes of New Zealand Writers and Scientists. Victoria University Press, Wellington. ISBN 0 86473 514 6. Paperback Price NZD 29.95.

News and advocacy

Marsden Fund – Allocation issues

Garth Carnaby
Chair, Marsden Fund Council

The recent discussion of the Marsden Fund, prompted by a series of articles in the *Sunday Star-Times*, has centred on four issues: the people on the panels, the processes used by the Fund, the topics chosen for funding, and the demand for funding.

Panellists

The Marsden Fund allocates funding on the basis of peer review. Each panel is made up of approximately eight people, who are selected because they are amongst the very best researchers whom we can find in New Zealand. Over a three-year appointment, panellists voluntarily donate hundreds of hours of their time as a contribution to their discipline. When the pool of New Zealand researchers is too small we have used top Australians to sit on the panels, but this option involves an even greater favour being asked by us of them. The cost of allocating the Fund would be prohibitive if panellists were properly recompensed for the time involved. Involving large numbers of Australian panellists would almost certainly soon lead to requests for proper remuneration for providing such a service to New Zealand science.

For many years we have allowed current panellists to apply for funds providing their obvious conflict of interest is properly managed by process (see below). Very few of the top researchers would make themselves available as panellists if they had to sacrifice the opportunity to seek funding for their own research from the only source available to them.

We would expect panellists to be more successful in applying to the Fund than non-panellists since the panellists represent a biased sample. Even so, regular analysis of granting statistics shows that approximately three-quarters of all panellists' own applications still fail. This awful rate of success (approximately 1:4) is, however, approximately three times higher than for non-panellists (approximately 1:12).

New Zealand Science Review is grateful to Dr Carnaby and the Marsden Fund Council for permission to reprint the accompanying article from the *Marsden Fund Update*.

Importantly, this same analysis shows that these researchers are equally successful **before** they join a panel, **while** they are on a panel, and **after** they have left a panel. Quite simply, panellists are better-than-average applicants. Any implication that they influence the awarding of grants to themselves is untrue. The contribution of panellists is highly valued by the Marsden Fund Council, which has no doubt about the integrity they bring to the task.

One of the main complaints made each year by unsuccessful applicants is that the panellists assessing their application lacked either the skill or the intellectual capacity to make the assessment. If panels were to comprise mainly panellists who themselves were incapable of winning a grant, this problem would rapidly escalate out of control. The mana of the panellists is vital to acceptance of the outcome.

In research, as opposed to some professions, there is a high expectation upon participants to contribute voluntarily to peer review. It is part of daily life in research and determines everything from grant approval, to acceptance for the publication of articles, and the award of recognition for achievement. On this occasion, particular panellists have been singled out for tabloid type attention, innuendo, and allegations of impropriety in the media. The Marsden Fund Council condemns the focus on these individuals and regards the inference made about their actions as offensive.

Processes

In a small community, conflicts of interest are inevitable and have always been carefully handled by the Marsden Fund. All panellists have to declare all of their conflicts, in writing, ranging from minor (e.g. an applicant works in the same department as a panellist) to major (e.g. the panellist (or a close relative) is an applicant.). The Fund has processes in place to manage minor conflicts, and to avoid the major ones altogether. The procedures for the 2006 round were as follows.

At the first round, proposals were graded independently by panellists and the scores submitted prior to the meeting. Panel-

Dr Garth Carnaby FRSNZ was appointed Chair of the Marsden Fund Council in April 2005 by the Minister of Research, Science and Technology, having served as Deputy Chair since 2002. He had been an early member of the Council for a term ending in 1997. He is Managing Director of G A Carnaby & Associates Ltd, research consultants, of Christchurch. Dr Carnaby was educated in New Zealand, Australia and the United Kingdom before returning to New Zealand to lead a wide range of research projects involving the application of mathematics and physics to the wool industry. His main speciality has been the mechanics of fibrous structures. He holds various international patents and has published over 200 research papers and articles. The Royal Society of New Zealand elected him a Fellow of the society in 1992 and in the same year he became chief executive of the Wool Research Organisation of New Zealand (WRONZ). Dr Carnaby has extensive governance experience and is currently a Director of the Institute of Environmental Science and Research Ltd (ESR) and a member of both the Society Council and the Academy Council of the Royal Society of New Zealand.

lists with major conflicts did not grade these proposals, and certainly under no circumstances, their own proposal. At the panel meeting, the unconflicted proposals and those involving minor conflicts were discussed first by all panellists and placed in a ranked order. In case of doubt, panellists with borderline conflicts (e.g. was once a co-author or associate), were asked to stay silent or leave the room, depending on the case in point. The cut-off for the second round was then decided, and remained fixed, irrespective of the fate of any conflicted proposals. That is, no proposal was denied an invitation to the second round because of a conflict. Panellists with a major conflict then stepped off the panel in turn and left the room. Their proposal and its relationship to the overall rankings for all proposals was then discussed by the reduced-size panel comprising unconflicted members only. The remaining panellists then recommended on that proposal to the Council via the panel chair. Conflicted panellists did not see their own grades at any point and did not find out the fate of their application until all other applicants were advised of their result. Approximately 73% of all applications come into the unconflicted category or trivially conflicted category, 23% involve a significant managed conflict, and 4% a major conflict which must be and indeed is avoided.

Two independent observers, the Chair of the Council and the Fund Manager, were present to ensure that the process was followed and that no bias or collusion was introduced into any aspect of the assessment. Their particular task was to monitor scoring patterns and verbal contributions of conflicted panellists in setting the original ranked order. Obvious issues such as below average scoring of any or all other applications are checked against. These matters were frankly discussed once any conflicted panellist stepped off the panel. This ensured that there was no opportunity whatsoever for the panellists who were applicants to influence the outcome of their own application.

There is a risk inherent to peer review that any panellist whether conflicted or not could use the scoring system to exercise an undeclared conflict. That is why we have eight scores.

The second round was carried out on similar lines, except that the panellists had the benefit of referee's reports from three top international researchers and the applicant's response to the referees' reports. These reports are critical discriminators at this stage.

Marsden Fund's decision-making processes have been described as 'international best practice' by prominent expatriate physicist, Professor Michael Kelly from the University of Cambridge. An independent evaluation for the Ministry of Research, Science and Technology in 2004 found that, 'The Marsden Fund operates a highly professional process that is well accepted by the scientific community in New Zealand and that would find widespread approval from the equivalent communities in other countries'. And another independent report commissioned by the Ministry of Research, Science and Technology to look at Royal Society contract management found that, 'The processes used by the Royal Society of New Zealand in relation to the assessment of applications are generally viewed by stakeholders as being "gold standard".'

The Marsden Fund Council stands by these processes, which were adhered to in the 2006 round, as being fair to all applicants. None-the-less, when funding is so competitive and the success rate so low, the Council does recognise that the perception of fairness is important too, and has amended the rules for applications from panellists. These were changed in August, several weeks prior to the first *Sunday Star-Times* article, and state that panellists can no longer apply to the panel on which they sit. The Council is aware that this change will make it more difficult to recruit top-rate panellists, and it may be necessary to restrict its application only to the second round of the process.

Research topics

The Marsden Fund selects projects on excellence, as judged by the experts – panellists and top international referees. The idea is to fund the best research, irrespective of topic, as required by the Terms of Reference for the Fund. That means that New Zealand's best minds are free to explore their ideas without any compromise.

The Marsden Fund allocates funding between the various disciplines according to the number of quality applications in such a way that the success rate is largely independent of discipline. This is the policy of the Government.

There has been some comment in the media about the merits of funding research projects in the humanities, at the apparent expense of additional science projects. In fact, the humanities joined the Marsden Fund in 1997, with additional funding from the Government. Professor Ken Strongman, who chairs the Council for the Humanities, has pointed out that the humanities and the sciences are complementary, with the 'knowledge society' requiring a mix of skills, from science and technology through to the arts and creative industries. 'Creative industries are every bit as likely to result from humanities and social sciences research as new industrial enterprises are to stem from discovery science'.

The Marsden Fund Council recognises the strength and benefits of humanities research and will continue to support it so long as it is the wish of Government to support this type of research. The Marsden Fund, however, is strictly to fund scholarly research involving the posing and testing of new ideas. It does not include in its brief, for example, creative performance.

Funding

The Marsden Fund is significantly too small for the demand currently being made of it by our best scholars and researchers. Many brilliant proposals are not being funded. This leads to lost opportunity, inefficiencies, and disappointment. The Marsden Fund Council will continue to make the case for growth of the Fund. We have set ourselves a target of a success rate of 1:5 of the applications made. We appreciate that funding by this most prestigious of funds should necessarily be a rare privilege. However at the current success level of less than 1:10, far too much effort which could be more constructively employed is being wasted or left on the shelf.