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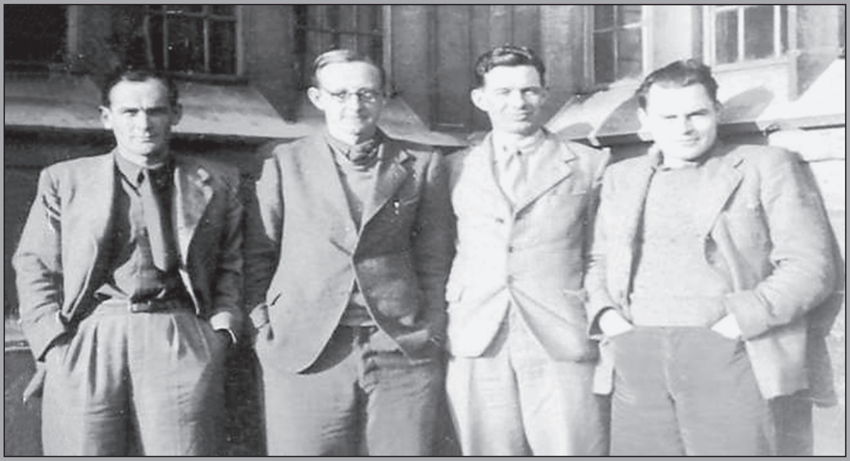

‘Four Musketeers’ at Cambridge

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A forum for the exchange of views on science and science policy.

Editor: Allen Petrey
Production Editor: Geoff Gregory

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Letters to the Editor

Cover photo: Four senior scientists, contemporaries of Dick Bellamy, at Cambridge University, 1946, where they called themselves the 'Four Musketeers': from left, Eric Godley, Ted Bollard, Alan Johns, and Dick Matthews. See page 123.

Instructions to Authors

New Zealand Science Review provides a forum for the discussion of science policy. It covers science and technology in their broadest sense and their impacts on society and the environment, both favourable and adverse. It also covers science education, science planning, and freedom of information. It is aimed at all scientists and decision makers, and the interested public. Readability and absence of jargon are essential.

Manuscripts on the above topics are welcome, two copies of which should be sent to:

The Editor
NZ Association of Scientists
P O Box 1874
Wellington

As well as full papers, short contributions, reports on new developments and conferences, and reviews of books, all in the general areas of interest of the journal, are invited. The journal also accepts reviews of a general nature and research reports.

Full manuscripts (with author's name removed) will be evaluated and authors will be sent copies of the reviewer's comments and a decision on publication. Manuscripts should not normally have appeared in print elsewhere but already published results discussed in the different, special context of the journal will be considered. They should preferably not exceed 2500 words.

To facilitate anonymous review, author's names on manuscripts and any acknowledgement of assistance should be on a detachable cover page. Manuscripts should be accompanied by biographies of not more than 100 words on each author's personal history and current interests. Authors are also expected to supply a suitable passport-size photograph of themselves.

Manuscripts should be typed double-spaced with wide margins on one side of the page. Articles may be submitted in Word for PC, rich text format, or plain text, by e-mail, or on floppy disk or CD-R, but a hardcopy should also be sent so that fidelity may be confirmed. Diagrams and photographs should be on separate files (preferably eps, tif, jpg, all at 300 dpi), not embedded in the text.

All tables and illustrations should be numbered separately – Tables 1, 2, 3, 4, etc., and Figures 1, 2, 3, 4, etc. – and be referred to in the text. Footnotes should be eliminated as far as possible. Diagrams and photographs will be printed in black and white, so symbols should be readily distinguishable without colour, and hatching should be used rather than block shading.

References should preferably be cited by the author–date (Harvard) system as described in the Lincoln University Press *Write Edit Print: Style Manual for Aotearoa New Zealand* (1997), which is also used as the standard for other editorial conventions. This system entails citing each author's surname and the year of publication in the text and an alphabetical listing of all author's cited at the end. Alternative systems may be acceptable provided that they are used accurately and consistently.

In this issue

In this final issue for 2011 we have an array of thought-provoking papers. Leading off is Geoff Chamber's et al. *Publish and perish: A new look at bibliometreic statistics in the PBRF age*. And although perhaps of immediate interest to academics involved in tertiary education, it poses questions and attempts to resolve the dilemma faced by all concerned with finding the best and most ethical way to present reliable evidence concerning the quantity and quality of their published research output and how this may influence their decisions about where to submit their manuscripts.

Rosemary Hipkin's *Public attitudes to science: Rethinking outreach initiatives* begins with an outline of the 2010 MoRST survey of the public's attidute to science (the third such survey this decade) and introduces a range of survey items with their basic response frequencies. It also introduces a segmentation analysis that looked for patterns of associations within each individual's responses.

The second part of Rose's article then asks questions about just what it is about science we might want members of the public to engage with. And finally Rose suggests a different avenue with the potential for making a constructive response to the challenges the survey results highlight. This paper is intended to spark discussion and a re-evaluation of a complex issue – and it does.

Willie Smith once again captures the essence of the life and times of a leading figure in recent New Zealand science history. This time, Emeritus Professor A.R. (Dick) Bellamy, who in 2008 retired after 40 years at the University of Auckland. Preceding this, Dick spent three years (1962–65) as a Research Scientist at the Department of Scientific and Industrial Research (DSIR), completing his PhD while on staff, and then as a 'postdoc' worked from 1965–68 in the Department of Cell Biology at the Albert Einstein College of Medicine in New York. Over his career, as Willie points out, Dick moved from being a 'young radical' to take on a number of significant roles, including Senior Research Fellow in the Department of Cell Biology (1968–74), Associate Professor (1975–80), Professor of Cellular and Molecular Biology (1990–2008), Inaugural Director of the School of Biological Sciences (1991–2001), and Dean of Science (2001–2008).

Dick's reflections on his career remind us that pressures on the science system to meet national goals are not new, introduces us to the 'younger days' of people such as George Pederson, Dick Matthews and Frank Newhook, the development of a research culture in this country's universities, the demise of DSIR, and the rise of the science system we know today. While mindful of current problems, Dick remains optimistic and believes that today – as in the past – the goals set for New Zealand science require the fostering of individual scientists whose efforts, as before, ultimately drive the science system.

And in this vein, the receipents of the 2010 NZAS Awards are Brian Robinson – the Marsden Medal; Ken McNatty – the Shorland Medal; Shaun Hendy – the Research Medal; and Marc Wilson, the Science Communicator Award.

Allen Petrey
Editor

Article

Publish and perish:
A new look at bibliometric statistics in the PBRF age

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There is no doubt that New Zealand scientists are living uncomfortably in a new age of accountability – the so-called 'audit society' (Power 1997). It is scant comfort to know that we are not alone in the world either (Lawrence 2007). This article is concerned with finding the best and most ethical way for scholars and scientists to present reliable evidence concerning the quantity and quality of their published research output and how this may influence their decisions about where to submit their manuscripts.

Introduction

There are clear obligations for transparency and accountability in association with any activity that makes use of public funds. Nothing is new about the need to recognise these values in science and science management. Practitioners have always borne greater or lesser requirements to account for laboratory management, ethical standards, student supervision and fiscal responsibility, etc. These obligations are now writ large in professional life and closely scrutinised by administrators. The latest development has been a request to provide clear evidence regarding the impact and standing of individual research efforts for promotions, etc. Even the status of a most distinguished contributor, like Professor David Penny of Massey University, is commonly reflected via statistics (see Berridge & Petrey 2009).

In New Zealand, the greatest challenge comes in the form of our regular *Performance Based Research Fund* exercises (PBRF, see Box A). This is a serious business because a significant fraction of base funding for tertiary education, c. $239 million in 2009 (www.tec.govt.nz) now comes from this source. A recognisably similar system in the UK called the *Research Assessment Exercise* (RAE) predates the PBRF, but has important differences; namely that the RAE unit of assessment is the department rather than the individual and only involves a qualitative peer review of selected work. Significantly, the RAE is presently moving towards a more quantitative statistics-based evaluation (see Noble 2010). In China, pressure derived from individual assessment practices is claimed to have led to

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Jonathan Gardner is a marine biologist and Director of the Centre for Marine Environmental & Economic Research at VUW. Since his appointment in 1994, Jonathan's research focus has included marine ecology, population genetics and aquaculture. He has served on VUW's internal committees for all Performance Based Research Fund (PBRF) rounds, as well as for the recent VUW internal assessment exercise. At the time of writing, according to his own records, he has published 69 peer-reviewed papers. He has no idea what his *h-index* score is because several of his papers are not listed in the usual databases.

Alastair Smith is a Senior Lecturer in the School of Information Management at Victoria University of Wellington. He teaches courses in reference work, information retrieval, and digital libraries on the postgraduate programme for librarians and record managers, Master of Information Studies. Prior to 1989, he was involved in database development at the National Library of New Zealand, and worked as a librarian in scientific and technical information services. His pre-library careers included school teaching and being a patent examiner. He has a BSc in physics, an MA on the use of expert systems, and is an Fellow of LIANZA, the Library and Information Association of New Zealand/Aotearoa. He has served on various committees of LIANZA. Alastair's web page is: http://www.vuw.ac.nz/staff/alastair_smith/

Box A: PBRF and other systems

Performance Based Research Fund (NZ)

This scheme was initiated by the *Tertiary Education Commission* (TEC: www.tec.gov.nz) in 2002 at the direction of the New Zealand Minister of Education and runs on a six-year cycle. Investigators each submit an *Evidence Portfolio* (EP) which is assessed by expert panel(s) based on their evaluation of data presented in various categories including four selected publications or *'nominated research outputs'*. Individual scholars are rated on their Research Output (70%), Peer Esteem (15%) and Contributions to the Research Environment (15%) by panels of discipline experts who award scores to the EPs. These scores range from A to C in decreasing order of scholastic merit plus R(NE) for *new and emerging researcher* or R for *research inactive*. The EPs contribute 60% to the institutional score for staff research quality plus 25% on external research income and 15% higher degree completion.The guidelines for the 2012 PBRF exercise have recently been published online (www.tec.govt.nz).

Research Assessment Exercise (UK)

This is run every five years on behalf of the various higher education research councils (www.rae.ac.uk) and scores are awarded on the basis of proportions of departmental work*… equating to attainable standards of international excellence…* The RAE ranking system seems to have changed with each succeeding round and is due to be replaced by a system of *metrics* incorporated in the new *Research Excellence Framework* following the completion of the 2008 RAE round.

Research Quality Framework (Australia)

This scheme is intended to measure quality and impact in research in the tertiary sector but has an *off again, on again* history. It seems destined to be reborn as *Excellence in Research for Australia* under the *Transforming Australia's Higher Education System* paper released in 2009 (http://www.dweer.gov.au).

a detrimental migration of scientists away from the important field of biological systematics (Jiao 2009). The PBRF scheme too has many critics. Middleton (2009) has provided a well-argued evaluation of the effect of the PBRF on a 'professional' subject, Education, and Roa *et al.* (2009) present a compelling description of the difficulties faced by Māori research.

The twin dilemmas

Clearly academic scientists face substantial novel complications in their present working environment. In the end, it all comes down to just two key questions: (1) What numeric indicators are most appropriate as evidence of individual scientific achievement? and (2) Where should they try to publish their research findings in order to maximise future scores? This article begins by trying to answer the second question first and includes some best-practice advice regarding the first along the way and in more detail, later. In one sense the answers to both are obvious – always pick the top journals in your field! Surely everyone is aware by gestalt of the standing of each journal and the standard of work one expects to find inside? This may feel like being back at school, where everyone knows how boys in their class rank as playground fighters and which girls are the most popular. So the optimum solution seems simple; keep your records up to date and publish lots of papers in the *best* journals and everyone knows which ones are the *best* journals. This reasoning (popular with some science managers of common experience) amounts to a covert expert system, i.e. one is actually making a series of analytical decisions without being aware of having done so. Naturally, when one tries to be explicit about such decisions and just where to find the best evidence to support them, things may turn out not to be so easy after all. Advice reported from certain managers to *…just quote any favourable statistic to support your choice of publisher...* is unhelpful at best and dishonest at worst.

Selecting a successful strategy

As argued above, the best way to select a successful strategy plus supporting facts and statistics comes down to routinely choosing to submit articles to high-quality peer-reviewed international journals and by showing metrics to prove that the journals are, in fact, high-quality. It also helps if you can show that lots of people want to publish in these chosen journals, which may be easier said than done. Alternatively, one might try to show that the editors are highly discriminating and consistently maintain a high rejection rate, which is not quite the same thing. Or perhaps demonstrate that the journals are influential, i.e. that articles in such publications are frequently cited in other papers as measured by the infamous *Journal Impact Factor* (JIF) – more on this later, and see Box B. Oh, and it helps if you make sure that you are the sole or first author. This is often an impossible condition for senior scientists and project leaders to satisfy, because modern science is frequently conducted via a contingent version of the *multidisciplinary team approach*. These collective criteria for journal selection may perhaps seem self-evident to some, but nonetheless they do bear scrutiny.

Peer review is a given, but how does one know that the reviewers are always of high quality? Here one must probably depend on the unmeasured social profile of the editorial board. Hence, there are no supportive statistics to be found here. International journals are conventionally preferred over national journals in the unvoiced belief that one is playing in a higher league. This may very well be generally true, but can never be taken as a certainty, and the dividing line is unclear. Local preference for overseas journals seems almost to be a defining characteristic of our national psyche. New Zealanders just seem to value recognition from overseas particularly highly. This may simply reflect the people of a young nation struggling for self-confidence. The result is that researchers could find themselves on the sharp end of ill-informed managerial mentoring and directed in no uncertain fashion to submit exclusively to international journals. Failure to do so might even be criticised as … *squandering time and effort*... or not being …*loyal to core institutional values and strategies*…. When followed to extremes, this practice would see the complete demise of domestic science publication!

Competition for entry to pages of a given publication is doubtless some sort of an index of impact/quality of their average article. For any given journal, this competition is some complex function of variables such as submission and acceptance rates, the number of issues per year, pages per issue, and relative numbers of different article types per issue. Admittedly, it is difficult to get comparative statistics that are equally applicable to different journals. There are next to no available statistics for such variables and besides, there may be obvious, or not so obvious, biases to acceptance. In any case, one must question if it really is intelligent behaviour to invest the required effort to submit an article to a prestige journal such as *Science* or *Nature* when one knows in advance that it will start out with a high chance of rejection. Some have even argued that good papers are often eliminated to make room for more newsworthy articles which may not represent such high-quality science (e.g. see Hilborn 2006 for comments on stories about collapsing fisheries). Hence our earlier advice to pick the best journals might be more effective when modified to: pick the highest-ranking sources in one's field and ones where there is a **reasonable** chance of getting them published.

So how can one show that one has picked the *best* journals? Here at last there is verifiable help in the form of various electronic databases and metrics. The best known of these are listed in Boxes B (metrics) and C (databases). Journal influence (or *impact*) is usually taken to be reflected by citation counts. The proposition is that those papers which have been most frequently quoted by other papers have the greatest influence on the progress of science; ditto for the journals themselves. This property is said by many to be captured by the JIF statistic (see informative comments by its inventor in Garfield 1996, 2005). The controversies surrounding this statistic and its application (or more correctly its misapplication) are legion. These include, but are not limited to, the following:

- Should the census period be longer than two years (say five years) to better reflect the regular pattern of citation history?
- Is JIF even a good measure when up to 90% of all citations may be attributed to the top 10–25% of articles?; e.g. see recent comments from the Editor-in-Chief of *Nature* (Campbell 2008).
- Should the JIF be applied exclusively to rank journals (as consistently recommended by Eugene Garfield – see above) or to rank scholars too?

Box B: Journal Impact Factors

The Australian Journal Ranking System

The Australian Research Council (www.arc.gov.au) produced a draft ranked journals list (ARC 2008) to reflect professional gestalt for their planned research assessment exercise. It does contain a few alarming assignments but was in general accord with popular wisdom in rating journals from A* to C, at least for some disciplines, but some in our view, including marine biology, feature some highly questionable rankings. A revised version is now available as part of their 2010 ERA exercise.

Journal Impact Factor

The *Web of Science* (WoS) is an online database available from Thompson Reuters (www.thompsonreuters.com) as part of their ISI *Web of Knowledge*. The JIF for a journal is calculated by counting up all the references to articles in a particular journal contained in other journals in the Thompson Scientific database over a period of two years and dividing by the number of articles published in the focal journal over the most recent two-year census period (effectively the mean number of citations per article).

Journal Citation Reports

The WoS also provides *Journal Citation Reports* (JCR) within various sub-disciplines. While these may simply seem to represent a descending list by Impact Factor, they do provide single compellingly simple statistics. The problem with JCRs is exactly that they depend on the Impact Factor – a score that properly attaches to journals and not authors or articles. This service is now (from 2009) enhanced by inclusion of Eigenfactor assessment of journal influence. The Eigenfactor method is not yet in widespread use, but seems to have promise because it creates scores by weighting citations based on the impact score of the journal in which the citation appears, and covers a huge number of sources (Bergstrom 2007).

Scopus Ranking Systems

The Scopus-based equivalent is *SCImago Journal Ranks* (SJR) and is available direct from the Scopus webpage (http://www.scimago.es). There is a fairly strong correlation between JCR and SJR values (Thomaz & Martens 2009), but Butler (2008) reported a few rather surprising discrepancies between the two in ranking ten top biomedical journals. Their weighted contextual statistic is the Source Normalised Impact per Paper (SNIP).

Box C: Electronic databases

Scopus (Elsevier)

This database requires institutional subscription and the URL will vary depending on one's host institution but a great deal of general information can be obtained from the home page (www.scopus.com). It covers more than 15 000 journal titles from 1996 to 2009.

Web of Science (Thompson Reuters)

Formerly known as the *Institute for Scientific Information* this database covers 9000 specially selected journals which the owners claim include all those of highest impact.

Google Scholar

This is a search engine (www.scholar.google.co.nz) which can recover lists of academic outputs in all sources together with citation information. It has much wider coverage than either WoS or Scopus, but is much less discriminating than either and it is difficult to refine searches effectively. It is not clear if it is safe to treat all citation scores returned under multiple listings as independent.

- Is it necessary to correct JIF scores for missing citations (i.e. those outside the Thompson Reuters database, including all books) and/or incorrectly made or incorrectly credited/duplicated citations?
- Is the JIF a non-linear metric with highly cited articles attracting ever-increasing numbers of citations – including, and perhaps especially, those that are erroneous?
- Would it be better to exclude self-citations from the lead author or his/her research group?

The last question is important in the PBRF environment and also impacts more on how scientists should present their individual citation counts (see below). Individuals are often encouraged to purge self-citations from the records that they supply for assessment exercises. This is viewed as somehow noble or at least as being the best and most ethical practice by avoiding the temptation to inflate scores by citing one's own work. Again it is not quite that simple. On the one hand, if a person wishes to show the extent to which they may have influenced others, then by all means exclude self-citations and those from the same research group. On the other hand, if one wishes to show the extent to which an article has influenced science itself, then self-citations etc. should stay in (if one can assume that authors really did behave ethically in quoting their own articles in the first place).

Indeed, it is clear that the JIF has probably become the most frequently abused bibliometric statistic. Managers often, even routinely, encourage scientists to attach JIF values to their PBRF Evidence Portfolio articles despite the inventor's insistence that this is not appropriate (see above) and as echoed by others too, e.g. by Seglen (1997) for medicine. Brischoux & Cook (2009) protest the tyranny of JIF for junior staff, reflecting similar recent comments and warnings from others (Cherubini 2008; Notkins 2008) who continue a well established critical dialogue (Colquoun 2003; Lawrence 2003). In addition, Cameron (2005) provides a librarian's perspective on the use of this tool. In short, the JIF attached to a journal says nothing for certain about the author(s) or their particular paper, except that they have convinced the editor to publish it in an outlet that has high visibility and that one suspects is also high quality with competitive entry. These latter two qualities are not guaranteed by high JIFs, since scores may depend on the composition of the journal. Those with a larger proportion of review articles may have higher, or even artificially inflated, JIF values.

Where should I submit my next paper?

This is perhaps the most important and challenging question for scientists aiming to enhance their PBRF profiles. It will be instructive to inquire at some later stage to what extent scientific publishing practice in New Zealand has actually changed in response to the introduction of this scheme. Hendy (2010) has shown that output has been static from 1995 to 2008 at the surprisingly low values of c. 0.53 papers/FTE/year for New Zealand university research staff [cf. around 0.75 for Crown research institutes, (CRIs)]. These numbers may undervalue university academic staff because graduate students are included in the FTE calculation. It is perhaps a matter of concern, or at least regret, that the student to staff ratio has declined from 3.4 to 2.7 over this period, which might be interpreted to suggest that the actual publishing outputs of universities themselves may have fallen by approximately 20% over this period as they are training fewer young researchers. It will be interesting to see if this has resulted in improved teaching quality. Interestingly enough, citation counts for both university and CRI scientists have risen steadily during this interval from 1.0 to 1.8 (confusingly called an *impact factor* by Hendy (2010) and not to be confused with JIF). However, these increases must be attributed to the appearance of increasing numbers of journals and articles between 1995 and 2008 rather than the effect of PBRF because the increase is seen in both sectors.

Questions about journal selection also seem to be a rather more widespread issue, and the potential of real or imagined influences of bibliometric statistics on author behaviour are now causing concern (see Lawrence 2003). It would appear to be sensible, even dutiful, to choose publications that might improve one's PBRF ratings in terms of bibliometric statistics. However, simply picking journals with high JIF scores may not be the way to go, and some alternatives are explored below. Further, there is a clear tension between trying to get a paper into high-exposure journals versus a conventional *best-fit* option. In other words, how should one decide between publishing in journals that have high research visibility and journals where the publication may influence science practice, for example in professional journals and local journals? In some instances, moving up to the middle ground and submitting an article to a journal that is a recognised leader in the field may be the preferred answer. At other times sticking with a lower-ranked national journal might be a better way to go, and in our experience often is the right choice for biologists. There is a clear trade-off between quantity and apparent quality. A failed submission to a high-status journal comes at a significant cost (see Lawrence 2007 for a poignant description of the process) which may preclude sending in other articles or seriously delay, or at worst permanently deflect, publication of the original work. It may be that those who do publish in prestige journals publish fewer papers overall (see Brashier *et al.* 2005). Thus, the trade-off seems to become that between being a *team player* and supporting the objectives of employers by trying to secure high PBRF scores, and being a *good citizen* with an obligation to account to the New Zealand public for funds invested by them in the original research work by making the results available for scrutiny in a peer-reviewed source. In the end, scientists probably know what is best for them, not their managers, but it probably would not hurt anyone to get a bit more ambitious once in a while.

A related question arises in connection with authorship and papers where scientists are first (or better still sole) author. These are widely thought to be among those most prized by PBRF panels. Generally speaking, it is, or should normally be, the person who did most of the lab/field work plus perhaps the data analysis and who almost certainly wrote the manuscript that is first author. With a few notable exceptions this is impractical for most senior scientists in academic institutions who most often function as team leaders, rather than bench workers. In some circumstances they may take over the first author role if a major investigator cannot, or will not, write up their original study or if data are being combined from several sources and the team leader does the write up. Review articles are a different matter and senior researchers often take lead or sole authorship on these. Such work does attract high citations, but may not be so highly regarded by PBRF panels and may not be included among Nominated Research Outputs (NRO), despite being products of quite extensive scholarship and significant effort. This seems to be particularly perverse when the PBRF is apparently trying to promote *excellence* and *paradigm changing* science. Reviews and syntheses often provide new insights and can pull together disparate threads in a field and/or make connections across disciplines.

Citation counts and summary statistics

If one elects not to use JIF scores what then are the options? A simple and direct answer would be to use the citation counts associated with each article individually as evidence that they are receiving attention. For instance, it is well known (Garfield 2005) that at least half of all scientific articles are never cited at all, even by their own authors. Hence, if a paper receives any citations at all, it would be fair to claim that it rates as being in the top 50% of all published work. This may not be fully effective for some PBRF purposes, as their census interval of six years is quite short compared with the citation lifetime of most papers (www.isiwebofknowledge.com). Older *citation classic* type articles can be included in the Peer Esteem (PE) or Contributions to the Research Environment (CRE) sections of PBRF portfolios. Further, it may sometimes be useful to roll a full or part publication record into a single summary statistic that allows comparisons with others in the same discipline. The following sections review the various tools for doing both of these tasks and offer advice on exactly how to go about using such tools based on authentic individual experiences. Before starting out, we warn that bibliometric statistics can be very hazardous things. First, one may make an error and underestimate the value of the publication record. Second, and worse still, one may overestimate it and thereby lose credibility. So there is constantly the very real risk that somebody on an assessment panel will check up on values presented to them and come up with different numbers by inadvertently using different tools or search procedures. Such an experience could easily erode the assessor's confidence in the candidate. Hence, the most practical advice that can be offered at the outset of any such exercise is to: (1) do it the best way possible for each individual system; (2) explain exactly what was done; and (3) state when the data were first recovered.

There are three widely consulted bibliometric databases; see Box C. Each one of these databases will yield a list of papers published by particular authors, citation counts for individual articles plus summary statistics that are either generated automatically or which can be constructed by hand from the lists and counts. These are defined in Box D. There are other databases such as PubMed or Aquatic Sciences and Fisheries Abstracts that are field-specific and other less well known summary indices which will not be considered here (see Browman & Stergiou 2008 and other papers in this volume of *Ethics in Science and Environmental Politics*).

Practical applications of databases

In Tables 1–3, data have been tabulated for five researchers representing various career stages and various disciplines broadly focused on biology and ranging from medicine to palaeontology. We also invite readers to go on line and check their own records and see if their experiences accord with those described below. If one is feeling mischievous, one can look up records for Deans or Heads of School, or even rivals for employment or promotion, to discover if justice has been done in terms of comparative research records. Finally, people can assess their imagined standing in the field at large by running comparisons with global leaders or directors of New Zealand's Centres of Research Excellence. The data are all there to do such things and all such searches will almost inevitably turn up a few surprises.

Those who do elect to interrogate the online databases need to be very careful with respect to the search parameters that they enter and to check the outputs thoroughly; see Table 1 for typical results. Records may be missed or duplicated due to variations in the spelling of names and inclusion or otherwise of initials. One also needs to check institutional affiliations carefully to make sure that outputs all come from locations where the search subject has worked in the past and that all such locations are included for a full career record, cf. single employer tally or PBRF census. Equally, one needs to exclude references to those others who have similar names and/or work histories. In general experience, Web of Science and Scopus now seem to perform equally well in this respect. Both of them capture around 60–70% of an individual's published outputs and duplicates or work by other investigators that must often be removed by hand. This process is more easily achieved working in Scopus as individual records can be excluded. However, in fairness to both WoS and Scopus it seems that precision of performance is improving all the time. Google Scholar is seriously polluted with duplicates and cannot be used in isolation for this purpose (e.g. Smith 2008 in a recent discussion of the utility of Google Scholar in the PBRF context). The great advantage that Google Scholar does enjoy is that its output includes citations in books. This is something that neither WoS nor Scopus can do because they search only journals and some conference papers. So one could locate these extra citations using Google Scholar and add them by hand to other scores – given that one has the time to do such things. Finally, readers should be aware that Scopus only counts citations back to 1996, although it will list quite a large fraction of articles published before this date.

It is well recognised that the output counts from Scopus and WoS are strongly correlated (Harzing & van der Wal 2008) so either may be taken alone as an index of citation count. What is also widely recognised by bibliometric experts is that the lists

Box D: Bibliometric summary statistics

The *h-index* (Hirsch 2005) is the maximum number of publications that have the same number of citations. Please note that Scopus returns two versions of this metric: *Author h-index* and *Citation h-index* – see text for details. The WoS database returns only one, which is their equivalent to the *Citation h-index*, but it can be made to output a comparable version of the *Author h-index* by setting the temporal limits on the search field to begin from 1996.

The *g-index* (Egge 2006) is obtained by counting up the first *g* articles that have g^2 citations.

The citation counts returned by both WoS and Scopus are derived from around 110 000 linked journals, i.e. many more than are searched for the source author publication lists. They include historical records, including even those before 1996 for Scopus.

Table 1. Database returns for five New Zealand scientists.

Individual	Scopus			Web of Science		
	Raw	Removed	Total	Raw	Removed	Total
A	96	5	81	121	31[a]	90
B	94	6[b]	88	100	6[b]	94
C	85	0	85	109	2	107
D	51	1	50	59	1	58
E	10	0	10	9	3	6

The values in the body of this table are numbers of papers on the publication list for that individual. The scientists included in the survey include three senior academics: A – full time medical researcher; B – academic staff member with interests in medical and biological topics; and C a conservation geneticist. Individual D is a mid-career marine biology researcher and E is an earth scientist and palaeontologist. They were specially selected as illustrations to ensure representation across fields in a single discipline (nominally biology).

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[a] These publications include a large number of single paragraph conference abstracts.

[b] The Scopus entries include 5 publications belonging to another scientist and one duplication compared with the WoS return, which includes 2 bogus entries and 4 minor publications.

Table 2. Set theory analysis of database returns for five New Zealand scientists.

Individual	Scopus	Common	Web of Science	Σ Global	Σ Citations
A	91	83 (91.7)	90	98 (108.3)	2503
B	88	76 (83.5)	94	106 (116.5)	2757
C	85	75 (78.1)	107	117 (121.9)	1380
D	51	47 (86.2)	58	62 (113.8)	656
E	10	3 (37.5)	6	13 (162.5)	120

The values in the body of the table are publication counts in each class and the numbers in parentheses show the values as a percentage of the arithmetical average of the Scopus and WoS scores.
The Σ Citations value is calculated by taking the Σ WoS citation score and adding to it the total citations recorded in Scopus for those publications captured by Scopus but not by WoS.
Self-citations have **not** been removed for these lists. The effect of doing so is to reduce counts and *h-index* values by up to 10–20% (data not shown).

Table 3. Bibliometric statistics for five New Zealand scientists.

Individual	Scopus				Web of Science			h_{global}
	Papers	Citations	h_{author}	h_{citation}	Papers	Citations	h-index	
A	91	1658	16 (54)	20 (91)	90	2411	26	27
B	88	1394	18 (48)	20 (88)	94	2710	27	27
C	85	1145	14 (70)	18 (85)	107	1339	19	19
D	50	424	10 (46)	13 (50)	58	633	15	16
E	10	123	4 (10)	4 (10)	6	34	2	5

Figures in parentheses after *h* values are numbers of publications from which these values are obtained.

of articles returned by WoS and Scopus overlap considerably, but not completely; see Table 2 where typical values are in the neighbourhood of 80%. Hence, the combined set of articles recovered from the two databases will nearly always be higher by up to 20% than that produced by either search individually. To these counts might be added whatever else in the way of articles and citations might be lurking in the reams of output from Google Scholar. In contrast to the lists of articles, the contents of the WoS and Scopus citation pools may only overlap by around 60% (see also Harzing & van der Wal 2008 for an in-depth commentary) – data from Table 1 were not examined in detail in this respect when preparing our present article but this fact is readily apparent from the scores in Table 2.

It is clear that an opportunity exists for some enterprising webpage software engineer to use a set theory-based approach to combine these outputs and create a comprehensive and accurate citation history for authors and articles. Note that in order to achieve the requisite accuracy the service will have to remove orphan and redundant citations within and between datasets (about 5%, to judge from the data in Table 1). The proposed software would be of widespread utility as the only present alternative is to do such things by hand. If the screening part of the system were to be fast and efficient, it might even be able to recover the missing citations arising from incorrect spelling or poor citation by relaxing the search parameters.

Practical applications of summary statistics

Hirsch (2005) invented the *h-index* (see Box D) which has become the *one size fits all* bibliometric statistic of choice for many scientists. Indeed, it is now often bandied about like a golf handicap. Scientists may find themselves put on the spot by managers who wish to know the *h-index* status of interviewees. So, it may be best to know what these things are and how to recover them properly from the online databases. The *h-index* certainly has a simple enough definition (the maximum number of publications that have the same number of citations – *thus an h-index of 14 means that the author has published at least 14 papers each of which has been cited at least 14 times*), but it often proves to be one that is hard to keep an exact mental grasp on. The idea is that the best scientists publish lots of papers and these get lots of attention. Failure with regard to either of these two desirable properties is not good. Hence, high values for the *h-index* are taken as being characteristic of the very best of scholars. The obvious problem is how to judge those who have aberrant *h-index* scores: the person who has published 50 papers (aka *the unspectacular plodders*), but never received more than 3 citations for any one of them v. the person who only ever published three papers, but who nonetheless may have changed our view of the world (aka *flash-in-the-pan scholars* or worse *cold-fusion types*) – both have the same *h-index* score of just 3 even though the latter scholar may have many thousand citations to their work. The *g-index* (Egge 2006) is intended to remove such distortions – any *g-index* value greater than 10 would be excellent for a biologist (refer to Box D for a definition of the *g-index*). However, it should already be clear that it is unsafe to quote an *h* value or *g-index* unless one knows exactly how to obtain them (see below) and that they should always be accompanied by a wider view of the citation profile on which they were based, e.g. as done for David Penny (by Berridge & Petrey 2009) and see Table 3. The potential effect of *h-index* scores on future careers has been examined (Kelly & Jennions 2006) and we will return to question the value of bibliometrics to assess scientific creativity later.

A quick visit to Scopus and running an *Author Search* will return a carefully sanitised minimum publication list (see earlier). An instant *h-index* can be viewed by activating the *Citation Tracker* facility. This is actually the *Author h-index* (see Box D) although it is not shown as such on screen. On no account should one use this number in isolation because it only relates to publications going back to 1996! That is unless you are a new investigator, but even then approach with caution as it may be lower than the value indicated by visual examination of the citation scores on your publication list. Scopus claim that this form of the *h-index* provides the fairest comparative metric as it has a wide (currently fifteen year) census window and relates to more recent performance. While this may seem reasonable enough to many minds, it does scant justice to the record of mid-career and older scientists who may have achieved significant recognition prior to the Scopus start date. So, for those who might have published papers before 1996, one needs to operate the *Show Documents* function and then select **all** entries on **all** pages by ticking boxes before activating the *Citation Tracker* function. This will now return a new and, one hopes, higher *h-index* value (see Box D) based on the entire publication list, but still only counting citations back to 1996. Hence, this too is still only a minimal estimate; see Table 3 for some examples.

A similar exercise using WoS usually returns an even higher *h-index* value, as the citation scores include references in papers published before 1996. The increase in magnitude of the *h-index* value is most marked for those with long research records; see data for Scientists A and B in Table 3 compared with say Scientist D. This is not always the case, and the *h-index* score for Scientist C only goes up by one point. Finally, one might be able to make even further progress by adding in by hand any extra papers with high citation rates that were captured by Scopus and not included on the WoS list. Alternately one can run a *cited reference search* from the WoS window. This can recover additional references and citations not captured on the original WoS results page. Another way to achieve similar goals is by using Web of Knowledge (WoK) rather than WoS. The composite WoK database contains all of the WoS source databases plus several others. In some cases WoK can return significantly higher publication counts for individuals than WoS. However, although both WoK and WoS have *Analyse Results* function buttons which operate on the scores returned, **only** WoS has the all-important *Create Citation Report* button, which returns *h-index* scores, plus a full temporal record of publications. It is feasible to perform such wider search operations by hand, but the rewards are often meagre (the largest increase in Table 3 is only one point), and probably not many scientists will have the patience to filter the actual citations for the sake of adding one or two to their *h-index* scores.

Only very few workers are likely to be able to find the time to collate up-to-date spreadsheets showing WoS and Scopus citation scores for all of their publications, even though it might be a wise thing to do. All of the preceding observations serve to show the need for caution in these affairs. Judgements and decisions can only hope to be as good as the data upon which they are based. Those who wish to use the *h-index* for evaluations should bear in mind that, like any metric, the index number has inherent inaccuracies due to citation variations, etc. Also it is extremely unwise to compare *h-indices* (or any other citation measures for that matter) that have been calculated using different databases and/or different methodologies, or to compare *h-indices* between different disciplines: different disciplines have different practices. Furthermore, the *h-index* is an accumulating statistic so that a long-time researcher will necessarily have a higher *h-index* than a newer researcher of equal ability. It is also quite difficult to calculate *h-index* values at previous points in time, so that an institutional requirement for a staff member to regularly increase their personal *h-index* at some predetermined rate will be difficult to audit retrospectively. Anxiety driven by unthinking administration of such targets by managers may even tempt some desperate individuals to use strategic self-citation in manuscripts to push the citation counts for selected past papers over the critical count value required to raise their *h-index* by one or two points.

How can scientists best protect their reputations?

It is incumbent upon working scientists in New Zealand to support our institutions by finding the best, most ethical and safest way to advertise the quality of their research records by means of bibliometrics. The system demands it. The core problem is that no tool is perfect and no statistic tells the whole story, or even perhaps the whole truth. However, at least the presently available tools do all seem to agree with one another to a first approximation. Doing it all the strictly correct way, i.e. exhaustively by hand, is far too time-consuming. So a secure heuristic approach is required, i.e. in the form of a commonly agreed index of research output and impact (true quality is a very different kettle of fish – see below). Finally, it comes down to reporting. Here best practice would seem to involve quoting the highest *h-index* values obtained from Scopus and/or WoS as required. These should always be accompanied by database publication counts (including as a percentage of *curriculum vitae* publication count) and citation count(s) including specific figures for all publications with over 100 citations (or perhaps just the five highest counts if, like investigator C, none of the papers has received this many). It is essential to include exact details of the search procedure that produced the data, i.e. pretty much following the fine example set by Berridge & Petrey (2009). Note that these procedures are valid for presenting career achievements and as some sort of measure of the person as a scientist. They are not helpful for comparing achievements over the very short PBRF census window, because too few citations will be accumulated.

In all of the preceding we have taken for granted that citation counts are a fair reflection of valid citations and good practice. This is necessary because it is well beyond all reasonable practical means to check all one's citations for accuracy. However, when this has been done carefully (Todd *et al.* 2010) it becomes apparent that as many as 25% of citations may be inappropriate. This serves to inflate citation counts across the board and may even compensate to some extent for omissions due to ignorance, professional envy, etc. True omission rates must probably remain unknown as there seems to be no obvious way to estimate them. Many scientists do feel that their work has been unjustifiably overlooked especially by particular rivals, but again there is probably no reliable way to judge if this is a fair assessment on their part.

Of course, the general citation assessment exercise will only work if everyone agrees to do it as recommended above, or perhaps better still if at least they can be evaluated independently to ensure a standard methodology. The alternative is anarchy, featuring random quotation of dubious impact factors accompanied by bogus statistics of uncertain origin. This is pretty much the *status quo*, in fact. There is one further possibility and that is to compare one's citation profile with the WoS global or discipline-specific profile. Hence, one might be able to claim that the publication sample obtained as their own database output maps on to the 90–95th citation percentile interval in the global distribution (www.isiwebofknowledge.com). Here, the career evaluation will still not be comprehensive, because not everything on the *curriculum vitae* is included, but at least it will be a large and high-quality sample, given WoS claims regarding the nature of its database. However, this type of approach can be applied in principle to subsets of publications (e.g. between institutions and/or intervals of years) provided that each set contains a reasonably representative sample of citations.

Conclusions

To date, scientists may all have thought they knew what they were doing when they sent in numbers to PBRF, etc., but did they really? This article has shown just how careful one has to be when collecting supportive bibliometric statistics and includes some suggestions for best-practice reporting. This is not to suggest that failure to follow the advice set down here will be damaging to otherwise promising careers, but the authors do feel that it provides a measure of added security. The world of science will have to await the development of new software and the adoption of standard reporting practice before assessors can be fully confident with respect to the process.

We have left aside the deeper questions of whether it is fair, decent, or even sensible to assess careers in this fashion, because those working in New Zealand simply must respond in some way. For instance, how are we to judge participation in huge, long-term, multi-disciplinary and multi-centre studies which may be required in a rigorous clinical trial and which may only ever produce one major report? Other distinguished writers have taken up this theme. For instance, in the field of molecular biology Lawrence (2007) has shown how poorly Watson & Crick's work on DNA and Ed Lewis's pioneering studies of *Drosophila* would have fared under such a regime. Noble's (2010) review of Gillies (2008) builds the bigger picture. Readers are encouraged to consult these sources to learn how research progressed in a previous and perhaps happier and more enlightened scientific environment than under the well intentioned inquisitors of the PBRF.

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Article

Public attitudes to science: Rethinking outreach initiatives

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> *The public doesn't understand science. You scientists need to put more effort into communicating your work.*
>
> *Today's kids leave school not knowing enough science. You teachers should teach them better.*
>
> *University graduates don't even know how to write a concise scientific paper. You tutors should give them more practice before they come to work for us.*
>
> *Journalists don't understand even the basics. You editors should employ someone who knows what they are talking about to write about science.*

Note the familiar pattern here. A shortcoming is found and it's someone else's fault. We don't like it when we are in the firing line but we unwittingly do the same to others. In this article I argue that the type of 'deficit thinking' that underlies the above sentiments is an inappropriate way to respond to the complex issue of engaging the wider public with science. It benefits neither the people being judged nor the community that does the judging. For example, when the science community is on the receiving end, as in the first of the sentiments above, no matter how seriously they take the challenge of trying to communicate more effectively, there is a very good chance nothing much will really change if, with the best will in the world, that effort was misdirected. The challenge here is that topping up a deficit is no guarantee of a cure for whatever caused it in the first place.

Thinking further in this vein, I suspect that asking scientists to put more effort into communicating clearly with a public, most of whom are not interested, is akin to asking a relative stranger to speak more loudly to someone who is hearing-impaired – futile and perhaps very annoying. I will draw on results from the latest in a series of surveys commissioned by the Ministry of Research, Science and Technology (MoRST) to make the case that, with the best will in the world, improving communications will not necessarily work to boost public engagement with science, except perhaps with the already-engaged audience. The article begins with an outline of the survey and introduces a range of items with their basic response frequencies. It also briefly introduces a segmentation analysis that looked for patterns of associations within each individual's responses. The second part of the article then asks questions about just what it is about science we might want members of the public to engage with. The third part of the article will suggest a different avenue with the potential for making a constructive response to the challenges the survey results highlight. The paper is intended to spark discussion and a re-evaluation of the complex issues raised.

A brief outline of the MoRST survey

In early 2010, for the third time in this decade, MoRST commissioned the Nielsen Company to survey public attitudes to science (Nielsen 2010). In 2010 a dual methodology was used for the first time, with 600 participants interviewed by telephone (the traditional method) and another 600 completing the survey on-line. Since there were only small differences in response patterns between the two survey methods they will not be further commented on in this article. As in 2002 and 2005, the sample was carefully weighted on gender, age and geographic location. Somewhat more females (622) than males (578) took part. The majority of respondents (964, 80 percent) had no formal science education beyond that received while at school.

Discussion of key findings of the survey

The 2010 survey was somewhat shorter than the earlier two. Key questions were repeated to establish trend data across the decade. When the 2002 survey was designed, the first questions served the dual purpose of setting a wide set of contexts around the terms 'science and technology' in respondents' minds while also ascertaining their levels of interest in these contexts and perceptions of benefits to be gained from new developments in them (Hipkins *et al*. 2002). With minor adjustments to reflect changing research and social priorities, this context-setting item series was continued in 2010, but respondents were only asked about perceptions of benefits and not about their personal interest levels.

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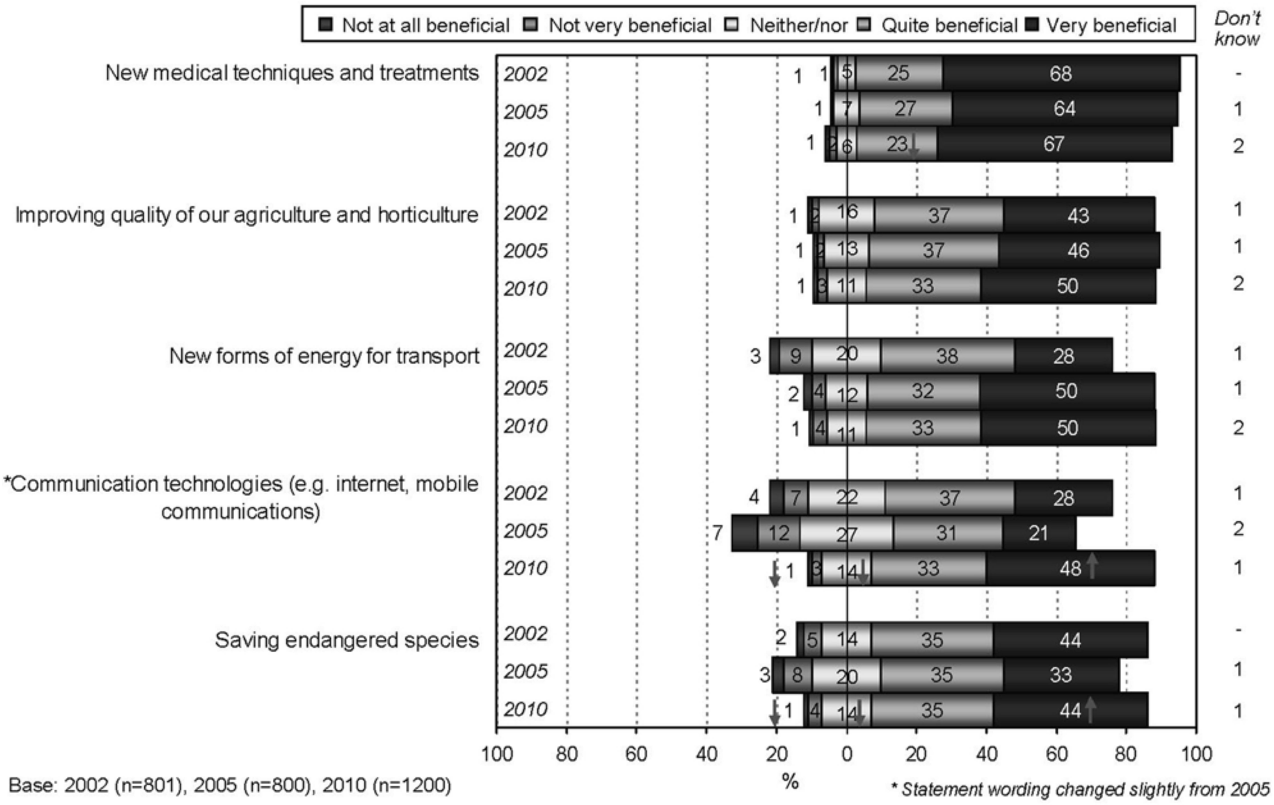
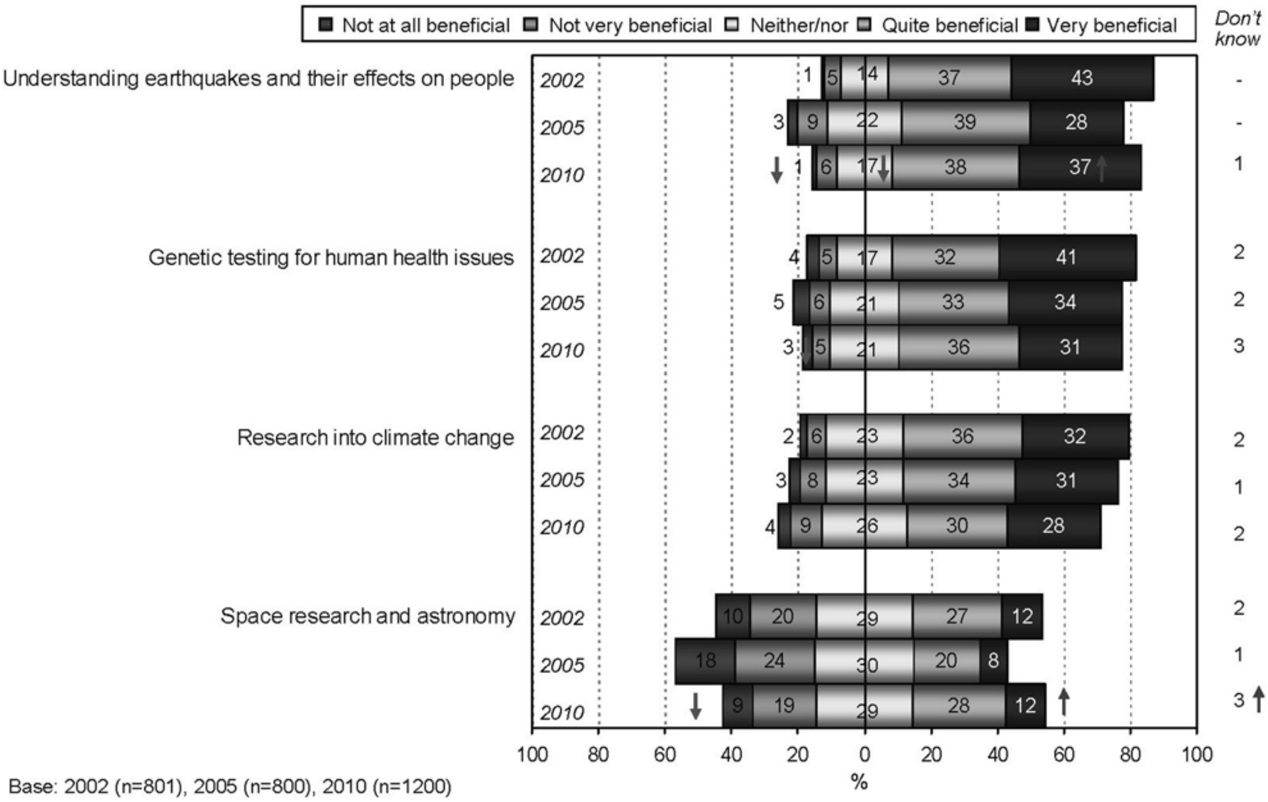




Figures 1 (upper) and 2 (lower). Benefits associated with developments in science and technology.

Figures 1 and 2 show responses to the 'perceived benefits' of nominated contexts across the three surveys. For most contexts, the series is notable for the lack of any substantive shift in perceived benefits and in the lack of change in the ranking order of the various contexts (arrows up or down denote significant shifts). Scientific research resulting in new medical techniques and treatments is almost universally seen as beneficial – no doubt most people can imagine themselves as potential recipients of such benefits, if not immediately then certainly some time in the future. Space research/astronomy was the lowest-ranked context in all three surveys, with climate change second-lowest. Arguably these two contexts would be furthest away from many respondents' direct experience and hence many people would be less aware of their potential relevance and impact. Supporting this suggestion, respondents with postgraduate qualifications (13 percent of sample), who we might expect to be widely-read, were more likely to rate these two areas as beneficial. Notable exceptions to the overall pattern were the more emphatic agreement (increase in 'very beneficial' responses) that transportation research brings benefits (first seen in 2005) and that new developments in communications technologies bring benefits (first seen in 2010). Again these changes are likely to reflect increasing encounters with changes and challenges in these areas over the last few years.

Is speculation about a relationship between benefits perceived and the motivation people might have to pay attention to science congruent with responses to other parts of the survey? Figure 3 shows responses to questions that canvassed *personal* responses to science, both in life contexts and as communicated through various media channels. Again the series is characterised by patterns that show very little difference in response patterns across the decade. The highest level of agreement is with the most passive item – 'it is important to be kept up-to-date'. (This item was added in 2010.) Three quarters of respondents agreed with the statement – but by whom and by what processes did they expect this updating to happen? Contrast the substantial majority who agreed with a need to be kept up-to-date with the lower numbers who agreed that 'science is important in *my daily life*' (emphasis added). Just over half agreed that conflicting information about science makes it hard to know what to believe, yet more than half were neutral or disagreed that science and technology are too specialised for their personal understanding. The picture building here is suggestive of a somewhat detached interest in science for around half the adult population. They generally appreciate there are benefits, they are aware of a need to keep abreast of new developments, but they lack the personal motivation, and in some cases the necessary confidence, to do so themselves.

Interpreting public attitudes to science in this way can lead to assertions that there is a need for more effort to be put into clear and accessible communication of key research findings. However, this type of response is underpinned (at least tacitly) by the deficit thinking illustrated in the introduction, where the suggestion was made that this might be futile in some cases. Do other data from the survey support this assertion? One item asked people to rate the amount of information they see and hear about science. Results were: far too much (2 percent); too much (8 percent); about the right amount (47 percent); too little (35 percent); far too little (6 percent), and don't know (2 percent). These responses suggest that over half the participants had no active desire to read or find out more about science. As might be expected, those with postgraduate qualifications were more likely to say they wanted more information, but the above analysis suggests they are more likely to be paying attention to science in the first place. More and better communication is unlikely to reach those who tend not to take an active personal interest in science. An exception might be where issues are sensationalised in the media, but this is hardly likely to be conducive to constructive conversations. So what do we know about the sense that people make of the science communications they are aware of?

Figures 4 and 5 show that most people do trust any information they can source to scientists, and also that the most trusted media outlet is TV documentaries, followed by TV news. Common sense suggests many people are more likely to see and

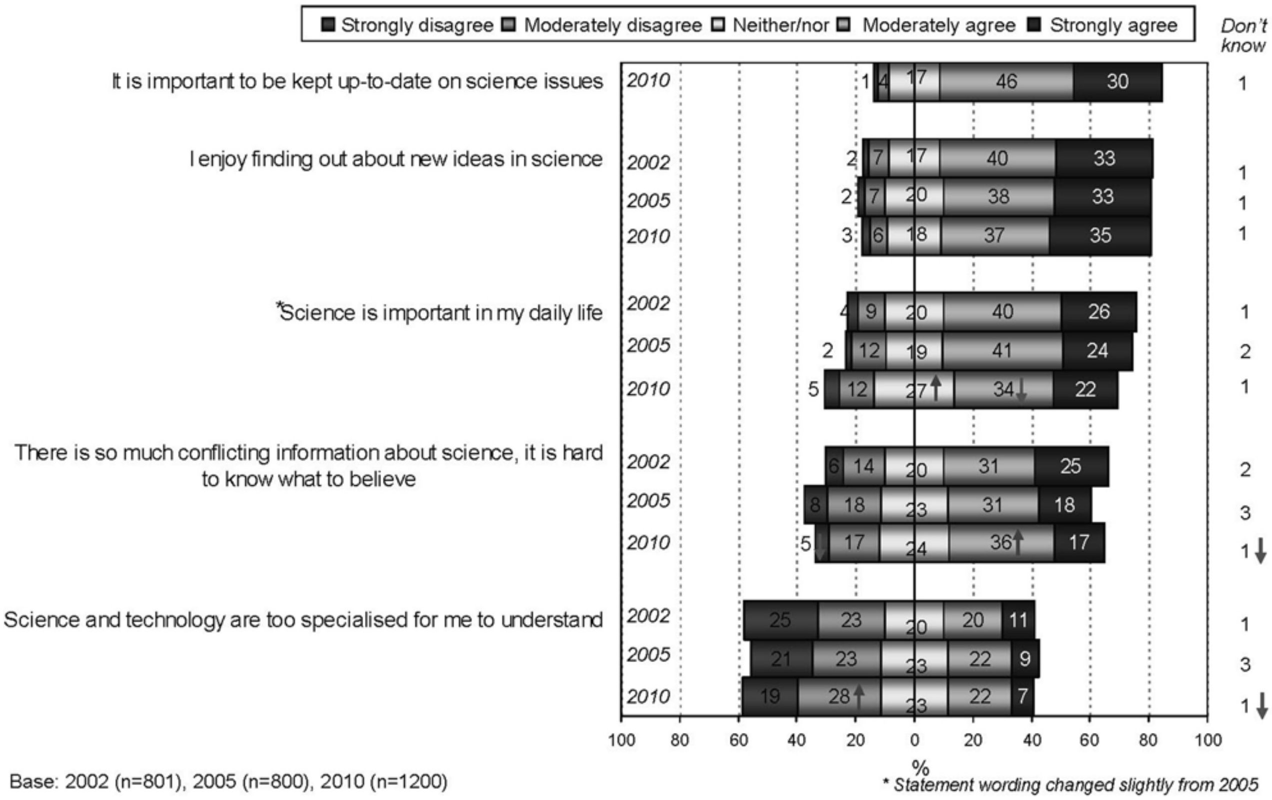
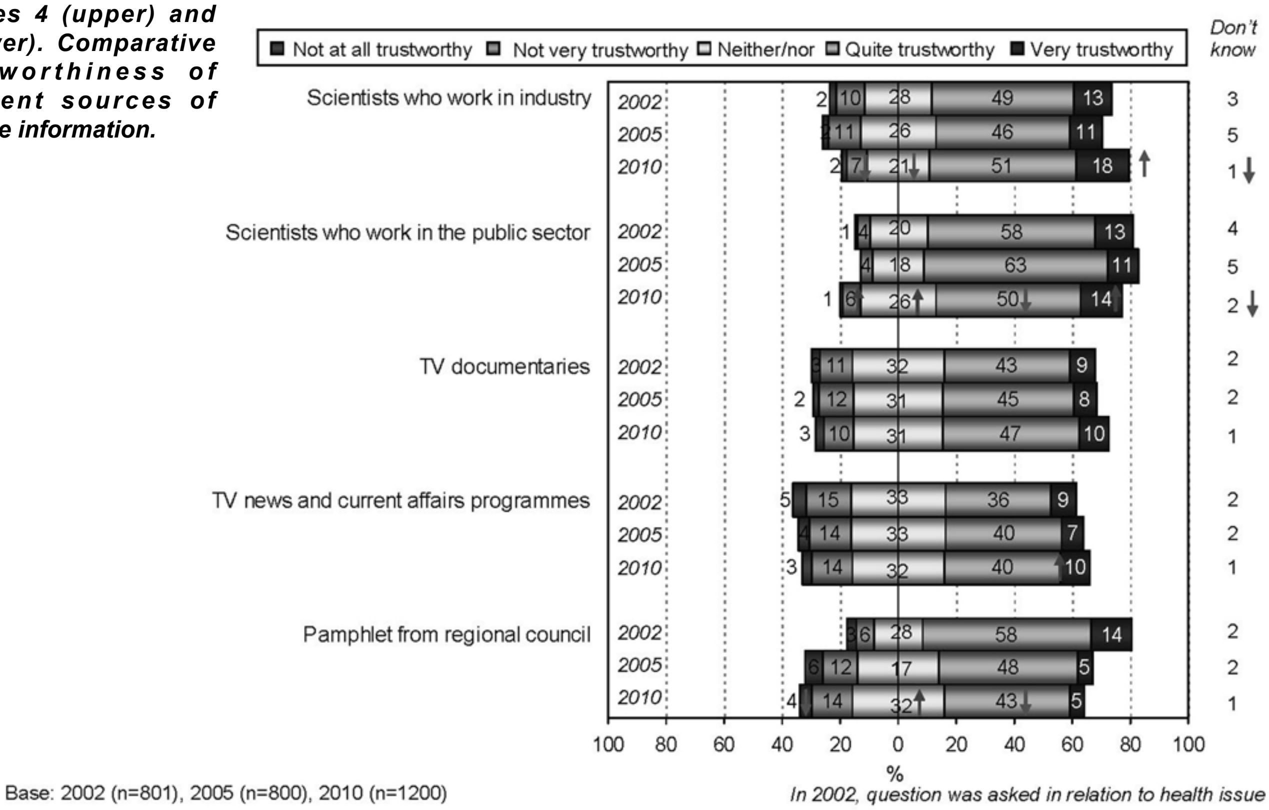


Figure 3. Attitudes towards science.

hear things about science via these media channels, especially given the lack of interest in the active pursuit of science, as documented above. Note the significant 2010 increase in perceptions that newspapers and the internet are at least 'quite trustworthy'. Respondents with no science education beyond the school level were more likely to find TV documentaries trustworthy, as were female respondents. In a decade-by-decade analysis, scepticism about the reliability of sources was likely to increase with age, across all communication channels (Hipkins 2010).

What else do we know about the group that appear to be less actively engaged? A segmentation analysis was undertaken to look for clusters of similar responses. It yielded the five clusters shown in Table 1. Full details of the characteristics of these clusters and the methodology by which they were determined can be read in the main report (ACNielson, 2010) . For the purposes of this article selected differences between the responses of the 'mainstream' group (at 44 percent of respondents it is by far the largest cluster) and the small group of 'science orientated'

Figures 4 (upper) and 5 (lower). Comparative trustworthiness of different sources of science information.



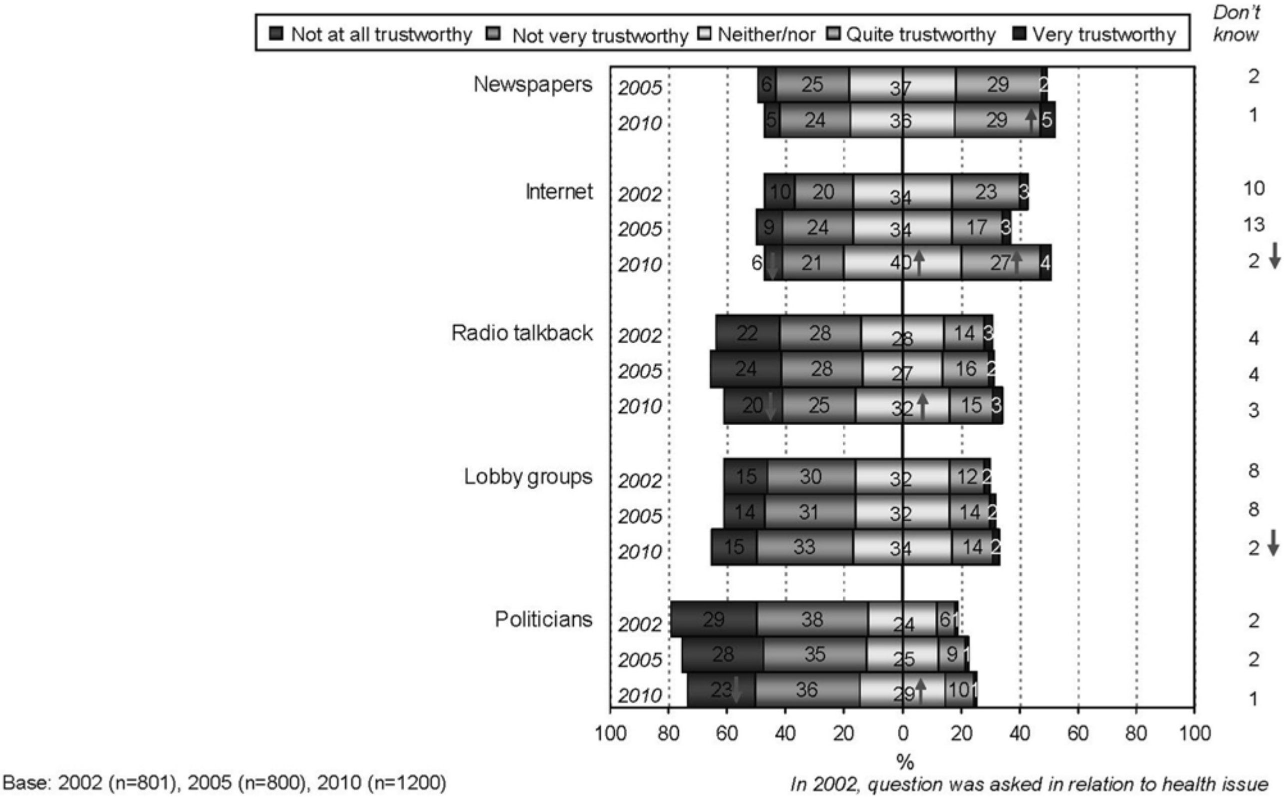


Table 1. Distribution of respondents regarding attitudes to science.

Cluster group	**Percent**
Mainstream	44
Science orientated	23
Science followers	13
Enthusiasts	11
Disengaged	9

(a smaller cluster at 23 percent) are described in the next section. They were chosen as groups who might be targeted as most likely to be impacted by communications initiatives. The 'science enthusiasts' (with more postgraduates and science-educated respondents) are already actively involved. The 'science followers' are mainly older people without formal qualifications who nevertheless support and follow science developments. The small 'disengaged' cluster is likely to be actively so – for example, they showed the highest disagreement of all groups in response to items related to science and the economy, which are discussed next. By contrast the two clusters explored in this article arguably sit on either side of a divide between inclining to engage or inclining to disengage. Understanding their differences could help us rethink communication strategies.

Why engage people with science?

Encouraging greater public engagement with science is generally seen to be a 'good thing' by the science community but for what *purpose*? How we answer this question is important to how we might rethink communication dilemmas and solutions. This section addresses three broad arguments for greater public engagement with science:

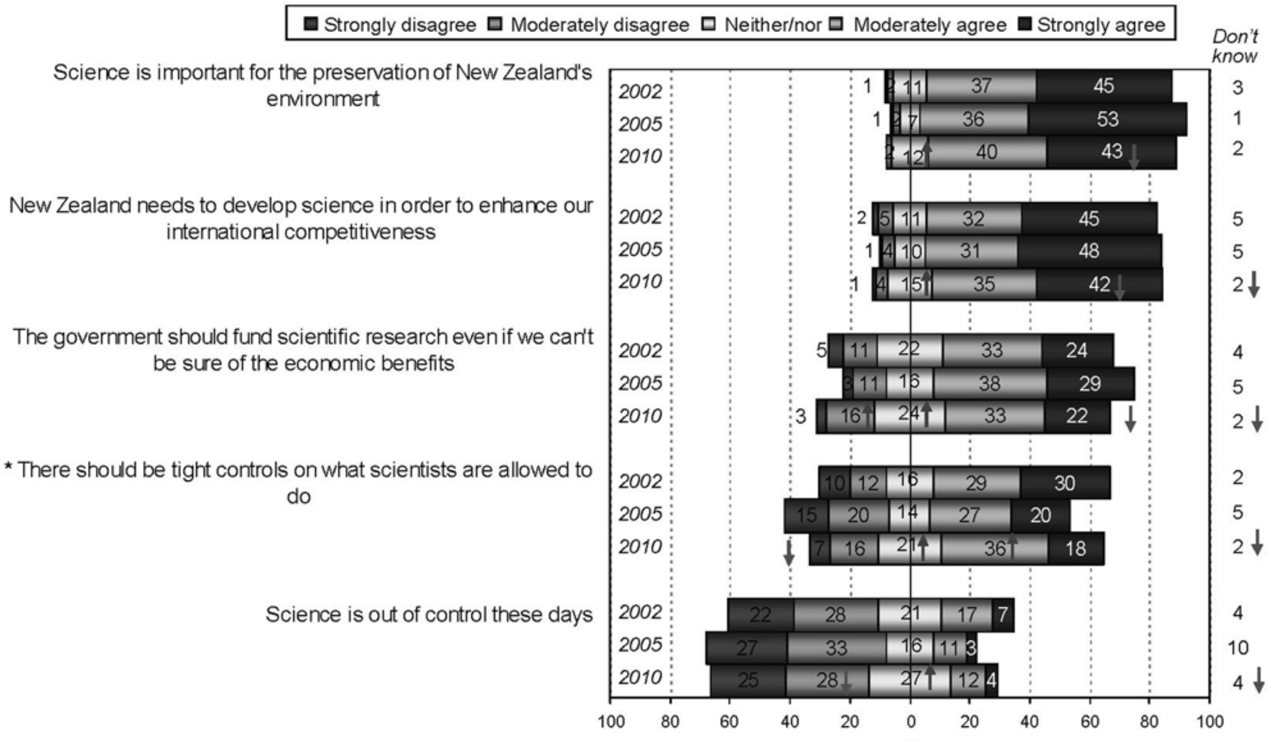
- To create conditions conducive to ongoing support for scientists' work.
- So people will make well-informed decisions when science findings and approaches are relevant to personal decisions.
- So people will be 'good citizens' when it comes to public decision-making about issues that have a science component (often called socio-scientific issues).

Purpose 1: Educate future scientists

In relation to the idea that a public who is aware of the benefits of science is much more likely to support public funding of research (e.g. through taxes), Figure 6 shows responses to a series of items that asked about 'science and the economy'. The pattern of responses suggests that a majority of respondents already believe science to be economically and environmentally beneficial. Three-quarters of them appreciate its potential to enhance our international competitiveness. Although 'blue skies' research is not as strongly endorsed, those who agree it should be funded are still in the majority. Note that the final item – science is out of control – is reversed. Disagreeing is a positive response and is again the view of a substantive majority.

We could take the overall response as an indication that all is well in this aspect of public engagement with science. However, differences between the largest 'mainstream' segment and the 'science orientated' segment add to the growing picture about communication challenges that are the main focus of this article. Table 2 outlines the demographic differences between these two clusters, along with differences in perceptions of the benefits of science and of its potential economic impact.

The differences here are suggestive of a *benign* lack of engagement for the mainstream group. Even though fewer respondents from the mainstream segment believe the government should fund scientific research, this is still the view of almost half of this group. Although relatively more of them believe science is out of control, it is still very much a minority view. If not actively supportive, neither are they actively opposed



Base: 2002 (n=801), 2005 (n=800), 2010 (n=1200)

* Statement wording changed slightly from 2005

Figure 6. Relationships between science and the economy.

to science, or unaware of its potential benefits. I will come back to question of differences in perceptions of the benefits of earthquake research when I discuss the third of the reasons listed above for engaging people with science.

Purpose 2: Make good personal decisions

Table 3 shows key differences between the responses of the two clusters in relation to the second reason – to make well-informed personal decisions where science findings and approaches are implicated. Notice that differences between these two groups when considering science in relation to *their own lives* (as opposed to a more abstracted economy 'out there') are mostly of a greater magnitude than those reported in Table 2.

Less than one-third of the largest mainstream segment believe that science is important in their daily lives. They are less likely to be confident of their own abilities to source and untangle scientific information. More than half of them rely on TV journalists and producers to report such science as they may pay attention to. Those who feel they already receive too much information may simply switch off or switch channels.

Clearly there is an opportunity here to shape communications that do foreground the impact of science in daily life, but there is a snag. Relating emerging science to daily life may not be easily possible or plausible for much contemporary research. This is more obviously so for the 'blue skies' category, but it also applies to all ongoing work streams where theories and the meaning of evidence are being actively contested within the science community (which doubtless impacts on 'conflicting information' anxieties where these exist). Once new science becomes more settled, perhaps via a process of application to

Table 2. Differences in support for science in contrasting segments.

	Mainstream segment (44%)	**Science-orientated segment (23%)**
Profile	Female bias (49% *of all* females fall into this segment cf. 39% of males).	More likely to be male (27% of all males cf. 20% females).
	All age groups represented equally, aside from those aged 45–54.	Older age groups (55+) are under-represented.
	Unlikely to have formal science training (but includes 50% of those with a high school qualification in science).	Most likely to have undergraduate or postgraduate qualification (includes nearly half of those with formal science training).
	Higher frequency of low income earners.	Higher than average level of household income.
Perceptions of benefits	Less likely to see the benefits in space research and astronomy (31% cf. 40% all respondents).	More likely than average to perceive benefits for most areas of science named in survey, including space research and astronomy.
	Less likely to see benefits of understanding earthquakes and their effects on people (71% cf. 75%).	80% perceive benefits for understanding earthquakes and their effects on people.
Science and the economy	Less likely to agree that the government should fund scientific research even if we can't be sure of the economic benefits (43% cf. 55%).	More likely to agree the government should fund scientific research even if we can't be sure of the economic benefits (64% cf. 55%).
	Less likely to believe that New Zealand needs to develop science in order to enhance our international competitiveness (73% cf. 77%).	More likely to believe that New Zealand needs to develop science in order to enhance our international competitiveness (81%).
	More likely to think that science is out of control these days (20% cf. 16%).	Less likely to believe that science is out of control (9% cf. 16%).

Table 3. Differences in personal responses to science between contrasting segments.

	Mainstream segment (44%)	**Science-orientated segment (27%)**
Perceptions of personal relevance	Less likely to believe that science is important in their daily lives (30% cf. 56%).	More likely to believe science is important in daily life (82% cf. 56% average).
	Less likely to think it is important to be kept up-to-date on science issues (70% cf. 76%).	More likely to think it is important to be kept up-to-date on science issues (88% cf. 76%).
	More likely to feel they receive too much science information (10% cf. 8%).	This segment has a split view on whether they receive just the right amount of science information or too little. (4% cf. 8%).
Self-efficacy in relation to seeking information	Less likely to enjoy finding out about new ideas in science (57% cf. 73%).	More likely to enjoy finding out about new ideas (98% cf. 73%).
	More likely to believe science is too specialised to understand (39% cf. 29%).	Believe they understand science (1% say it is too specialised to understand cf. 29% average).
	More likely to believe that there is so much conflicting information, it is hard to know what to believe (59% cf. 53%).	Less likely to believe there is so much conflicting information about science, it is hard to know what to believe. (39% cf. 53%).
Trustworthiness of information sources	Most trust TV documentaries (60% cf. 57%).	Less likely to rate TV documentaries (50% cf. 57%) or other media.
	Less likely to trust public sector scientists (58% cf. 64%).	Most trusted sources are industry (71%) and public sector (69%)scientists.

new technologies, relevance to daily life is more likely to be apparent, but still not necessarily so, and by then it may no longer be the focus of scientists' science programmes. The flip side of this argument also applies. In the first round of this research we held focus group conversations, one of which was with a group of mothers of young children, held in their local kindergarten after hours (Hipkins *et al*. 2002). An science-related issue of great concern to them at the time was an outbreak of head lice (it was late summer) and the pros and cons of treatments involving strong insecticides, compared with methods intended to deprive the lice of oxygen (e.g. oiling the hair and then putting on a tight rubber cap to keep it surrounding the hair while eliminating air spaces). In this conversation they showed a strong awareness of the relevant body systems and several were active seekers of internet information on the topic. Obviously these mothers could engage with science when they had a powerful motive for doing so. The snag is that the relevant science ideas might well be long-settled and of no specific interest to communication efforts.

Purpose 3: Participate in socio-scientific discussions

Where does this leave us? Before proposing a possible reframing of the engagement/communication dilemma, I return to perceived benefits of earthquake research, placing this in the context of the third reason for seeking to engage the public in science – to be 'good citizens' when it comes to public decision-making about socio-scientific issues. In a recently published article, a US school principal with an obvious interest in science pondered the earthquake in China's Sichuan province that resulted in the death of so many children inside their collapsed school buildings (Bailey 2010). She asked if a similar tragedy could happen in the USA and, state by earthquake-prone state, summarised the evidence that indeed it could. She described legal, political and financial barriers to the retrofitting of unreinforced masonry schools in several states and made a plea for people to ask questions about the condition of the schools that their children attended, or in which they worked as teachers.

Of relevance to our discussion are the additional dimensions to engagement with science that this article illustrates. Here is a school leader who is clearly aware of earthquake research (she cites several examples) but this science knowledge on its own was not sufficient to the task she undertook. She was also able to place the scientific questions within a wider framing of social systems (legal, political – local and national, financial, and insights into reasons why others might not be paying attention). Most importantly, she thought to ask the question in the first place. This had to involve imagining a link between distant events and local possibilities, and then pursuing answers to that question. The *dispositional* components to her actions were important enablers to her use of her knowledge and skills.

A substantial majority of the mainstream segment were also aware of the benefits of earthquake research (Table 2). Following the head-lice example above, they could presumably pursue more information if they felt a need to do so, although their lack of self-efficacy could certainly be a barrier to action. The greater barrier though, might be dispositional. To make the necessary links and ask the right questions, you do need to be paying attention in the first place. To think it is worth making the effort, you need to believe your actions could make a difference. (Nancy Bailey's call for action is the clear motivater of her research and advocacy.) Where then does this line of argument leave thoughts of improving communication strategies? In my view, the dispositional dimensions highlighted here need to be fostered while we are young, and hence science communication efforts might be better directed to supporting teachers to achieve this important goal.

Catch them young…

> *In science, students explore how both the natural physical world and science itself work so that they can participate as critical, informed and responsible citizens in a society in which science plays a significant role* (Ministry of Education 2007a, p.17).

The quote above is the one sentence 'essence statement' that justifies science's inclusion as one of eight learning areas in the New Zealand Curriculum. A few pages further on this statement is expanded to four broad purposes:

> *By studying science students:*
>
> - *develop an understanding of the world, built on current scientific theories;*
> - *learn that science involves particular processes and ways of developing and organising knowledge and that these continue to evolve;*
> - *use their current scientific knowledge and skills for problem solving and developing further knowledge;*
> - *use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures and to the sustainability of the environment.* (Ministry of Education, 2007a, p.28)

All of these are relevant to the discussion above, the last bullet point directly so. Obviously some working knowledge of the 'big ideas' of science is needed to access further knowledge (bullet one). An understanding of how science 'works' (second bullet) can help with questions of conflicting information and deciding who to trust and why. This aspect is addressed in a 'nature of science' strand that is intended to weave through the more traditional disciplinary areas: living world; physical world; material world; Planet Earth and beyond. The aim in the third bullet point arguably works towards strengthening dispositions of the sort briefly indicated above. Some of the generic features of the curriculum, such as the development of 'key competencies', further reinforce the message that learning in all the learning areas is about *using* not just getting knowledge (OECD 2005).

While this particular version of the curriculum is relatively recent, these aims have been broadly held for many years now in Western nations, sometimes foregrounded and sometimes not, depending on which interest groups dominated curriculum thinking at the time (DeBoer 1991). Why, you might be asking, is there so little evidence that they have been successfully met? The prevailing attitudes to science exhibited by the largest mainstream cluster certainly suggest that if the confidence and willingness to engage with science was an aim of their schooling, it has not worked for many people. Supporting this assertion, the OECD's international assessment programme (PISA) recently reported that just 56 percent of New Zealand's 15-year-olds thought science was 'very relevant' for them (Caygill 2008).

We need to ask why so many of our young people do not see personal relevance in their school science learning, and we need to reframe their learning if school science education is to shape dispositions such that young people leave school on the way to being actively engaged with science when and where appropriate.

At the heart of the dilemma is another set of conflicting purposes – this time in *science education,* which is a discipline in its own right. In common with other 'difficult' school subjects such as mathematics (and in earlier times Greek and Latin) the science disciplines have been used as both a preparation for, and gatekeeper to, tertiary education in the sciences (Gilbert 2005). This foregrounds the purpose of educating future scientists. Laying down a foundation of knowledge on which to build tends to stress content 'coverage'. Perceived omissions on the part of schools are likely to be met with the sort of deficit criticisms illustrated in the introduction to the article. Gate-keeping that allows only the most talented to proceed requires that at least some of that content be too difficult for 'average' learners, who do tend to turn away from science as soon as they can. The message here is not that educating our future scientists is unimportant, but rather that it can conflict as a purpose with preparation for participation as 'responsible citizens in a society in which science plays a significant role' (Ministry of Education 2007b).

A widely cited discussion of science education for the 21st century pointed out that future scientists are also future citizens (Millar & Osborne 1998). This is self-evident but important. The aim of educating future citizens applies to *all* students. The aim of educating future scientists only applies to some. This logic suggests the former purpose should prevail, at least in the years before senior secondary school when wider curriculum choice opens up.

There are several ways that the science community can actively support teachers in rethinking their practice to better achieve this purpose. First and most obvious is to desist from deficit criticisms, which teachers do tend to take to heart. Learning time is limited, and teachers cannot 'cover' all the content scientists think may be desirable, while also doing justice to developing the understandings, skills and dispositions our future citizens will need. Something has to give. While they are on the receiving end of criticism, many teachers – especially those whose tacit thinking privileges the gatekeeper role of sciences – will be reluctant to fully take up the future-focused opportunities provided by New Zealand's widely acclaimed curriculum.

The second way that scientists can help is to engage constructively with conversations about the 'big ideas' that really are necessary to developing a foundation for responsible citizenship. What concepts and theories are so centrally important that not knowing them is a barrier to engagement with socio-scientific issues, or even just making good life decisions? This question is a current focus for the National Research Council in the USA and a new '21st Century Science' curriculum has engendered considerable debate in the UK. If teachers are to seriously engage with this curriculum debate (and many have not yet done so) they do need scientists' support and input. They also need fresh new materials, examples from actual science-in-progress that are accessible for students and most of all support and encouragement as they wrestle with new directions. This is the third way scientists can help, and many are already doing so – for example by contributing to the science stories documented in the MoRST-funded Science Learning Hub developed and maintained by the University of Waikato. Here is a ready-made audience with whom to engage. Maybe we will see the fruits of these new directions in science education a decade hence – but only if we pull together to make the necessary changes.

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Article

A.R. Bellamy: People, places and things – reflections on a life in science

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The massive restructuring of the national science system in 1989 led many scientists to crave a stability that would allow them simply to 'get on with the job'. The on-going debate on the place of science and research in national development, and the role of the CRIs and the universities suggests such stability remains some way off. Behind this debate is an implicit assumption that policies for science 'drive' the system. Professor Dick Bellamy, who retired at the end of 2008 after a long and distinguished career as a research scientist, senior manager, and champion of science, is well positioned to put such changes in perspective.

Back in 1953, Dick as a thirteen year old schoolboy in his first year at Auckland Grammar School, was yet to receive his first lesson in biology (Bellamy 2003). In 2008 he retired after 40 years at the University of Auckland. Preceding this, Dick spent three years (1962–65) as a Research Scientist at the Department of Scientific and Industrial Research (DSIR), completing his PhD while on staff, and then as a 'postdoc' worked from 1965–68 in the Department of Cell Biology at the Albert Einstein College of Medicine in New York. Over his career Dick moved from being a 'young radical' to take on a number of significant roles, including Senior Research Fellow in the Department of Cell Biology (1968–74), Associate Professor (1975–80), Professor of Cellular and Molecular Biology (1990–2008) Inaugural Director of the School of Biological Sciences (1991–2001), and Dean of Science (2001–2008).

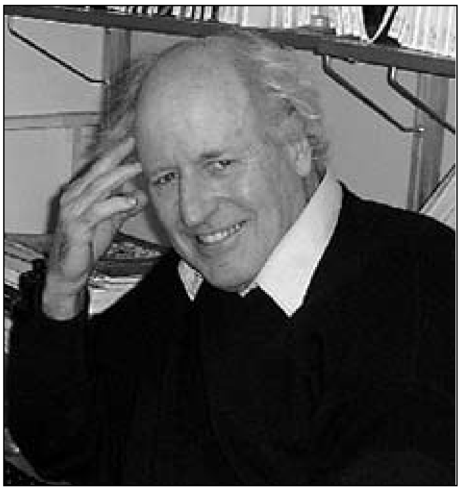
Dick combined his research and other academic responsibilities with a number of other roles including that as a Director of New Zealand Forest Research Ltd, President of the Auckland Museum Council, elected Member for Eden in the Auckland Regional Council, and Member of the Establishment Unit of Transportation Auckland Corporation (and subsequent service on the Board of the Yellow Bus Company, the corporatised entity responsible for most of Auckland's bus services). Dick also played an active role within professional societies, becoming President of the New Zealand Microbiological Society (1975–76), and Chairman of the New Zealand Society for Biochemistry and Molecular Biology (1992–97). In 1983 he was elected as a Fellow of the Royal Society of New Zealand, and in 2005 was made a Companion of the New Zealand Order of Merit.

When Dick went to Auckland University College as an undergraduate in 1958, relatively few New Zealanders completed 7th form and perhaps only 15% went on to university studies. As he recalls, for those who did, the disciplinary pecking order was clear. Those who were clever in science took maths and physics and largely went on to enrol in engineering. Those weak in maths and physics went to biology. The clever in languages took law, and those somewhere in-between took medicine. Commerce was still perceived as a 'night-school' subject, and law for the most part was part-time. Although the arts and humanities were well established, the social sciences were still in their infancy and largely represented by the Department of Geography (established in 1946). There were, of course, exceptions, but as Dick puts it, his marks in maths and physics were poor and so his obvious choice was to get into the natural sciences – biology. That may be so, but Dick's decision was also supported by a genuine curiosity and interest in the natural world and the environment, characteristics which shaped his career and continue to influence his life and activities today.

Graduates seeking employment as scientists also perceived a hierarchy. For the most part the brightest went overseas to undertake higher degrees, or were drawn to the DSIR because of its superior facilities. A few went to the universities, which at that time relied heavily on staff recruited from offshore (especially the UK) to take-up the slack.

As is the case today, the pressures on the science system to meet national economic needs were substantial. Consequently the bulk of funding and resources for research had traditionally gone to the Ministry of Agriculture (MAF) and the DSIR and was focused primarily on agriculture and other land-based activities. As problems were identified and solutions sought, field research stations had been developed and expanded around the country. This had encouraged the staffing of the DSIR with scientists committed to expanding understanding and applying their findings. Close relationships with 'user groups' were an inherent part of the job. The result was also a strong research culture and collegial approach, including efforts to peer-review potential submissions for publication, whether written by young scientists or more senior researchers. This stood in stark contrast to the universities, where teaching tended to dominate and research frequently came a poor second.

The research focus within the DSIR was further reflected in a clear hierarchy among the researchers. Each individual



Professor A.R. (Dick) Bellamy.

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scientist's salary was public knowledge. DSIR managers emerged from the ranks of the scientists and were spliced on to the research system. Such managers generally saw their role as scientific administers (now a somewhat neglected term), supporting and promoting their staff rather than as the bureaucrats many managers are perceived to be today. In a pre-computer age – certainly a pre-email age – this was aided by the fact that the Wellington HQ was for most some distance away. For the senior managers at the different research centres around New Zealand, it was a place visited only three or four times a year, when the budget was 'divied up', scientists' gradings were negotiated, and the like.

In the Plant Diseases and Fruit Research Divisions of DSIR at Mount Albert, Auckland, in the early 1960s, Dick felt the building pressure for further change. As he recalls, it was evident first in a pull away from basic science – exemplified for him in genetics – in favour of more narrowly focused applied work on 'whole plants', which sometimes overlooked the extent to which the value of such work hinged on a sound underpinning of basic research. By the late 1960s, feeling constrained, a number of top scientists began to move elsewhere, often to the universities. Among this group was George Petersen (then a biochemist in DSIR's Plant Chemistry Division in Palmerston North), who went to the University of Otago; Dick Matthews, who left DSIR for a chair in Microbiology at the University of Auckland; and Frank Newhook, who moved to become Professor of Plant Pathology at Auckland.

With the space race, which characterised the 'post-Sputnik era' (in the late 1950s), the political focus had shifted. An increasing proportion of funding had started going to the universities. University chairs were better paid than their equivalent positions in DSIR, and the University Grants Committee (formed in 1961) had started to provide substantial set-up funds to equip new buildings. Of course, the most ambitious or most politically astute responded quickly and scored highly, pointed-up in the (possibly apocryphal) tale of the cell biologists at Auckland University accessing expensive gear while some other biologists requested only a chaise-longue for their office.

What didn't alter over this period was the availability of funding for PhD students. The practice had been for such students to go overseas, primarily to the UK. However, in the post-war era, national pride had increased and there was some general antipathy towards 'Poms', exceeded only by that reserved for those New Zealanders who did go to the UK and returned with airs and graces that exceeded those of their role models. The result was a shift in focus which, by the early 1960s, saw an increasing number of New Zealand PhD candidates drawn first to Australia, where generously funded teaching assistant positions were available and then subsequently to North America – to both Canada and the USA. Dick's own decision in 1965 to go as a postdoctoral fellow to a Medical School in New York raised eyebrows, but was part of this widening of national horizons in the post-war world. It was also perhaps some acknowledgement of the extent to which the USA, at least in some areas of science, had overtaken the UK and had used its much more abundant resources to gain a significant research edge.

The decline in the research vitality of the DSIR, the strengthening of the research culture in the universities, shifts in funding patterns, and some re-orientation of research linkages from the UK towards North America reflected longer-term trends. These were shaped in turn by individual personalities, national policies, and broader shifts in global society and political relations.

In 1968, when Bellamy returned to New Zealand, Auckland University was essentially a microcosm of the national scene, with the level of research across the disciplines being very uneven. In the post-war period, the Manhatten Project had given 'big physics' substantial clout. Chemistry had solid, well estab-

The practice at the end of WWII was for scientists to undertake postgraduate studies overseas, especially in the UK. These four senior scientists were together as young returned servicemen at Cambridge University in 1946: (from left) Dr Eric Godley, former Director, Botany Division, DSIR; Dr Ted Bollard, former Director, Plant Diseases Division, DSIR; Dr Alan Johns, former Director-General of Agriculture; Dr Dick Matthews, former Professor of Microbiology, University of Auckland.

lished industry links. Both physics and chemistry at Auckland University consequently developed a sizeable base of research funds and considerable influence as academic power brokers. Chemistry and physics also both had a strong income flow from their capture of the funding stream provided by first year engineering students. However, there were also far fewer science departments than today, and this also allowed key individuals to hold sway. In the right hands, enormous achievements were able to be secured. Universities in New Zealand were at the start of an expansion period, with the University Grants Committee investing in new buildings. The first of these inevitably housed chemistry and physics, but buildings for biology soon followed.

Dick Matthews, as Foundation Professor of Microbiology, is viewed by Bellamy as pivotal in the emergence of the current School of Biological Sciences. He also played an important role in the early stages of the founding of the new Medical School, which was a development opposed in some quarters. Matthews was at the cutting edge of the emerging discipline of molecular biology and had wide international linkages. Locally he was influential in setting scientific directions for the work funded by the then Medical Research Council and the New Zealand Cancer Society. The linkages he had built within the DSIR also were important in enabling him to influence the directions of biology, now in a university setting.

These contributions were grounded in his efforts and those of others to move biology from being a largely observational, natural science to become a much more quantitative, experimental discipline. This was backed by his own research experience in the UK and in the USA, and his strong personal international research links. In the process, Matthews transformed the status and role of microbiology and cell biology at Auckland, and provided the long-term support required that ultimately led to the integration of the biological sciences as a coherent area for research and study.

Dick Matthews also became part of an influential and able ‘mafia’ of scholars who came together at a time of critical change in the University. He and other former pupils of Mount Albert Grammar School, then one of New Zealand’s top secondary schools, joined the staff of the University in the 1960s and played transformative roles. Others included Bruce Briggs in Anthropology, who championed research and teaching on Mâori and Mâori language, Jack Northey, who is credited with creating the modern Law School, and Keith Sinclair, who stamped his imprint on the Department of History and did much to shape New Zealand’s self-image. As Bellamy recalls, these were heady days, because for the first time the direction of the University was being shaped by New Zealanders with a strong sense of New Zealand values and identity. Many had completed their training after the war and returned home with strong views on where the nation should be heading. Quite a few had seen service in the Western Desert and the Italian campaigns and were battle-hardened. As a group they did not find it easy to accommodate those with inflated egos or academic pretensions.

New Zealand’s universities were also at that time increasingly impacted by wider global trends At Auckland the response was spearheaded by Colin Maiden. Appointed Vice-Chancellor in 1971 from his then position as a senior manager at General Motors, Maiden was the youngest ever appointed to such a position in the Commonwealth. Under his guidance, and supported by many of the academic power brokers noted above, university procedures were tightened. Maiden championed change, exemplified in his broadening of Senate membership beyond professors, to include students and non-university appointees. The ripples from the Berkeley riots and fear of their replication closer to home helped the process. The move away from the concept of sole professors as Heads of Departments followed soon after.

The University Grants Committee had ensured a rational distribution of resources and avoided the proliferation of core capacity, including setting limits on the duplication of core programmes in medicine, engineering, veterinary science, and the like. Its disestablishment in 1990 generated increased competition between universities at the very time they were consciously building and expanding their own graduate programmes. In the short term, the result of this was perhaps to revive the universities’ provincialism, but in the longer run it encouraged them to strengthen their international links. Paradoxically the DSIR was at the same time heading in the opposite direction. By the mid 1970s its basic science role had withered and almost collapsed. There had been an expansion of its head office from a small core facility to a more dominant and intrusive presence. Continuing competition between DSIR and the Ministry of Agriculture had from time to time promoted the idea of reorganisation, and in the late 1980s, under the crafting of Simon Upton, Ray Meyer, Andy West and others, the CRI model emerged.

Throughout the ’70s and ’80s, Dick notes that the drive for ‘relevance’ and demand for research to promote economic growth and development remained a consistent theme. Today it has found new political expression. At that time, government research, including the DSIR, continued to address the economic and development needs for which it was designed. The universities, too, while increasingly striving to meet international benchmarks, fed into the national innovation system and trained employees to meet national economic and social objectives. All this was directly reflected in the type of staff appointed, whether to MAF, the DSIR, or to the universities. Awareness of ‘clients’ needs’ was an established component of scientists’ work. Equally New Zealand’s size, isolation and cultural heritage had long encouraged its scientists to build and maintain powerful international connections. Going overseas for PhD studies and post-doctoral opportunities and the inflow of scientists from overseas to work in New Zealand is a long-standing tradition, and too often poorly recognised and undervalued. Such interchanges promoted the exchange of ideas, bolstered confidence and cemented long-term friendships and research links. Inevitably such interchanges were not limited to research activities within the bounds of formal institutional structures. Scientists, whether working in DSIR or within the universities, listened, watched, learned and responded to changing social needs.

These and other traits came together and found expression in the contribution research scientists in the universities made to the broader community. Such contributions were often, too, extensions of experience gained by scientists who had left New Zealand for graduate work overseas. As a biologist and in the context of his times, for Dick Bellamy this found expression in the environmental movement. New Zealand had been transformed by European settlement, the clearance of the forests, and the promotion of agriculture, but almost entirely lacked heavy industry and the pollution associated with such activities. Driving down the New Jersey turnpike from New York in the 1960s had opened Dick's eyes to the impact on the environment of much modern development, in much the same way that the impact of the Industrial Revolution had impacted on the environment of his forebears in England. As he puts it, 'They left England; I decided to return to New Zealand!'

Before he had left New Zealand there already had been a few major conservation battles that influenced his outlook. The raising of Lake Manapouri was the most important, but upon his return in 1968 he found the conservation movement pretty disorganised. After some initial involvement with the New Zealand Conservation Society (now defunct) and the Federated Mountain Clubs of New Zealand, Dick became associated with the Environmental Defence Society (EDS). This group had been founded by David Williams (now David Williams QC) and was modelled on the US Environmental Defence Fund – the concept was to combine lawyers and scientists to present evidence in defence of the environment. It remains a powerful combination.

Dick together with a number of other University staff soon became involved in EDS activities in a major way. There were some significant cases. Dick was first attracted by their initial case, which involved the prosecution of the Huntly Borough Council for the illegal discharge of sewage into the Waikato River. On reflection, Dick acknowledges that he probably spent more time than he should have done on these activities, and he pays tribute to the University 'that they were prepared to tolerate such an extensive involvement by me in many high-profile cases'. Those were the days of the Town and Country Planning Act (1957) and the Water and Soil Conservation Act (1968). It was a relatively easy task to mount credible presentations – with legal help – because environmental case law was in its infancy and the development agencies such as the Electricity Department and the Ministry of Works were inexperienced in litigation. They had not yet come to terms with the change in public attitude from 'all development is good' to one that was increasingly critical of the impacts created by major projects. Involvement with EDS introduced Dick to a wide circle of contacts outside the University, and his subsequent involvement in local government arose from this recreational interest. A period spent on the Board of the Tongariro National Park at least in part stemmed from involvement in these and other conservation issues.

Looking back over the past 50 years, Dick believes that a few major trends stand out as having impacted upon his own career in science and administration and on the development of New Zealand science in general.

First, in his own research field, the revolution introduced by molecular biology and molecular genetics changed the balance of research internationally in a major way. Molecular biology commenced in the 1950s when a small group of physicists at Caltech became interested in evolution and genetics and were smart enough to see that phage and bacteria formed the model system to sort out the fundamentals.

Although the success of molecular biology initially impacted adversely on the chemical and physical sciences, he sees much recent evidence that this trend is reversing as it becomes increasingly evident that these core scientific disciplines – and engineering – hold the key to further advances in the biological and biomedical sciences.

Second, Dick believes that the inter-university competition introduced by the dissolution of the University of New Zealand and establishment of independent universities has perhaps not been entirely a good thing for the nation overall. New Zealand remains a small isolated country with limited capacity to invest. A University of California model (i.e. retention of the University of New Zealand model) might have been more beneficial for New Zealand overall and prevented some of the unnecessary duplication in resources that has occurred in recent years. Today's eight independent universities are far too many and some of these constantly struggle to remain either academically or financially viable. In the long-run Dick sees some rationalisation as inevitable.

Third, Dick thinks that the continued spread of science across separate university and CRI sectors is wasteful and rather silly for a nation of our size. There are too many CRIs and, like the small universities, several also struggle to remain viable. Recent successful (and unsuccessful) merger proposals reflect this reality. The American model of major government-funded facilities more closely associated with universities would perhaps be more sensible, enabling better utilisation of staff and providing much better opportunities for graduate training. This is the model currently applying to the Jet Propulsion Laboratory (administered by Caltech on behalf of NASA) and the Lawrence Livermore National Laboratory (administered by a consortium that includes University of California at Berkeley) and Dick believes it is one that would better suit New Zealand. There are, as Dick sees it, a number of other ways that universities and CRIs could be brought closer together, but this would require more vision and political courage than he has seen exhibited by governments over the past 20 years.

Dick, however, remains optimistic. Notwithstanding organisational and funding difficulties, New Zealand science has managed somehow to remain internationally competitive. Funded about 40% below the Australian average, the quality of New Zealand's scientific publications remains just as high and the taxpayer gets value for money. 'Over recent years, cheaper air transport and electronic connections have revolutionised our ability to communicate with the rest of the world. If we can be smart about how we manage our energy and water resources over the next decade and if we can diversify our exports further, we should be in good economic shape in future. All this requires the better use of science and technology as the underpinning engine to achieve our economic goals. This will remain an enduring challenge for the current government and any in the future. As in the past it will also require the fostering of individual scientists whose efforts today, as before, ultimately drive the science system'.

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Article

Addressing the quantitative skill shortage in the social sciences

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Increasingly social science graduates in New Zealand, especially those in the subject areas of sociology and political studies, are graduating without essential skills in the area of quantitative data analysis. In an attempt to address these issues, the research team at the Centre of Methods and Policy Application in the Social Sciences (COMPASS) at the University of Auckland have developed two initiatives. The first of these, the New Zealand Social Statistics Network (www.nzssn.org.nz) organises short courses in research methods training. The second, the New Zealand Social Science Data Service (www.nzssds.org.nz), provides secondary data for analysis and teaching resources linked to quantitative research methods.

Introduction

Increasingly social science graduates in New Zealand, especially those in the subject areas of sociology and political studies, are graduating without essential skills in the area of quantitative data analysis. This lack of skills has a number of impacts, both personal to the students and more broadly to the social science sector in New Zealand. For the students, it limits their employment opportunities and their choices for ongoing study. For the social science sector, the implications are that there is a lack of researchers who are able to analyse the sometimes necessarily complex data with which they are faced and address important policy questions that require quantitative methods skills.

This article briefly describes the nature of the quantitative skills shortage in the social science sector in New Zealand and why finding solutions to this problem is important. It then describes two initiatives to address some of the issues in this area which have been developed by the COMPASS research team at the University of Auckland. Finally, it identifies a number of additional measures which, if adopted, would also assist in addressing the quantitative skill shortage.

The quantitative skills shortage

Concern about the shortage of research capability, and in particular, the dearth of quantitative skills is not a recent phenomenon in New Zealand. In its 2001 report, the Social Science Reference Group noted that ‘policy agencies have reported to us a dearth of the evaluation and quantitative skills required for policy positions’ (Social Science Reference Group 2001, p. 24). Later in 2005, in a follow up report the Social Science Reference Group noted that ‘There are long run capability issues to be addressed across the wider social science community’(Social Science Reference Group 2005, p. 33).

Disquiet with the shortage of such skills in the social science sector is not confined to New Zealand. In the UK, the Economic and Social Research Council (ESRC) recently launched an initiative to address the skills deficit in quantitative research methods across the social sciences, noting ‘there is a need to enhance quantitative skills across the full breadth of the ‘educational life course’, from building new capacity at the undergraduate level to refreshing the quantitative skills of mid-career academics that teach undergraduates and supervise PhD students (‘training the trainers’)’(MacInnes 2009).

The lack of quantitative skills among social science students, particularly those in political studies and sociology, has two sources. Firstly, there are insufficient teachers trained in

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Gerard Cotterell is the Research Centre Manager for the Centre of Methods and Policy Application in the Social Sciences (COMPASS) at The University of Auckland. His recently completed PhD was an analysis of recent welfare reforms in the United Kingdom and New Zealand. His research interests lie in the areas of political sociology (particularly related to understanding the processes and effects of globalisation and neoliberalisation), the political economy of the welfare state, comparative social policy, and research methods.

Martin von Randow is the Operations Manager for the New Zealand Social Statistics Network (NZSSN) and the New Zealand Social Science Data Service (NZSSDS). In addition he works as a Data Manager/Analyst on a number of externally funded research projects. Martin has a Masters of Science (Statistics) First Class Honours from The University of Auckland quantitative methods to deliver such courses. Furthermore, when courses in quantitative methods are taught they are often delivered by staff on short-term contracts who do not necessarily have the training or resources required to deliver these courses. In addition, the development of the resources necessary for the proficient teaching of quantitative methods is expensive and time-consuming, making these courses less desirable to teach. These factors all combine to limit the number of skilled quantitative methods teachers available to teach in the social sciences, thus limiting the options available to students.

Secondly, students opt not to take courses offering skills in quantitative methods for a variety of reasons. Often students are not taught the utility of, nor are they exposed to, numbers in their undergraduate courses and hence do not attach value to learning such skills for employment and future study opportunities. In addition, students in an Arts Faculty may often express a 'fear' of numbers and avoid such courses. Furthermore, the existence of a 'quantitative versus qualitative' divide in these subjects, especially in sociology, means that the use of quantitative methods is often associated with a dogmatic empiricism which appears to deny the richness of social life, again reducing student interest.

These two sets of factors serve to limit both the number and range of quantitative methods courses available to students and to reduce the interest of students in taking such courses.

Why is the lack of quantitative skills a problem?

The resulting lack of quantitative skills is a problem for a number of reasons. For the students, firstly, it denies them access to good jobs. Most students graduating in these disciplines do not work in the academic sector. Instead, many of them will work in the public sector or for nongovernmental organisations where there is fierce competition (especially in the current environment) for jobs. Those students with quantitative skills typically are given preference for many of these positions. Second, a lack of quantitative research skills limits students' choices when deciding to undertake postgraduate study. Many overseas universities require students to hold quantitative research skills, and the lack of these may mean that students are not able to take opportunities to study at these institutions.

For the social science sector, the lack of analysts with comprehensive quantitative research skills limits its ability to analyse a mountain of data that includes official statistics and to address important research and policy questions.

The COMPASS response - our contribution to the solution

As a contribution to finding solutions to this issue of lack of quantitative skills, the research team at COMPASS,[1] led by Professor Peter Davis, have undertaken two initiatives which will be discussed in the next sections of this paper. We do not profess to have all the answers to the issue of the skill shortage with regard to quantitative methods. Our intent at this point is to share our experiences and posit some ideas and potential future directions for discussion among the wider social science community. We are firmly of the belief that such solutions need to be part of a collective and, although located at the University of Auckland, we strongly believe in the collaborative model of sharing teaching and other resources, in order to ensure the best possible outcome for both students and the broader social science sector in New Zealand.

The first of the initiatives discussed is the New Zealand Social Statistics Network (NZSSN) and the second is the New Zealand Social Science Data Service (NZSSDS).

The New Zealand Social Statistics Network

The New Zealand Social Statistics Network (NZSSN; www.nzssn.org.nz) was established in November 2004, with the aim of assisting in the development of social science research skills, with a particular but not exclusive focus on quantitative skills, in the academic, government and private research sectors.

The first research methods courses were run in Auckland in early 2005 and since then have been delivered in Wellington, hosted by the School of Government at Victoria University of Wellington. Courses in quantitative, qualitative and mixed methods are typically offered. In February 2010 the following mix of introductory, intermediate and advanced courses was run: Introduction to Statistics, Qualitative Research Techniques, Case Study Research, Introduction to Survey Design, Data Analysis in SPSS, Introduction to NVivo, Introduction to Program Evaluation, Research Synthesis for Policy and Practice, Introduction to Structural Equation Modelling Using Amos, and Advanced Analysis of Linked Health Data. The courses were attended by 125 people including postgraduate students, academics, public sector staff and other researchers.

Each year we seek to strengthen the range of courses offered and build on the previous year's foundations. In 2011 the additional planned courses include: Longitudinal Data Analysis, Fundamentals of Multiple Regression, and Advanced Structural Equation Models using Mplus.[2]

Along with hosting the annual research methods summer school, the NZSSN has also run occasional workshops on such topics as event history analysis, and social simulation (both microsimulation and agent-based).

The New Zealand Social Science Data Service

The New Zealand Social Science Data Service (NZSSDS; www.nzssds.org.nz) was established with assistance from the Tertiary Education Commission (TEC) in 2007. The NZSSDS was established with a broad-based stakeholder group including; Statistics New Zealand (SNZ), Broadband-enabled Science and Technology Grid (BeSTGRID), Building Research Capability in the Social Sciences (BRCSS), Data Saving and Sharing Work-

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[1] *The Centre of Methods and Policy Application in the Social Sciences (www.compass.auckland.ac.nz) is a research centre at the University of Auckland headed by Professor Peter Davis. COMPASS specialises primarily in health services and social science research. COMPASS has a staff of 1 professor, 3 research fellows, 4 statisticians, an administrator, and a research manager. It obtains its research funding from the Health Research Council, the Foundation for Research, Science and Technology, the Marsden Fund, and other sources*

[2] *For more information and/or to enrol, please visit: www.nzssn.org.nz or email: courses@nzssn.org.nz*

ing Party, Social Policy Education and Research Committee (SPEaR, Ministry of Social Development), Massey University ,and the University of Canterbury

Initially, the intent behind the data service was to provide a hosting service to ensure that high-quality, publicly funded, social science datasets containing information of relevance to New Zealand were retained and made available for re-use. However, the data service has been expanded over time and now performs three functions.

The first of these is preserving and making available research datasets and metadata. In this regard almost 50 datasets have been archived and made available for further analysis. These include the New Zealand Election Study (NZES) data (1990–2008), the International Social Survey Programme (ISSP) data for New Zealand (1991–2009), the World Internet Project for New Zealand (2007) and a number of health datasets (adverse events, oral health care, primary care, sexual health). These datasets are accessed by researchers in a number of countries and are also used as a teaching resource for a number of courses at the University of Auckland, namely postgraduate courses in Sociology and Statistics.

The second function of the data service is to make available to a broad audience a number of 'Enhanced Publications'. These comprise publications 'enriched' with three types of information: research data (evidence of the research), extra materials (to illustrate or clarify), and post-publication data such as commentaries. Enhanced publications are useful as they promote the availability of reusable scientific data, allow verification of the outcomes of the research, and reduce the need to 're-invent the wheel' and thus make better use of scarce resources. To date a small number of these advanced publications have been made available, and more will be added as resources permit.

The third function of the data service and the one that is of most interest for the purposes of this article is that of making available teaching data subsets and associated workbooks. These teaching resources have been made available, and more are under development, in order to assist with both the teaching and the learning of quantitative research methods. At present two teaching workbooks and their associated datasets are available on the data service. The first is based on the International Social Survey Programme data and changing family and gender roles. The second is based on data available from the New Zealand Election Study data to examining attitudes to politics. Additional teaching workbooks and associated datasets are under construction.

Where to from here?

These modest contributions from the COMPASS team aside, there are a number of additional responses available which we believe have the potential to raise both the number of students graduating with sufficient quantitative skills and the quality of teaching of such courses.

Firstly, postgraduate students could be taught quantitative (and qualitative) research methods in a block course model at one or more universities around the country at the beginning of each academic year. Each participating university could provide some resources to lessen the cost, and such a means of teaching would also strengthen links among postgraduate students in different disciplines. Secondly, postgraduate students could be taught such skills across the Kiwi Advanced Research and Education Network (KAREN) in a hands-on workshop environment with expert help available. Again universities could pool scarce resources to provide such training, or jointly hire an acknowledged high-quality research methods teacher. Thirdly, teachers across the country could jointly work to produce an agreed curriculum for the teaching of research methods at stage 2, 3 and postgraduate level through the pooling of resources. Fourthly, an annual prize could be provided for the best masters' and PhD thesis produced using quantitative methods in each discipline. Finally, students at both undergraduate and graduate level should be introduced to the utility of numbers by demonstrations of their value in non-research methods courses. For example, the ISSP data on changing family and gender roles could be used in more theoretical courses on gender.

Conclusion

Postgraduate students in both sociology and political studies in New Zealand suffer from a dearth of quantitative research skills which limit both their employment choices and their options for further studies. This also reduces the capability of the social science sector to address important research and policy questions. This paper has outlined two initiatives under way to deal with the problem and has suggested additional ways in which this issue can be addressed. A collaborative approach across universities would ensure the best use of scarce resources and help to ensure the best outcomes for the future of quantitative research methods skill development in New Zealand.

Acknowledgements

We thank the research team at COMPASS for their helpful comments on this article.

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Letters to the Editor

Re: Creating engines of growth

The conclusion reached by the authors of 'Creating engines of growth', *NZ Science Review* (Vol 67 (2) 2010) is demonstrably factually inaccurate and the contents typify the 'sexing up' approach of politicised science writing. The authors claim:

> *The creation of the CRIs 18 years ago was a brave move. The reorganisation now being proposed is equally brave….*

I must beg to differ for two reasons: first to protect the accuracy of the historical record, and second, because the governance and management of science is crucial to the future performance of New Zealand Inc. and can only be improved by **evidence-based decisions**, rather than political fawning.

The CRI reforms were predicated by two significant reports. The first, by Beattie *et al.* (1986) noted three essential components which must be improved if New Zealand was to follow the …. 'Well-established trend of many other developed countries towards dependence on knowledge-based rather than labour-based industries ...'

These elements were:

- An appropriate investment in R&D in both the public and private sector. (In fact they recommended doubling of the 1986 public expenditure by 1993–99.)
- An adequately-trained and informed work force.
- A confident awareness on the part of managers and boardrooms of the potential of R&D to facilitate innovation in their particular areas.

The conclusion reached in the Beattie Report remains inescapably true and is probably more pertinent now than when it was written:

> *We are convinced that New Zealand's overall present performance in all three aspects is less than adequate to achieve a significant rate of real growth. Market forces cannot be expected, unaided, to influence these important factors sufficiently to allow New Zealand to hold its own against competition, let alone do better.*

The Beattie Report was ignored by the Government, who responded by establishing another committee to review science and technology. Their report: 'Science and Technology Review: A New Deal' (Arbuckle *et al.* 1988) noted that… 'A reason for the luke-warm reception which the report of the Beattie Committee encountered from some officials was the fact that Beattie relied on simplistic assertions of market failure as a justification for government funding.' The operative phrase here is… '…the luke-warm reception…by some officials.' Here is the nub of governmental thinking operating at the time, which assumed that unless the market was measuring value, there was none, and that commercialisation would ensure outcomes in dollar terms **in order to make it measurable.**

The 'New Deal' was the blueprint for the CRI reforms and introduced to science the management concepts of contestability, funder/provider split, input and outputs, allocative efficiency, market focus, market failure, etc. It also put science into a commercial model, setting up the CRIs as Limited Liability Companies owned by the Crown but required to generate a return (profit, tax, and dividend) to the Crown.

Science now had two goals: to undertake public good research and make a profit.

The difference in purpose and tone between these two reports is stark. The Beattie Report was pro-science, arguing on rational grounds the need for more funding for science. In contrast the Arbuckle Report was effectively anti-science in adopting politically-correct ideology and argued the case for the commercialisation of science through contestability, sponsorship, private funding, anticipating some 'wisdom' of market forces. The Government should not fund Research and Development unless the Market failed to deliver.

> *Driven by political ideology, not evidence, the 'New Deal' reflected the one-size-fits-all solution of Rogernomics where Science was forced to fit the 'Market Model' and no other options were considered feasible.*

In researching a paper on science management in 2004, I was very surprised to learn that, in the time leading up to the formation of the CRIs, it appeared that no-one had bothered to wrestle with the fundamental question: What is science in terms of its principles and values, and, based on this, what governance and management model best preserves, protects and enhances these principles?

In brief - what is the optimal organisational model for science? I searched the world of management departments and the best I got was: 'Good question; we don't know!'

It would have proven beneficial, before the sweeping reforms were introduced in the 1990s, to have conducted a minimal review of the available evidence. Such a basic courtesy to the sector might have avoided so much pain, wasted effort, wasted money and disillusionment among science personnel.

It would have shown that (see Edmeades 2004, 2006, 2009 and note that if there are others who have contributed to these issues who I have omitted please let me know):

- Of all the professions, science is unique.
- Science is a normative activity based on a set of principles and values and which must be upheld with honesty and integrity.
- Science has, for this reason, very specific governance, management and operational requirements.
- Of all the available organisational models across the spectrum from corporate, co-operative, not-for-profit to public, the model with the best fit to the requirements of science is the Not-For-Profit (NFP) model.
- The worst model to choose for science is the commercial model.

Of course we now have evidence to support these truths from damning surveys of scientists' views (Sommer & Sommer 1997, Sommer 2002) together with the never-ending tinkering with the Market Model, since its inception, to somehow make it fit the purpose and needs of science. The latest review by the Crown Research InstituteTaskforce (Jordan *et al.* 2010) is yet another effort to drag science back to its proper normative role. But the CRIs are to remain dual-purpose commercial entities seeking profits while serving the public good. They will remain a 'house-divided' while this dichotomy remains.

The Taskforce did consider the NFP organisational model which was rejected for two reasons as recorded in their report:

1) *The Taskforce did consider moving to a not-for-profit model with charitable status, or changing the tax status of CRIs. On balance we concluded that such a change*

> *would not be advantageous, not least because it would give CRIs a commercial advantage that would make it harder for private sector research providers to emerge.*

What? The logic is confusing. I can only assume that the Taskforce believes that the only benefit of the NFP model is that no taxes are paid, which is, of course not so, and that a non-taxable entity undertaking public good research would limit the emergence of other science-providers, who presumably wish to compete with the Crown to undertake public good research! Yes, we need to develop mechanisms to encourage commercial entities to work alongside CRIs and one sure way to do that is to get the CRIs to do public good research and stop competing with commerce for short term contract research.

> 2) *Since their establishment CRIs have invested a great deal in making the company model work effectively. The Taskforce believes it would be counterproductive to move from this model. Indeed the company model provides a strong framework for defining the Government's expectations and for monitoring the CRI performance.*

Once again the logic is baffling. It seems to suggest that we must persevere with the commercial model because we have persevered so hard to make it work even though the model will never work – a bit like telling a wrongly-convicted prisoner that he cannot be set free because so much effort has been invested in his confinement! Extending the metaphor it seems to me that one reason why the Taskforce Report was so readily accepted by scientists was because they were at least allowed some time out of the cage.

Similarly the last sentence is an indictment. The central theme of the report is an attempt to refocus science back to public good research and away from profits. This confusion over the role of the CRIs arises directly from placing science in a commercial model which the Taskforce now claims to be ideal!

Yes, the Taskforce recommendations are steps in the right direction, taking science back towards a normative model, but they appear small and timid. They can hardly be called brave. I am counseled by those involved in the politics of science to tread softly on this matter – the only way forward I am told is to take small, mincing, incremental steps. It is indeed ironic that the reforms which gave us the CRIs were a single, large, irrational jump into stupidity. That apparently was okay. Now science must claw its way back, chastened, to normalcy!

The Taskforce also recommended that the CRIs needed to clarify their purpose. In the words of the report each CRI is to '… develop a Statement of Corporate Intent …'. Really! To use one example, is it the case that after 20 years, AgResearch does not know why, how and with whom it is doing public good research? And the performance of any given CRI is to be measured against the Statement of Corporate Intent. But how do you measure principles, values, honesty, and integrity, the key indicators of any normative enterprise?

The decision to commercialise science in New Zealand by establishing the CRI model can only be described as brave in the same sense that it would be brave for a deaf, dumb and blind person to drive a motor vehicle down an Auckland motorway in rush hour. It was a decision based on ideology, not evidence – Marx, Hitler, Stalin, and Mussolini come to my mind as prominent examples of promulgators of blind ideology. The recent reshuffling of the deckchairs, as suggested by the CRI Taskforce, and now accepted by Government, is best described as a 'repair job' – a small step to take science back towards a normative management model. Are we being brave in our retreat?

While the position of those who are beneficiaries of the commercialisation and politicisation of science is perfectly understandable, it does not make their conclusions in any sense 'true' or helpful at this time. Bravery is a quality which does not exist without courage. To confront wrong and rectify mistakes is to show courage, not the limp hand-wringing, cap-fiddling obsequiousness, suggested by the authors. Bravery or slavery?

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Reply

I appreciate the chance to reply to the letter from Dr Doug Edmeades.

'Engines of growth' had but one author – me – therefore all errors are my own. 'Brave' is, however, an adjective, not a noun, and therefore could be described as an error of opinion, rather than 'factually incorrect'. Furthermore, 'brave' isn't associated with outcome – it is like 'courage under fire'… death can follow. In education we try to build improvements by using encouraging words followed by suggestions. This approach allows a message to be heard and adjustments in behaviour to be made. In contrast, negative words lead to justification, and it becomes difficult to make progress – that thing which gives us satisfaction in the workplace and in life in general. It is my hope that others in the scientific community don't see lack of attack as 'political fawning', but as an attempt to build a better environment for science in New Zealand, one where they can make progress in their research.

I do, of course, thank Dr Edmeades for his ongoing efforts to improve my communication skills.

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19 September 2010

The New Zealand Association of Scientists Awards for 2010

The Marsden, Shorland and Research Medals and the Science Communicator Award were presented by Mr Murray Bain, Chief Executive of the Ministry of Science and Innovation, on Thursday, 4 November, at a ceremony at Turnbull House, Wellington.

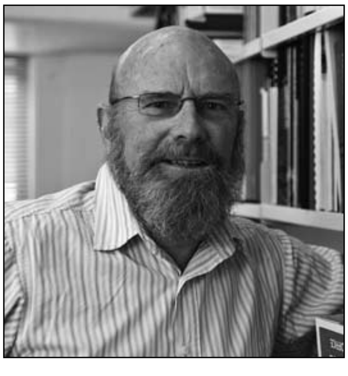
Mr Bain briefly addressed the audience and stressed that science was a central plank in the Government's strategy to achieve its economic goals and seen by Government as an investment rather than a cost.

Marsden Medal

The Marsden Medal is awarded for a lifetime of outstanding service to the cause or profession of science, in recognition of service rendered to the cause or profession of science in the widest connotation of the phrase. The receiptent for 2010 is **Emeritus Professor Brian Robinson FRSNZ.**

Brian Robinson has served the Chemistry Department of Otago University for over 40 years, and taken a very active role in all areas. Although his core research area has been organometallic chemistry, he has continued to be very innovative in examining new areas. His publications have been widely cited in the scientific literature; his work has been appreciated internationally. In addition to the normal roles in teaching, mentoring and research he has served as Head of Department for 10 years, and his service role has been extensive in several areas such as quality assurance and academic audits, controlling chemical hazards, safety, and commercial developments. In all this Brian has maintained an innovative approach to new areas of chemistry – he has served science extremely well.

Shorland Medal



The Shorland Medal is awarded in recognition of major and continued contribution to basic or applied research that has added significantly to scientific understanding or resulted in significant benefits to society.

The recipent for 2010 is Professor **Kenneth McNatty FRSNZ,** Victoria University of Wellington.

Ken McNatty is one of the world's leading figures in reproduction biology, having made a number of important basic research discoveries and then seen them through to applications with significant economic benefits. He is the author of 260 peer-reviewed research papers and holds 10 patents. Ken's reputation was founded on a number of discoveries during the '70s and '80s relating to follicular development and egg viability and the differences between humans, sheep and cattle. This work led to Ken becoming a Fellow of the Royal Society of New Zealand in 1992, having been nominated by Brian Shorland. Further fundamental research on ovulation followed, and provided insight into the system that regulates the number of eggs released at ovulation. This work provided the basis upon which Ken's team at AgResearch developed AdroVax, a sheep twinning vaccine that has made a substantial contribution to the New Zealand economy, estimated to be in excess of $100 million per annum. Now based at Victoria University, Ken continues to develop new insights into reproduction, with projects focused on human health, agricultural benefits, environmental impacts on reproduction and even seeking to improve rates and success of reproduction in New Zealand's native avian fauna.

Research Medal

The Research Medal of the New Zealand Association of Scientists is awarded for outstanding fundamental or applied research in the physical, natural or social sciences published by a scientist under the age of 40, during the year of the award or the preceding three calendar years. The recipient for 2010 is **Dr Shaun Hendy** at Industrial Research Limited (IRL).

Shaun Hendy has pioneered, established and continued the transformational research area of theoretical nanotechnology in New Zealand. Shaun's major research discoveries include identifying new solid–liquid phase behaviour induced from nano-scale collisions, and the classification of novel recoil behaviour of nano-particles. These new phenomena are absent from both the smaller atomic-scale, and from the larger macro-scale. Their discovery by Shaun attests to his scholarship, especially given the very applied and industrially-motivated aims of the research programmes. Shaun's mathematical discoveries have resulted from the application of new numerical methods, called Hybrid-Kinetic Monte Carlo methods, developed jointly with Prof Tim Schulze from the University of Tennessee, which allow both a fine computational grid where significant atomic redistribution is occurring, but with a coarse grid where atomic distributions are largely static. Shaun has also discovered new laws relating at the nano-scale, for the drag between a liquid and a solid surface; and obtained new results for droplet entry into nano-tubes. His IRL responsibilities have included successful application for, and management of over NZ$20 million of research contracts.

Shaun has been employed at IRL since 1998, where he is a Distinguished Scientist and is currently Deputy Director of the MacDiarmid Institute for Advanced Materials and Nanotechnology.

Science Communicator Award

The Science Communicator Award is made to a practising scientist for excellence in communicating science to the general public in any area of science or technology.

The recipient for 2010 is **Dr Marc Wilson**, Victoria University of Wellington.

Marc Wilson describes himself as 'intellectually indigenous' to Victoria University, having started studying psychology there in 1991 and never leaving. After completing his PhD in 1999, he undertook some of the less popular academic jobs at the time. These included teaching research methods to 100-level psychology students in one of the largest courses offered at VUW. Marc is a teacher, first and foremost, whether this involves teaching formal classes, or through print, radio, and television media. He regularly presents to schools, organisations, and anyone else who will listen and, taking seriously the obligation of tertiary education in New Zealand to contribute to 'the development of cultural and intellectual life', he has gone out of his way to help out various media organisations in New Zealand. Marc routinely provides commentary on topical social issues – after all, what better way to champion one's discipline than through media willing to do the work for you? In the words of one journalist 'I swear to God, you seem to be the only psychologist in Wellington who speaks to the media'. Marc has won both local and national recognition for his teaching, and this has led to the opportunity of an academic lifetime – the chance to design material for, and present, two of TVNZ's consumer psychology series, 'The School of…' in 2007 and 2008 (watched by more than 800 000 people). He has collaborated with several outlets (including TV3 and the *Sunday Star Times*) on large-scale studies on topics such as supernatural and superstitious beliefs, and personality and criminality, which have also served as vehicles for data collection for his research – these partnerships are a win-win for both academics and media. Most recently he has been engaged in a study of public beliefs about evolution that has involved surveying Fellows and Members of the Royal Society of New Zealand, Secondary School science teachers, members of the general public, and (because it's traditional) first-year Psychology students. On the down side, he has also been described by Paul Henry as a 'Kiwi cultural commentator'.

New Zealand Association of Scientists

Registration Form

I wish to become a member of the New Zealand Association of Scientists.

Applications must enclose payment to be complete. Please photocopy this form and return to:

Membership Secretary
New Zealand Association of Scientists
P O Box 1874
Wellington

Name ....

Preferred title ....
....
Position..

Mailing address (work address preferred) ....

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Membership Fees:

Individual - $65.00 (overseas postage $15)
Joint membership - $75.00
Student/unwaged/retired - $42.00
Corporate membership (receive
2 copies *NZ Science Review*) - $121.00

Subscriptions to *NZ Science Review* only:

School libraries - $42.00
Libraries (NZ - incl. postage) - $82.50
Libraries (overseas - incl. postage) - $95.00

New Zealand Association of Scientists

For over 50 years the New Zealand Association of Scientists has existed to -

- improve conditions for scientists
- benefit society through the application of science
- promote science
- defend freedom of expression
- increase public awareness
- influence government
- encourage excellence
- eliminate gender and ethnic barriers
- promote social responsibility
- expose pseudo-science
- promote free exchange of knowledge
- increase international co-operation
- debate science policy

The Association membership includes physical, natural, mathematical and social scientists and welcomes anyone with an interest in science education, policy, communication and the social impact of science and technology. Members receive *New Zealand Science Review,* the official publication of the Association.

Applications for membership should include name, postal address, scientific background and interests and be addressed to -

Membership Secretary
New Zealand Association of Scientists
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