2008 Survey of New Zealand scientists and technologists

Jack Sommer, PhD, MRSNZ
Knight Distinguished Professor of Public Policy (Emeritus)
University of North Carolina at Charlotte

New Zealand Association of Scientists Inc
PO Box 1874, Wellington

www.nzas.rsnz.org

Foreword

It is with great pleasure that the New Zealand Association of Scientists (NZAS) is able to present the 2008 survey of New Zealand scientists and technologists. In 1994, the first survey was carried out by NZAS. This was followed by surveys undertaken by the Royal Society of New Zealand, in collaboration with Professor Jack Sommer, of the University of North Carolina at Charlotte, N.C., USA, in 1996 and 2000. While there has been a longer interval than we would have liked following the 2000 survey, we now have an opportunity to see if there has been any generational shift in the profile and attitudes of the research community. Given the recent appointment of the first Prime Minister's Chief Science Advisor, the publication of this Survey is particularly relevant.

We are very fortunate to have been able to collaborate once again with Professor Jack Sommer. We have been able to take advantage of his long experience with such surveys, in New Zealand, the United States and elsewhere. Our sincere thanks go to Jack who has worked very hard to make this a success. We acknowledge support (both financial and in kind) from the Ministry of Research, Science and Technology and the Royal Society of New Zealand. Nevertheless, We also thank those who made the time to assist in this study, especially the Technical Advisory Group (Dr Jason Gush (Convener), Royal Society of New Zealand; Drs Mike Berridge and Janet Bradford-Grieve, New Zealand Association of Scientists; Dr Sean Devine, Victoria University of Wellington; Mr Jonathan Hughes, New Zealand Vice-Chancellors' Committee; Dr Lesley Hunt, Lincoln University; Mr Anthony Scott, Science New Zealand; Dr Yelena Thomas, Ministry of Research, Science and Technology) and others who advised on the form and content of the survey questionnaire.

To facilitate the 2007/08 Survey, and in the absence of any database of scientists and technologists, NZAS had to construct such a database. This major task could not have been accomplished without the active participation of most of the large scientific research institutions from which we needed to obtain up-to-date information.

Professor Sommer has been able to build upon the valuable baseline created by past surveys. Many questions have been repeated so that trends can be examined. New questions of immediate pertinence to the current situation in New Zealand have been added.

We now have an opportunity to benefit from the information arising from the Survey. By publishing these results, NZAS aims to inform public discussion of science and technology policy and contribute to an understanding of what makes the research workforce 'tick'. In this way, NZAS hopes to improve the working environment of scientists and enhance the contribution they make to the nation's well-being.

Survey Committee,
New Zealand Association of Scientists

Ross Moore (Chair)
Mike Berridge
Peter Buchanan
Janet Bradford-Grieve
Ken Richardson

NOTE: The New Zealand Association of Scientists (Inc) is responsible for the 2008 survey report in this issue of *New Zealand Science Review*. The independent Survey Director, Professor Jack Sommer, was authorised to undertake survey design, collection and aggregation of data, and to interpret the results. Participants in the survey are assured of absolute anonymity and their individual responses remain strictly confidential to Professor Sommer based at the University of North Carolina at Charlotte.

Abstract

The results of the 2008 New Zealand Association of Scientists Survey of Scientists contain a wealth of information on the attributes and accomplishments of the New Zealand research, science and technology (RS&T) workforce, the concerns of scientists, their values relating to science and society, and their opinions on the performance of the RS&T system. The results of this survey include factual information as well as opinion. Several results stand out, given the recent policy concerns over participation in the workforce, the need to improve collaboration, and the morale of the workforce:

1. The proportion of women entering the profession has gone up between 1996 and 2008, with women now making up 32.4% of the survey population as opposed to the sample respondents (28.8%). There has been a modest increase in Māori scientists from 0.7% in 1996 to 1.7% in 2008. Q. 6, Q. 13, Q. 20
2. Crown research institute (CRI) scientists are younger than their university counterparts. Those in the under 35 category are four times more numerous in the CRIs and the over 55 age group in CRIs is two-thirds of the size of this group in universities. Cross tabulation of Q. 10 and Q. 14
3. Nearly two-fifths (38.5%) of scientists in 2008 were not employed in S&T in New Zealand when the 1996 Survey was taken. Q. 8
4. Scientists' sense of job security has improved from 50.8% in 1996 to 60.9% in 2008. Young people under 35 feel the most secure (70.3% in 2008 versus 35.4% in 1996). We point out that this survey was taken before the global economic crisis. Q. 70
5. Scientists are very concerned about 'interruptions to research funding' and 'bureaucratic accountability', among other issues, and this concern has intensified between 1996 and 2008. Interruptions to funding are particularly acute among agricultural and soil, physical and biological scientists. CRI scientists (49.3%) were twice as likely to cite interruptions as university scientists (24.2%) in 2008, and this concern has gone up since 1996 (24.2% and 17.5%, respectively). Q. 23
6. The two most important conditions considered necessary for a strong scientific workforce were 'A productive research environment that is compatible with the requirements of the research endeavour' (28.3%) closely followed by 'A climate in which scientists feel valued and trusted' (26.0%). Q. 32
7. Only 13.6% of the respondents agreed with the proposition that government science strategy development is open and inclusive of a large segment of New Zealand scientists, and none of them did so emphatically. Nearly half (48.5%) disagreed and the emphatic disagreement (13.6%) matched the entire level of agreement. Q. 42
8. Scientists in general have skeptical attitudes towards the government's role in setting science agendas. There is a large gap between CRI and university scientists in their negative opinion of governments setting research agendas: in 2008, 68.5% of university scientists disagreed that governments should set the broad research agenda whereas, among CRI scientists, only 37.3% disagreed. This level of disagreement in both institutions has increased since 1996. Q. 35, Q. 36
9. There has been an apparent improvement of the opportunities for cross-institutional collaboration since 1996, with 42.1% agreeing with the statement 'Over the past five years the opportunities for cross-institutional collaborative research have greatly improved'. Q. 68
10. In 2008, 64% of scientists disagreed with the statement that the 'management systems in New Zealand are appropriate for the effective advancement of research' whereas 8.6% agreed. Disagreement with this statement has increased since 1996 (53.2% disagreed and 11.1% agreed). Q. 52
11. Only 41.2% of scientists would recommend research as a career to New Zealand youth. CRI scientists were the most negative, with only 26.7% able to recommend research as a career, whereas university scientists were more positive, with 43.8% feeling they could so recommend. Q. 51
12. A summary judgment of whether New Zealand science is 'headed in the right direction' received a majority negative response of 53.5% from CRI scientists compared with 30.9 % for university scientists. Q. 74

Introduction

Origins of the Survey

The 2008 Survey of Scientists and Technologists is derived from earlier successful survey efforts. The original idea of a survey of the scientific community was developed by the New Zealand Association of Scientists (NZAS) and carried out in 1994 by a team of individual members of the organisation. Results were published in *New Zealand Science Review* in 1995 (Berridge *et al*. 1995). Subsequently, interest developed within the Royal Society of New Zealand (RSNZ) to enlarge and enhance the survey, and in 1996, the first comprehensive survey of the scientific community was carried out under the direction of Dr Jack Sommer, a Senior Fulbright Scholar and science policy research scientist at the University of North Carolina at Charlotte. The development and results of this survey are reported in the RSNZ document, *Profile: a survey of New Zealand scientists and technologists* (Sommer & Sommer 1997). Dr Sommer had extensive experience in the survey of scientists as Chief Advisor of a major survey of scientists in 1986 for Sigma Xi, The Scientific Research Society (Jackson 1987, Sommer 1987) and then as Director of their 1988 Survey (Sommer & Seltzer 1988, Hively 1989; *see also* Sommer 1991, 1995).

The 1996 Survey asked individuals if they would be willing to be re-surveyed after the passage of several years, and about one-third indicated their agreement. This group, with inevitable attrition, formed a panel that was re-surveyed in 2000 and again in 2007. Unpublished reports of results for the 2000 and 2007 panelist surveys are on file at the RSNZ and with the NZAS. This longitudinal inquiry of the same scientists at different stages of their careers is an invaluable source of information on the effect of changing conditions and policies. The serial application of the survey has also permitted refinement of the survey instrument; some questions have been abandoned entirely, some new questions have been developed, and a large core of the original survey questions have been retained for sustained comparative purposes. The 2007 Panelist Survey served as a test run for the instrument used for the 2008 Survey of Scientists and Technologists. At all stages of the development of these survey instruments, the advice and recommendations of New Zealand scientists and technologists have been valuable. Qualitative responses sought from respondents to each survey, comments from focus groups, and test runs of the instrument before each survey have been crucial to the refinement of our inquiry.

For the 2007 and 2008 Surveys, a select Advisory Group of prominent New Zealand research scientists and science managers was constituted (named on the title page of this publication). Their critique of the survey instruments and analysis of results of test runs contributed greatly to the entire survey process. In addition to the specific support of these individuals has been the material and moral support of RSNZ, NZAS, and the Ministry of Research, Science and Technology (MoRST). We heartily acknowledge that the entire survey process from its origins to the present would not have occurred without the steadfast contribution of Mr Ross Moore, former CEO of RSNZ, who envisioned the important functions of a survey for the New Zealand science community.

Four functions of the Survey

A voice for the science community

There are a number of questions in the survey the collective answer to which give the wide community of scientists a clear 'voice' about matters of interest to that community. In this respect, the **Attitudes and opinions** section of this survey provides an open forum for anonymous, randomly selected scientists to register their ideas and concerns on issues rather than filtering these through organisational or social structures. The results offer the general public, other scientists, and science managers in New Zealand and abroad more direct insight into those concerns than do consensus statements by groups and organisations or by institutional leaders. The **Attributes and accomplishments** section of the survey provides fundamental demographic information on such matters as age, gender, field of science, and work location, and this permits detailed analysis of all responses.

Questions have been grouped under the following headings to convey this 'voice' on selected issues: ***Concerns of scientists; Science, values, and government; Scientific inquiry and education; and Performance of the S&T system***. Questions range from the personal, such as reasons one has chosen a career in science, to career satisfaction and the impact of government policies on the development of one's career. Although the results may present a sometimes troubling snapshot of current opinion it should be remembered that the real value in asking these questions is found in repeating the asking of the same questions over several years. This survey is, after all, a baseline from which change may be measured. Of the 45 questions in the 2008 Survey that were also present in the 1996 Survey, 17 concern Attributes and accomplishments and 28 relate to Attitudes and opinions. Twenty-nine questions in the 2008 Survey are entirely new, many replacing earlier, no longer relevant, questions with ones that address current conditions.

As one reads the survey instrument, it is obvious that many of the 'questions' are 'assertions' to which one is invited to respond along a scale running from 'emphatic agreement' to 'emphatic disagreement'. The results convey a range of intensity of opinion. Most of the questions we have discussed have been in simple terms of 'agreement' or 'disagreement' derived from adding the emphatic and less emphatic responses. Unusual degrees of emphatic agreement or disagreement (and equivocation) are noted when this sheds special light on the issue. More in-depth examination of the issues of emphatic agreement or disagreement usually involves comparisons between 1996 and 2008 with respect to one or more of the four important categories of demographic information mentioned above.

Results from the 1996 Survey, reported in the 1997 publication of *Profiles: a Survey of New Zealand Scientists and Technologists* by RSNZ (Sommer & Sommer 1997) stimulated much policy discussion and many citations over the past decade (see also Sommer & Sutherland 1998, Sommer 2001, Campbell *et al*. 2005, RSNZ 2008). The results of the 2008 Survey amplify the 'voice' of New Zealand scientific community.

A source of unbiased information for development of science policy

There is no escape from some degree of bias in any survey enterprise; this was true in 1996 and it is true of the 2008 Survey as well. The selection of scientists and engineers who hold advanced degrees presents an immediate bias toward the research community over the wider community of teachers and practitioners who are instrumental in the advancement of scientific thought and praxis. Moreover, below in the section on Database development, we have identified limitations to the database of scientists and technologists which one hopes will be overcome through dedicated effort before the next survey.

This said, the data from the survey have been developed with as much care as possible, thereby providing information that can confidently be used in science policy deliberations. The opinions and concerns of scientists are important to an understanding of the morale of the community. Gauging the morale of the community is one of the goals of the *RS&T 2010* document (MoRST 1996) and has been reiterated in subsequent government publications such as *Science for New Zealand* (MoRST 2006a), *Research and Development in New Zealand* (MoRST 2006b), and *From Strength To Strength* (MoRST 2008), which effectively sets out a vision for 2020. It will be important to those responsible for the management of science in New Zealand to track morale indicators enunciated a decade earlier and which are now revealed in the 2008 Survey results. This report seeks to understand both the sources of concern expressed by scientists and the direction of change in opinion over the years.

Attitudes on the management of New Zealand science, or views on what scientists perceive to be the most important issues facing science are obviously important to follow, but much of value for the management of science and technology can be derived from examination of the **attributes** of the science community. Age, gender, fields of science, income, publications and patents, time spent by scientists in research versus paperwork, and other data, are the hard bits of evidence upon which policy may be formulated. Formal analysis of correlates of these attribute data with opinion data has given us a more complete understanding of the landscape of New Zealand science and technology.

A source of performance measures of government science policy

MoRST developed the *RS&T 2010* report (MoRST 1996) for the Government of New Zealand, taking bold steps to set goals, and wise steps to suggest indicators by which progress toward those goals can be measured. Many of the data developed through the 1996 Survey of New Zealand Scientists and Technologists (Sommer & Sommer 1997) were developed with those goals and indicators in mind and has been repeated in the 2008 Survey. In some instances, such as Question 15 which asks if the respondent has been appointed to a board of directors, the wording of the question is virtually lifted from the 2010 goals report. There are other very specific examples of paired 1996 and 2008 data linked to the development of indicators, such as Question 22 which provides extensive information on publications and patents, or Questions 16 and 17 concerning sources of significant research funding. Subsequent Government goals statements mentioned above have been the source for new questions in the 2008 Survey. Tracked over time, these are examples of data that can lead directly to measurement of both progress towards Government-enunciated goals and the effectiveness of the management of science.

Funding mechanisms are an area of special importance for science management because it is so close to the heart of the research enterprise. The results of Questions 61, 62, and 63 should be considered carefully, both for what they reveal and for what they do not. The low level of satisfaction with the review process in general, and at the Foundation for Research, Science and Technology (FRST) in particular, must raise questions of whether there are alternatives to a grants regime or a 'negotiation' process. What other models exist? Question 65 poses a lottery as an alternative, and the results are surprising. Could these obviate the main concerns of the scientists without introducing different and more troubling issues? These are some of the questions that should be considered, particularly as the Marsden Fund support will be experienced by a greater number of scientists and as the university science community is drawn more closely into the restructured science framework.

A source for enhanced public understanding of science and technology

This survey can be an exceptional source of information for the lay public when used as a basis for editorials and commentary. In both the 2008 and the 1996 Surveys, New Zealand scientists have given 'voice' to their concern about diminished public understanding of science and technology, and they have uttered their sense of responsibility for its enhancement. They have also provided insights to delight an alert public. In 2008, questions about specific issues such as stem cell research, nuclear power, genetic modification, global warming, and scientists' views of the journalistic coverage of science issues provide a window to the mind of scientists.

Background information on the income of scientists and their reasons for undertaking their careers help to create a lively profile of individuals in a profession critical to the future of New Zealand. Matters of the responsibility of scientists to society are revealed in Questions 31–34, for example, and as the responses are more widely discussed there is sure to be a productive dialogue between scientists and the taxpayers who provide the preponderance of their support. This is all to the good.

Greater understanding of the views of scientists and the working of the system of public support for science does not automatically translate into ever-richer research budgets upon which to draw, nor should one infer that this is the reason scientists are so interested in being understood. In fact, it is quite clear from these results that scientists are motivated greatly by 'the search for truth and knowledge' rather than for personal wealth or prestige. Much of what concerns them seems to be barriers they believe stand between them and the achievement of their goals. It is precisely on these issues that a vigorous dialogue must exist between scientists, science managers, and the public, both directly and through its Parliamentary representatives.

The research plan

The survey instrument

The survey instrument for 2008 evolved from survey techniques developed in 1988 (Sommer & Seltzer 1988) to address science policy issues in the USA and which were modified to address prominent issues in New Zealand at a time of major change in the New Zealand science system (Science and Technology Advisory Committee 1988, MoRST 1992a, b). These techniques have continued to be adapted with successive New Zealand surveys in 1996, 2000, and 2007. Particular care has been taken to develop parallel information on **attributes**, e.g. demographics, fields of science, and on some questions of universal importance. These categories of questions were developed with special reference to international comparison, and for linkage to other scientific and more generalised databases. Questions of direct significance to New Zealand science policy were developed from a close reading of the Government's strategic plan documents for science and technology and through review of an earlier attempt at a survey of scientists by the New Zealand Association of Scientists (Berridge *et al*. 1995).

To collect this attitudinal and demographic data a survey instrument was created that contained two sections. The first section of the questionnaire addresses the attributes and accomplishments of scientists and seeks demographic and other descriptive data about participants using structured response categories. The Age, Gender, Field of Science, and Work Location of individuals are four critical variables used in detailed analyses of most of the other questions in the survey.

The second section consists, in large part, of a series of statements or assertions about which respondents were asked the extent of their agreement or disagreement. Survey participants were provided with a five point response scale ranging from (5) 'emphatic agreement' to (1) 'emphatic disagreement.' A mid-range response (3) 'Neither agree nor disagree' indicated a neutral response to the statement. A few questions required a simple 'yes' or 'no' and a few others involved the ranking of choices in relation to a number of topics, for example, one's reasons for choosing a career in science (Q. 44) or concerns over the grant award process (Q. 61). The specific choices listed in these questions were derived from focus group discussions and interviews.

Survey respondents were encouraged to add comments about the instrument itself and about the issues raised by any of the questions. These qualitative comments have proved to be extremely valuable in providing perspective on the survey but only those that have been released by their author are authorised to be published.

Through the good offices of RSNZ, and with the assistance of NZAS, MoRST, and acquaintances at universities and Crown research institutes (CRIs), focus group meetings were arranged during March 2007. These meetings permitted the author to seek advice on current issues of greatest concern to scientists, and to adjust the survey instrument accordingly. A formal Technical Advisory Group was established in April and pre-testing of the survey instrument occurred during May.

During June 2007, a test run of the survey instrument and the survey procedure on 25 scientists led to further revision of the survey and rewording and re-sequencing of some questions. These series of tests convinced us that the use of an electronic survey medium could be a cost-effective method compared to past paper surveys that required expensive postal and coding costs. Moreover, the 1996 Survey revealed that nearly 95 per cent of those surveyed had access to the internet. University of North Carolina at Charlotte, home institution of the Survey Director, provided access to SurveyShare, an electronic survey research firm contracted to the university. With the great assistance of Mr Owen Watson at the RSNZ, email addresses were secured for the panelists who had participated in the 2000 Survey.

The 2007 Panelist Survey of New Zealand Scientists and Technologists was initiated on 1 September and the response window closed on 15 October. Analysis of the data by the author and by members of the Technical Advisory Group followed and the success of this survey instrument and process indicated that the immense effort it would take to build the database of the universe of New Zealand scientists and technologists should be undertaken.

Database development

To re-establish the database of scientists and technologists for the 2008 Survey required a major effort by NZAS leadership, RSNZ staff, and the Survey Director to develop cooperation from the many supplying institutions: universities, CRIs, polytechnics, research associations (RAs), and museums. The 2008 database took more than a year to complete. It is improved over that developed for the 1996 Survey but there are flaws to be understood and challenges posed for the establishment of a process of continuous database development and maintenance necessary to sustain and enhance the Survey. This section reports on the development of the 2008 database and specifies in what ways it differs from that developed for the 1996 Survey. Recommendations are made for the continued improvement of future databases.

Survey population

The survey population is created from lists of scientists and technologists in New Zealand who hold masters-level or doctoral-level degrees in the following broadly defined scientific fields. The survey population is the base from which a survey sample is drawn. The broad fields of science used in 1996 and 2008 and in the 1988 USA Survey are:

- Agriculture & Soil sciences
- Biological sciences
- Engineering sciences and Applied sciences & technologies
- Earth & Environmental sciences, and Natural Resources
- Medical & Health sciences
- Mathematics & Computer sciences
- Physical sciences
- Social & Behavioural sciences
- Other

The choice of this level of accomplishment and schedule of eight fields was made for the 1996 Survey so that comparisons could be made with a major 1988 Survey conducted by the Survey Director in the USA. Individuals who had achieved a BSc in one of these fields and who were enrolled in a S&T doctoral programme were also included. The percentage breakdown of these degree levels for the three surveys is given in Table 1.

Table 1: Degree level of survey respondents 1988, 1996, and 2008

	New Zealand 2008	New Zealand 1996	USA 1988
Doctorate	78.9%	80.0%	78.0%
Masters	15.8%	17.3%	17.0%
BSc.+	1.9%	2.7%	5.0%*
Other/Skipped	3.4%	na	*BSc. & Other

In 1996 the survey population numbered 4341 and in 2008 there were 5966. The sources of these populations were slightly different, as displayed in Table 2.

Table 2: Workplace origin of survey populations 1996 and 2008

	2008 Survey population	1996 Survey population
Universities	4033 (includes AUT*)	2900
CRIs	1549 (ESR* excluded)	1341
RAs & Other	100	82
Polytechnics	241	Did not participate
Museums	25	Did not participate
Other	18	18
Total	5966	4341

* AUT = Auckland University of Technology;
ESR = Institute of Environmental Science and Research Ltd

Because there is no complete roster of such scientists in New Zealand, and the number is in constant flux anyway, it is impossible to know definitively what proportion of this community has been covered by the study. From anecdotal evidence, the author estimates that about 90 per cent of New Zealand scientists and technologists possessing the degree-level qualifications established for the survey are represented in the population sampled. Among the active scientists not included in the database, and therefore missing from this survey, are those with private firms, those in government service (e.g. scientists in various Ministries), and those employed at the Institute of Environmental Science & Research Ltd (ESR), the sole CRI that chose not to participate in the study.

Efforts were made to include qualified individuals in private firms for both the 1996 and 2008 Surveys but without success. To include this important but putatively relatively small number of qualified scientists and technologists required a level of organisation and financial resources we could not achieve.

The 2008 Survey population is an improvement over 1996 in several ways. By including polytechnics and museums the Survey signalled the recognition of these institutions as contributors to the New Zealand S&T research community even if the number of qualified individuals did not add many to the total. The most important augmentations of the survey populations from 1996 to 2008 were the addition of Auckland University of Technology followed by the polytechnic institutions. The abdication in 2008 of ESR, a CRI, while not preferred, did not diminish the CRI population significantly. In 1996 there were 73 ESR scientists in the survey population. In several other instances it was difficult to obtain the cooperation of some institutions because of privacy considerations, but these were eventually overcome.

The most important advance in the survey population from 1996 to 2008 is the addition of information on gender, which, when combined with work location, provided a valuable cross-check of the survey sample, for random selection of individuals to be surveyed and for responses to the survey. The 2008 survey population ($n=5966$) is 32.4% female ($n=1931$) compared to the male population 67.3% ($n=4033$). The randomly selected survey sample is 30.3% female ($n=317$) and 69.5% male ($n=729$). Survey respondents were 28.8% female ($n=104$) and male 71.2% ($n=257$).

The gender difference between the survey population and the survey sample is insignificant, but the difference between the survey sample and survey respondents, while not great, prompted closer examination of non-respondents. In effect, there are 12 (11.1%) fewer females among respondents than expected. Careful analysis of the individual database entries indicates that research leave and maternity leave contributed half of the shortfall.

The more interesting question arises over the gender distribution differences between the 1996 and the 2008 Surveys. In 1996 we did not have an accurate gender count of the survey population or the survey sample, but of those who responded to the survey, 22.2% were female. The jump in the proportion of female respondents in 2008 may be indicative of increasing interest by, and encouragement of women in science and technology positions (or the opposite for males), but it is also possible that the more inclusive nature of the survey population (polytechnics for example) plays a role.

Survey sample

For the 2008 Survey each of the 5966 individuals in the survey population was a assigned a unique record number, and statistical consultant, Dr Nancy Shoeps, withdrew a random sample of 1046 names to create the gross survey sample. Close checking of the random sample against the lists submitted by the different organisations revealed that 43 (4%) of the names drawn were unable to be used because an email address was unavailable. The effective pre-distribution survey sample was 1004. Once the survey instrument was distributed, other flaws in the original database were discovered.

In early June, the survey sample was tested by emailing notices to the individuals who had been chosen to participate in the survey, alerting them to expect the survey instrument. Within minutes an avalanche of rejections came from spam filters and servers at the various institutions. For the next two months, the Survey Director and members of the Technical Advisory Group contacted authorised individuals at the several institutions to clear the way for receipt of the survey. The result of these exchanges was to reduce the effective survey sample to 930 individuals. Thus, the difference between the gross survey sample and the effective survey sample is 117 individuals, or 11.2 per cent. When extrapolated to the survey population, the author estimates that 668 individuals would not be able to be contacted.

Survey implementation

On 4 September 2008 the survey instrument was emailed to the verified survey sample of 930 individuals. Difficulties with institutional spam filters continued throughout the period of the survey until it officially closed on 31 October 2008 and 349 responses had been received. Persistence of this difficulty was monitored throughout the survey period and three separate reminders were emailed to individuals who had not yet completed the survey. During November a few responses that trickled in were checked for consistency, validated and permitted to be included. Several responses were substantially incomplete and these were removed from the respondent pool. The final count of 361 complete and valid records serves as the basis for the analyses that follow.

The response rate of 38.6 per cent for the 2008 Survey was substantially lower than that for the 1996 Survey *(57%)*. The Survey Director hypothesises this difference may be attributed to three main factors: insufficient contact by the Survey Director with the IT officials at institutions that provided lists of personnel to insure that institutional spam filters would not block the e-survey; reluctance of individuals who received the survey to open 'suspicious' emails in spite of prior communications about the survey; assurance by the Survey Director in a covering letter that the survey could be completed, on average, in twenty minutes was nevertheless daunting to some individuals. A rigorous post-survey inquiry of non-respondents has not yet been undertaken due to resource constraints. Future survey efforts must address these issues and others that are part of a technical report too detailed for inclusion in this document.

With these caveats stated, the survey results are robust and highly informative of the state of the New Zealand S&T system. Analysis of the results was performed during the first half of 2009. The Technical Advisory Group provided invaluable critique and offered perceptive insights about the data that resulted in re-evaluation of several questions and in the interpretation of others. Mr Chengxiu Sun, a doctoral student in the Public Policy Program at the University of North Carolina at Charlotte processed the data and prepared graphics for this report.

Survey results

Results are reported on 74 items of the survey. Two other items, one identifying the individual respondent and the other their qualitative remarks, are not reported, in keeping with the Survey Director's pledge of confidentiality. This report begins with questions of general interest that describe the New Zealand scientist in socio-demographic terms. This is followed by groupings of questions that round out the profile of the respondents in terms of their employment, income and productivity. Throughout the report, questions are grouped for relational purposes rather than in strict sequential order of their asking; therefore the reader may refer to the Contents page (p. 3) for the location of a question in the text. For most of them, the question itself and the aggregate responses are shown in a separate font style; in others, particularly those concerning attributes, the question is incorporated into the text and is obvious. Narrative and data related to the 1996 Survey is shown in italics throughout. Data related to the 1988 USA Survey is shown in bold in the few places this information appears. Where percentages do not sum to 100 per cent the missing data are for those who did not respond.

Following the section on attributes and accomplishment are four sections that focus on the personal and professional attitudes and opinions of the respondents. The major concerns of scientists are revealed first, and these concerns are parsed with respect to some important attributes. A section dealing with science values in relation to government is followed by another where attitudes concerning the nature of scientific inquiry and science education are explored. The report concludes with a discussion of the respondent's views of the performance of the New Zealand S&T system. These results provide a foundation for the establishment of performance indicators.

Attributes and general accomplishments

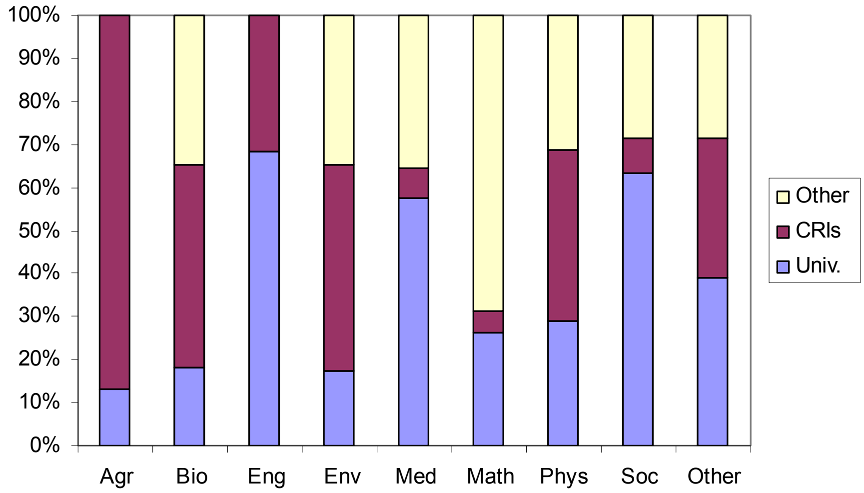
General interest

Four questions of general interest will help to give a profile of the composition of the New Zealand science community: the **field of science** of the individuals, their **gender**, their **age**, and their **work location** in a university or a CRI. With respect to questions of field of science and age there are interesting and notable differences between the university and the CRI scientists. There is little difference between these institutions in terms of gender. These differences and similarities help with interpretation of responses to other questions and they can be extremely important in crafting science policies that are more attuned to the diverse conditions under which scientific research can thrive.

The field of science is displayed in Figure 1, which reveals major differences between the CRIs and the universities: CRIs are loaded with Agriculture and Soil scientists and with Biological scientists, whereas Health scientists, Mathematics and Computer scientists and Social and Behavioural scientists are much more heavily represented in the universities. The proportions in these categories are little changed from 1996 except for Engineering and Applied Sciences and Technologies, which enlarged in universities and fell in the CRIs. These institutional differences are striking, and may point the way to issues relating to the management of science, such as the potential for collaboration between physical scientists and social scientists (see Question 67). Analyses of the work location of individuals in this report, except in a few instances, are focused on univer-

Figure 1: Proportion of each field by institution.

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.



sities and CRIs for ease of comparison with the 1996 Survey. The 'Other' category includes polytechnics, RAs, museums, and other unaffiliated individuals, which combined make up less than seven per cent of the survey population.

The proportion of females in the surveys' New Zealand science community has grown from roughly 22.8% in 1996 to 28.8% a decade later. It seems that female scientists are replacing male scientists in New Zealand more rapidly than in the USA, where roughly one in four scientists who hold advanced degrees is female. It is worth noting that in 1996 there was virtually no difference in the aggregate gender ratio and that between CRIs and universities, but by 2008 women represented 23.2% of the CRI respondents and 33.7% of scientists employed at universities. Throughout this report there will be discussion of gender in relation to age and field of science, thus providing information that is valuable to all who are trying to mobilise the human capital of New Zealand to promote the highest quality science.

Age differences are another matter. The CRI scientists are younger than their university counterparts. In the under-35 category proportionally they are four times more numerous, but in the combined age brackets of 55–64 and 65 and over, they are only two-thirds that of the universities. University tenure policies undoubtedly account for this distribution.

Socio-demographic characteristics

Gender, age and income (Q. 13, 14, 20) *(1996 data shown in italics: Q. 64, 65, 78)*

Slightly more than two-thirds of New Zealand scientists are male, but over the past decade the proportion of women in the science and technology workforce has increased substantially. Of respondents reporting gender, 71.2% *(77.2%)* are men and the remaining 28.8% *(22.8%)* women. The survey population (as distinct from the sample and the respondents) is 32.4% female, as noted above. Less than one-quarter of the CRI scientists are female, whereas slightly more than one-third of the university scientists are female. The male scientist tends to be somewhat older than the female (Figure 2), but the proportion of males entering the profession has fallen; only 5.8% *(13.4%)* of the men in this survey are under 35 and 61.9% *(56.8%)* are more than 45 years of age. Women account for three-fifths of the scientists under 35 years of age.

Women scientists do not enjoy the same level of financial rewards as do men in the New Zealand science workforce. Age/gender differences account for some of the income disparity. The proportion of men with personal incomes above $80,000 (61.4%) exceeds that of women (38.4%), whereas the proportion of women is greater in income brackets below $70,000 annually (46.2%) compared to men (35.4%). Almost one-third (31.1%) of the men report personal incomes which exceed $100,000. About one-fifth (19.2%) of the women report personal incomes that exceed $100,000, or roughly two-thirds that of the men.

Ethnicity (Q. 6) *(Q. 63)*

Ethnicity brings no surprises and little change from 1996: scientists of European ethnic origin make up four-fifths (80.9%) *(82.3%)* of the respondents, and 11.6% described themselves as 'Other', a figure close to the *(10.1%)* who described themselves as 'New Zealander/Pakeha' in 1996 despite not being offered that option. Asian origins account for 4.4% *(6.0%)* of the scientists, and less than two per cent are Māori, 1.7% *(0.7%)* or Pacific Islander, 0.6% *(0.5%)*. The modest increase in Māori

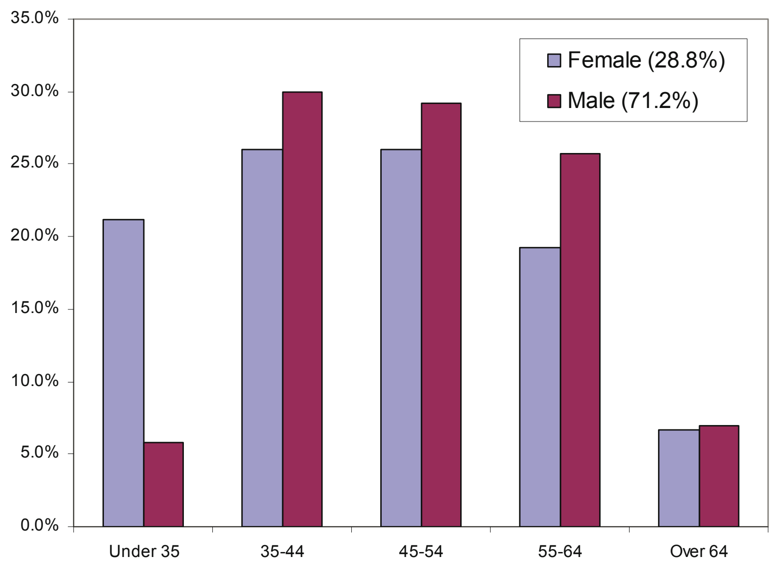


Figure 2: Age and gender of respondents.

Each age category shows the proportion of each gender relative to their total population.

scientists represents a glimmer of success for those who have sought to develop policies to bring more Māori into the science and technology workforce.

Citizenship (Q. 7) *(Q. 66)*

In terms of citizenship, New Zealanders compose 75.6% *(78.4%)* of the respondents. Of the remainder, 20.8% are Resident non-citizens and 1.9% are in the country on a Temporary Work Permit or other arrangement.

Field of primary scientific specialisation (Q. 1) *(Q. 59)*

The survey respondents represent a wide range of scientific specialties (Figure 3); 24.4% *(21.9%)* are in Biological sciences, and Social & Behavioural sciences account for 16.1% *(10.3%)*, while 10.5% *(9.9%)* describe themselves as Engineers. These three fields have gained relative to the other five fields: Physical sciences 7.8% *(13.5%),* Agriculture & Soil sciences 8.6% *(12.6%),* Health sciences 9.7% *(13.5%),* Earth & Environmental sciences & Natural Resources 7.8% *(9.2%),* and Mathematical & Computer sciences 7.2% *(7.4%).* The notable increase in Social & Behavioural sciences may be accounted for in the survey population increases due to the addition of Auckland University of Technology and the full range of the polytechnic institutions.

Among men, Biological sciences and Engineering and Applied sciences & technologies are the most frequently reported fields, being 24.1% (*22.5%)* and 12.5% *(10.6%),* respectively. Among women, the greatest proportion is in Social & Behavioural sciences 35.6% *(14.5%)* followed by Biological sciences 25.0% *(19.8%)* and Health sciences 10.6% *(19.8%).* In fact, there are absolutely more women who identify themselves as Social & Behavioural scientists than men. Seven in ten women scientists are in Biological sciences, Social & Behavioural sciences, and Medical & Health sciences, a fact that introduces a gender dimension into government policies aimed at fostering cross-disciplinary cooperation.

The age structure of the various fields of science is important for those authorised to 'manage' science in New Zealand and for those who may be curious about the impact of policy on the 'pipeline' of specialised human resources. Age emerges as a factor with respect to Biological sciences, where 30.7% are under 35 years of age and this translates into 26.0% of all scientists under 35 years of age. Engineers and applied scientists are also relatively young; 52.6% are under 35 years of age and account for 19.2% of all scientists in this age bracket. At the other end of the age scale, the 65 years and older cohort is heavily represented by Physical sciences (14.3%), Earth & Environmental sciences (14.3%), and Social & Behavioural sciences (6.9%). When combined these three fields comprise more than half (52%) of all scientists in this age bracket.

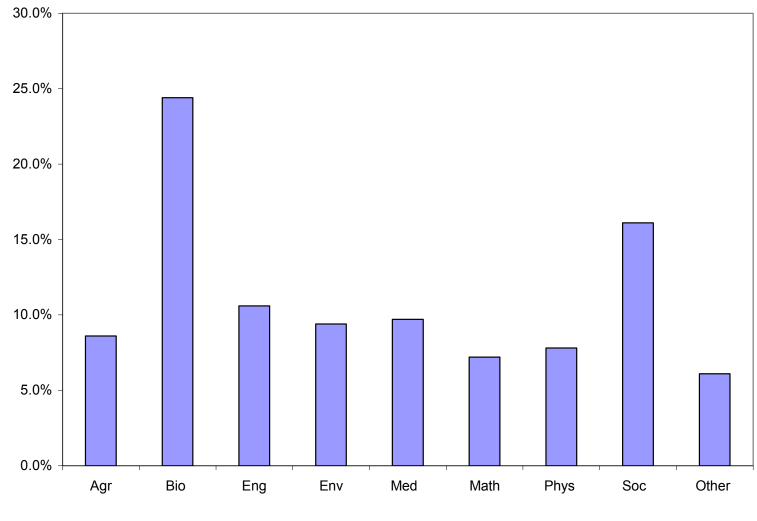


Figure 3: Primary field of scientific specialisation.

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.

Field of highest degree (Q. 2) *(Q. 60)*

Small, but interesting differences may be seen between the reported primary field of scientific specialisation and the field in which the highest degree was awarded. Of the highest degree awarded 28.3% *(26.3%)* were in the Biological sciences, compared to the 24.4% *(21.9%)* who identify their field of science as the Biological sciences. Differences between **Source** fields that supply interdisciplinary migrants and **Attractor** fields that received them shrank between 1996 and 2008, possibly indicating that the academic marketplace responds to opportunity. Similarly 11.9% *(19.7%)* of the respondents received their highest degree in the Physical sciences, whereas 7.8% *(14.0%)* said this was their primary specialisation. These two areas of science may be thought of as the **sources** for other fields, most noticeably Agriculture & Soil sciences and Earth & Environmental sciences. In the former, 8.6% *(12.6%)* identified Agriculture & Soil sciences as their primary field of specialisation, but only 6.6% *(7.0%)* received their degree in that area. With respect to the latter, 9.7% *(9.2%)* identified Earth & Environmental sciences as their field whereas 6.9% *(5.7%)* received their degree in this area. Thus, these two areas might be thought of as **attractors** among fields of science and highlight the possibility of tracking migrations between fields of science. Such tracking may be important for considerations of the management of human capital in the sciences and an indicator of the influence of government policy choices.

Highest degree attained (Q. 3) *(Q. 61)*

The New Zealand scientist tends to have at least one, and usually two advanced degrees. About 15.8% *(17.3%)* of the scientists in this survey have a Masters degree and 78.9% *(80%)* hold a PhD degree or other doctorate. A slightly higher percentage of males 80.9% have a doctorate degree than females 74%. Unlike the 1996 Survey, the 2008 Survey did not seek information on the country from which the degree was conferred. In 1996, half of the scientists with a doctorate degree attained it at a New Zealand university.

Employment

Employment status (Q. 9) *(Q. 74)*

The 2008 Survey concentrated on the active population of scientists; 89.5% of survey respondents are currently employed full time and 9.6% are employed for 30 hours a week or fewer. Less than one per cent are retired. In 1996, these two employment categories were combined, and *96.4%* were employed.

The remaining *3.6%* were retired or seeking work. The Survey had no systematic procedure for ascertaining the number of unemployed scientists in New Zealand.

Current primary employment (Q. 10) *(Q. 75)*

The greatest proportion of survey respondents reported that their current primary employment activity has been carried out in a CRI (39.3%) *(43.6%)* or in a university position (49.3%) *(45.5%)* (Figure 4). Within universities, 42.8% *(38.7%)* hold a continuing position and another 6.6% *(6.8%)* are in temporary positions. The remaining 11.4% of respondents to the 2008 Survey are scattered among RAs, museums, private sector consultants and polytechnics, the largest such group at 3.5%.

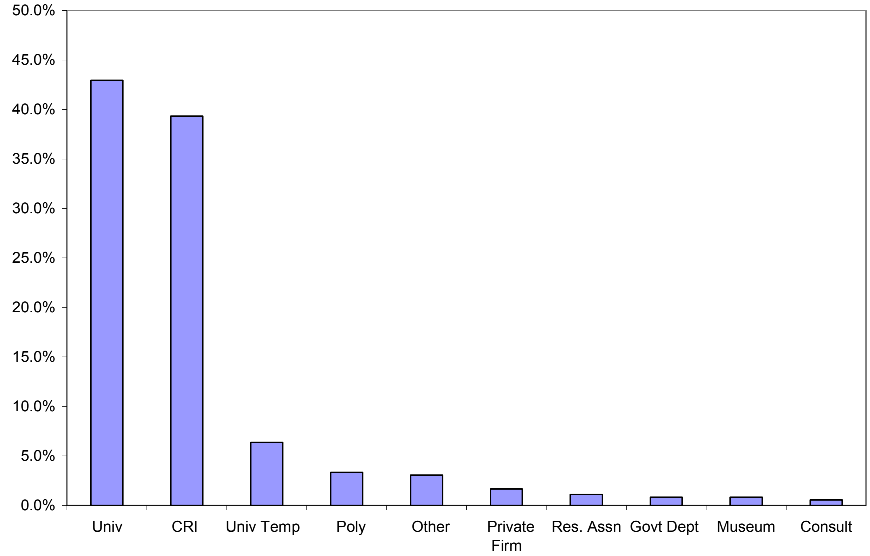


Figure 4: Institution of primary employment.

Primary employment over the past five years (Q. 11) *(Q. 76)*

Among 57.1% *(62.7%)* of the survey participants, scientific research is their primary employment activity and an additional 6.1% are in research management, a category not specifically identified in 1996; 26.3% *(22.4%)* teach; 3.9% *(3.8%)* are administrators or in policy development; and 1.1% are in technology development, also a category not identified in 1996 (Table 3). The remaining 6.6 per cent are involved in other activities.

Table 3: Primary employment over the past five years.

Administration	2.8%
Other	4.2%
Policy analysis and development	0.8%
Professional practice or consulting	0.8%
Research as an investigator	57.1%
Research management	6.1%
Teaching	26.3%
Technology development	1.1%
[Skipped the question]	0.8%

Among these other activities is professional practice or consulting (0.9%) *(9.3%)*.

The severe drop-off in this category cannot be attributed to the slightly different wording of the question in 1996 (the question specified 'Over my career') and is more likely an artifact of the database development for the 2008 Survey, in which greater reliance was placed on institutional collaboration and relatively fewer independent researchers may have been included.

In general, this distribution of men and women in primary employment activities is consistent with the Survey's gender distribution. There are two exceptions, and those involve research administration and teaching. Men are more likely than women to be research administrators, namely 7.4% *(2.3%)* versus 2.9% *(0.0%)* for women. Women are more likely to be teachers (32.7%) *(16.9%)* compared to men (23.7%) *(24.1%)*. The dramatic increase of females in the teaching profession between the two surveys suggests that many of the new female entrants into New Zealand's S&T workforce are choosing teaching careers or have not yet developed a research reputation that would reduce teaching responsibilities.

Secondary employment over the past five years (Q. 12)

One-fifth of the respondents (20.2%) reported no secondary employment over the past five years. One-third (33.6%) identified research as an investigator and another 12.3% reported research administration. Teaching accounted for 17.3%, professional practice and consulting 7%, and technology development 3.2%. There is no way to sort out whether these secondary jobs are held at the same time as the primary job or are activities that preceded their current position. Women (25%) were more likely to identify a secondary employment than were men (17.5%).

Length of time employed in New Zealand (Q. 8) *(Q. 67)*

The length of time employed in New Zealand reflects the age structure of the respondents in large part, but it also provides a snapshot of the scientific population experienced in the New Zealand environment (Figure 5). Nearly two-fifths (38.5%) of the scientists in the 2008 Survey were not employed in S&T in New Zealand when the 1996 Survey was

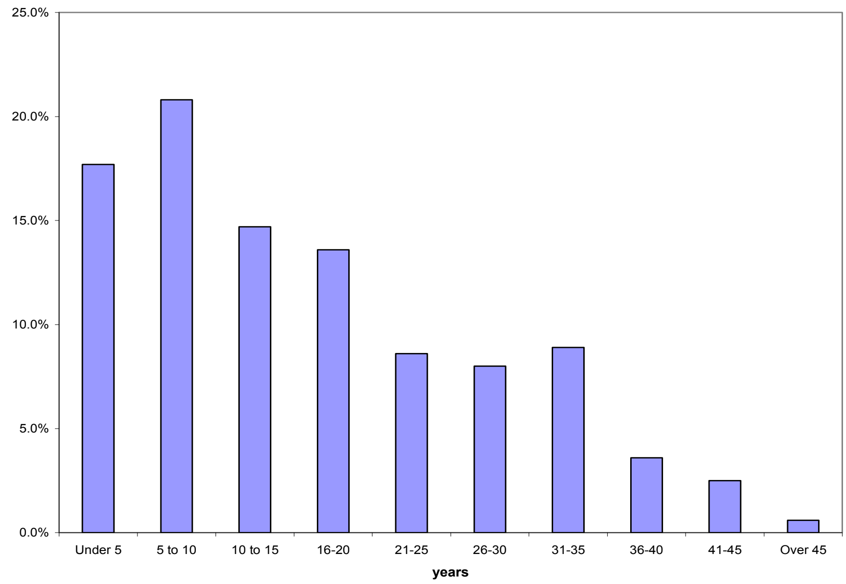


Figure 5: Years in New Zealand science.

taken. Slightly more than half (52.9%) *(47.7%)* of females have worked in New Zealand for less than 10 years, compared to 32.7% *(28.0%)* of the male scientists.

Overseas research experience (Q. 4) *(Q. 57)*

Although qualitative gains in scientific capability are not a necessary outcome of a sabbatical it is widely accepted that overseas research experience usually enhances one's career. New Zealand scientists appear to have been substantially more active in their pursuit of offshore personal development opportunities in the 1996 Survey than in 2008, but this is likely to be a consequence of the 2008 question being limited to the past five years whereas the 1996 question was not constrained to a particular period. In the 2008 Survey, 37.7% *(62.7%)* had studied, worked or had a sabbatical for more than three months in a research environment outside New Zealand during the past five years. This is true for 38.5% *(66.9%)* of men and 35.6% *(53.1%)* of women. University scientists have had greater overseas experience (50.0%) *(73.6%)* compared to scientists at CRIs (26.8%) *(54.0%)*.

Where has this experience taken place? Four destinations dominate the distribution: the EU (not including UK) (24.6%) *(15.6%),* was the primary destination for those who worked overseas, closely followed by the USA (23.1%) *(29.2%).* The UK was the third most popular destination (13.8%) *(28.4%),* and fourth was Australia (12.3%) *(11.9%).* As noted, the same four destinations dominated the 1996 Survey results, but the order is very different: the EU has jumped from a distant third place in 1996 to first in 2008 and the UK has dropped precipitously.

Sought permanent employment outside New Zealand (Q. 5)

When asked whether, during the past five years, they had sought permanent employment in a research environment outside New Zealand, less than one-quarter (23.3%) said that they had. Australia was the most popular destination, followed by the UK and USA. Social and Behavioural scientists were the most active in this search (34.5%) and Physical scientists the least (14.3%). These data do not shed light on who has been successful in their efforts to find employment elsewhere.

Appointment to a board of directors (Q. 15) *(Q. 53)*

Appointment to a board of directors of a company has been identified as a measure of the degree to which scientists are becoming involved in the active commercialisation of science, and while it is known that the phenomenon is not widespread, it is understood that, by tracking changes in this datum over time, a measure of progress on national policy goals may be achieved. Scientists were asked if they had been appointed to a board of directors during the past five years, and 5.2% *(1.2%)* said yes. In 1996 the question stated 'over the past two years', but nevertheless the direction of change in appointments may be taken to be positive.

Income

Annual personal income (Q. 20) *(Q. 78)*

Income has already been discussed with respect to gender but it is also important to re-focus here on its relationship to the science career individuals have chosen.

It is clear that personal income varies between scientific disciplines (Figure 6). More than half of the individuals in Biological sciences (52.9%) and one-third in Physical sciences (33.7%) have annual personal incomes of less than $70,000. By contrast, more than three-quarters of those in Mathematics & Computer sciences (75.8%) *(43.9%)* and Health sciences (77.2%) *(49.3%)* have annual personal incomes which exceed $70,000, and nearly half of those in the Health sciences (48.6%) *(28.0%)* have incomes greater than $100,000. Biological and Physical sciences lose out at the upper end of the scale, recording 19.3% and 28.6% of their populations, respectively, receiving $100,000 or more. Does this lend evidence to an economic interpretation of migration from these fields of science, a phenomenon noted above wherein there is a five per cent differential between those who have their highest degree in Biological sciences or in Physical sciences and those who declare these as their primary field of specialisation?

CRI scientists are much better paid than university scientists in all wage brackets up to $80,000 at which point university scientists capture the remaining part of the wage spectrum, nearly doubling the percentage of CRI scientists in each bracket over $80,000.

Research funding experience (Q. 16) *(Q. 79)*

Individuals were asked what their principal source of research support was during the last five years. In the aggregate, 33.2% *(42.5%)* cited funding from the Foundation for Research, Science and Technology (FRST), 21.3% *(24.9%)* from university

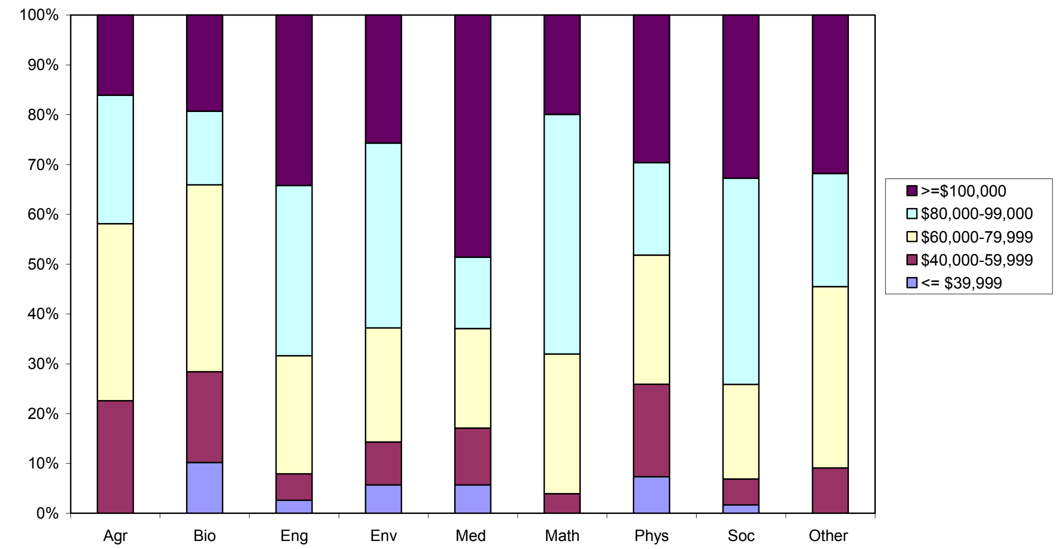


Figure 6: Income and field of science.

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.

sources, 3.9% *(5.6%)* from the Health Research Council, 6.9% *(4.7%)* from commercial contract, 6.9% *(4.5%)* from CRI non-specific discretionary funds, and 6.1% *(1.4%)* from the Marsden Fund (Table 4). The Marsden Fund was newly established in 1994; hence the growth in the number of scientists who derive their principal research support from it between 1996 and 2008 is not surprising and may account for the drop in the percentage of scientists who identified FRST as their primary source in 2008.

Table 4: Principal sources of research support.

Centres of research excellence	1.1%
Commercial contract	6.9%
Consulting fees	1.7%
Crown research institute	6.9%
Foundation for Research, Science and Technology	33.2%
Government department	4.2%
Health Research Council	3.9%
Marsden Fund	6.1%
Museum	0.6%
New Zealand philanthropic organisation	1.7%
New Zealand university sources	21.3%
Other	6.6%
Overseas philanthropic organisation	0.3%
Overseas university and government sources	1.4%
Research association	0.3%
Scholarship or fellowship	1.4%

Gender differences are minimal on this issue with the exception of HRC funding, in which women get 6.7% *(12.1%)* of their research funding compared to 2.7% *(3.8%)* for men. FRST awards favour men to some degree, 35.8% *(44.1%)* to 26.9% *(37.9%)*.

University faculty are, of course, more likely to receive funding from the university's own resources than CRI scientists are from CRI sources: for 41% *(47.4%)* of university personnel their principal source of research funding is the university itself, but only 14.8% *(8.6%)* of CRI scientists received their principal research funding from CRIs' own funds. By contrast, 63.4% *(79.1%)* of the CRI scientists cited FRST as their main funding source whereas only 12.9% *(11.3%)* of university scientists cited FRST as number one. In 2008 the third principal source of research funds for university scientists was the Marsden Fund (11.8%) and for CRI scientists it was commercial contracts (10.6%). When all principal sources of funding are taken into account, university scientists are shown to have relied on a wider range of sources than scientists in CRIs.

Age is a relatively insignificant variable on this issue, revealing no pattern of special interest with the exception that 51.4 % *(25.0%)* of scientists under the age of 35 received their principal research funding from FRST.

Table 5: All sources of research support.

Foundation for Research, Science and Technology	51.9%
New Zealand university sources	41.5%
Commercial contract	39.5%
Crown research institute	37.8%
Consulting fees	25.4%
Government department	24.8%
Other	16.4%
Marsden Fund	15.9%
Overseas university and government sources	14.1%
Scholarship or fellowship	12.1%
Health Research Council	8.7%
New Zealand philanthropic organisation	7.5%
Research association	6.3%
Centres of research excellence	4.3%
Overseas philanthropic organisation	2.6%
Museum	0.9%

Non-primary sources of research funding (Q. 17) *(Q. 54 & 55)*

By broadening the question to assess which sources of funding have been tapped for ***any*** support, not principal support, the major funding sources reported above are most important. Table 5 shows that 51.9% of the respondents had received funding from FRST during the past five years, 41.5% from New Zealand university sources, 39.5% from commercial contracts, 37.8% from CRIs, 25.4% from consulting fees, and 15.9% from the Marsden Fund. These data sum to more than 100 per cent because an individual may have had more than one source of funds during the past five years.

New research funding sources (Q. 18)

> *Within the past few years, new Government research funds have been introduced in support of RS&T. Please check which of these funds have provided support for your research.*

The funding sources listed are shown in Table 6.

Table 6: New research funding sources.

Performance-based Research Fund	26.2%
Technology New Zealand	12.4%
Centres of research excellence	6.6%
Research consortia	4.5%
International Investment Opportunities Fund	2.4%
Venture Investment Fund	0.9%
None of the above	55.1%
Skipped the question	5.1%

Respondents were asked to indicate which, if any, of these funds had provided support for their research. Obviously, in a limited number of cases an individual had support from more than one fund, hence the 100+ per cent total. Table 6 shows that more than half of the respondents indicated 'None of the above' and 5.1% skipped the question entirely. This is interesting because Government has lauded these initiatives as important new sources of funding aimed at stimulating research in specific areas of interest to Government. The Performance-based Research Fund (PBRF) accounted for half of responses of those who had received support. PBRF funds go exclusively to university scientists, so it is not surprising that they would choose 'None of the above' (38.8%) less frequently than CRI scientists, who recorded 65% for this choice.

Annual R&D budget (Q. 19) *(Q. 58)*

The survey participants were asked what is the annual average research and development budget, including salaries, for which they were responsible. This information gives a sense of the scope of the research and development enterprise and a hint of research management experience within the science community (Figure 7). The question was asked slightly differently in 1996 and results have not been inflation-adjusted, thereby rendering formal comparison dubious.

More than one-third (35.2%) reported having no research and development budget. Those groups who reported a budget of less than $100,000 make up one-quarter (24.6%) of the respondents. About one-third (31%) are responsible for budgets up to $1,000,000 while 8.3% oversee budgets greater than $1,000,000.

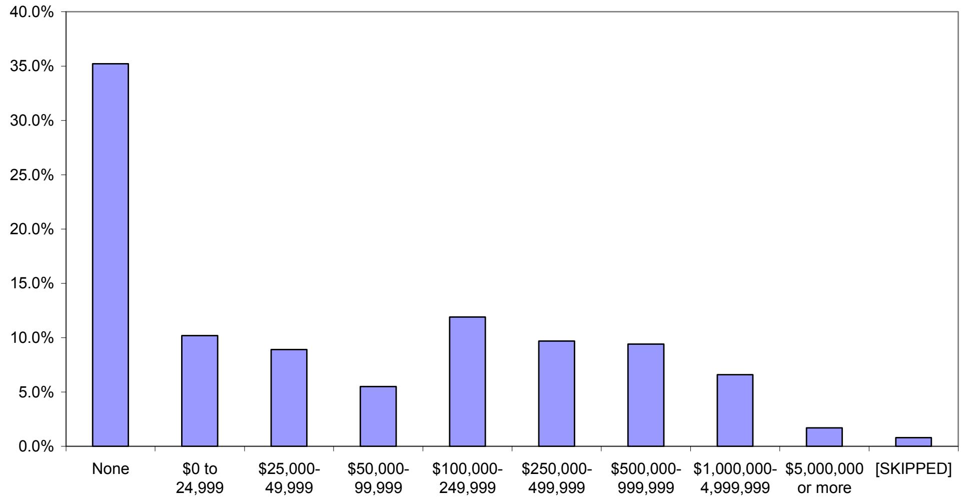


Figure 7: Annual R&D budget responsibility.

Men have greater budgets than women, a fact accounted for chiefly by their greater age. Nearly half (48.1%) of women have no responsibility for an R&D budget compared to 30% of the men. At the other end of the scale, 2.9% of the women are responsible for budgets over $1,000,000 compared to 10.5% of men.

Substantial differences exist between university scientists and CRI scientists, the latter exhibiting much greater experience with large research budgets. At the lower end of the range, 52.3% *(55.4%)* of the university scientists control research budgets of less than $50,000 compared to 31.7% *(26.2%)* of the CRI scientists. At the other end of the scale, 27.5% *(21.4%)* of the CRI scientists control budgets greater than $500,000 compared to 16.8% (*6%*) for university scientists. Such differences should be treated with some caution, given the differing institutional organisation of these two entities.

Productivity

Authorship (Q. 22) *(Q. 80)*

Respondents were asked to which types of publication they had contributed in their professional capacity over the past five years (Table 7).

Table 7: Authorship.

Peer-reviewed journal articles	90.1%
Refereed conference proceedings	63.9%
Major reports	46.9%
Chapters in books	43.5%
Items for lay readers	29.0%
Technical notes	24.2%
Edited books	13.4%
Patents	12.5%
Books	11.4%
Other	6.0%

New Zealand scientists contribute to the productivity of society in many ways, but one enduring kind of contribution is the creation and dissemination of ideas through authorship. Almost all New Zealand scientists have made a contribution of this kind in one form or another and most to more than one kind of publication. A peer-reviewed article in a professional journal is the most common form of expression in the scientific community, and of those responding to the Survey 90.0% *(87.0%)* had written at least one article. One in every 11 respondents (11.4%) *(19.7%)* had written a book, and 43.5% *(46.7%)* had contributed a chapter to a book. Major reports and technical notes also are publications of choice for many New Zealand scientists: 46.9% *(56%)* have written major reports and 24.2% *(32.6%)* have published technical notes. Some scientists have been particularly attentive to the lay readership of science, and 29.0% *(46.2%)* have contributed to this important forum for increased public understanding of science and technology.

Patents are especially important items of intellectual property, and patent production is used as an indicator of productivity of a science community in cross-cultural comparisons. In New Zealand, 12.5% *(13.6%)* of scientists and technologists have been responsible for a patent. The 2008 Survey instrument specified a period of the past five years whereas the 1996 Survey instrument did not, a factor that contributes to the slightly reduced percentages in 2008. The sole exception to this observation is in the important category of peer-reviewed articles.

Time spent on administration and compliance (Q. 69)

The amount of time meeting administrative responsibilities versus the time spent in research has implications for the productivity of the science community and has been a universal source of irritation for scientists. An attempt made in the 1996 Survey to quantify how much time was not fruitful. In the 2008 Survey a newly designed question sought this information. Figure 8 shows the distribution of responses to this question in ten per cent intervals, with a peak of 25.5% of the respondents saying they spend 20–30% of their work time on matters of administration and compliance. About two-fifths (42%) spend more time on bureaucratic matters and one-third (33.5%) spend less.

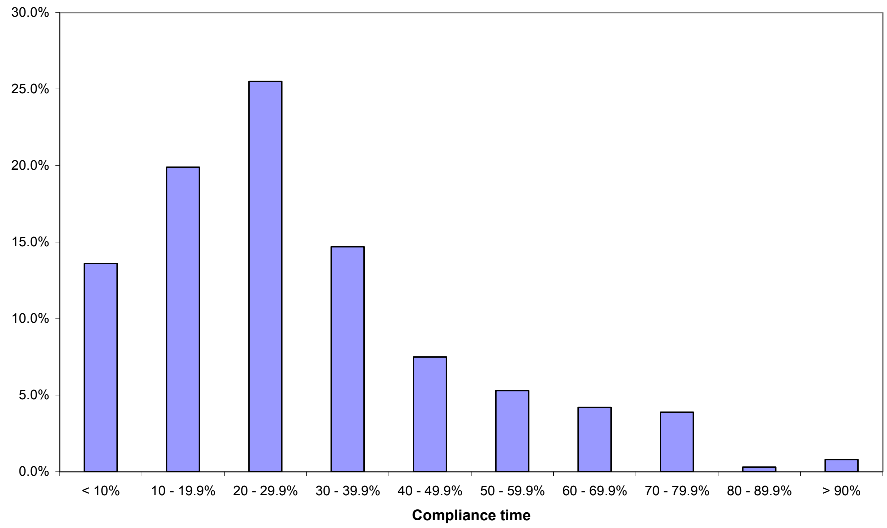
University scientists (37.6%) who reported spending more than 30% of their work time with compliance are less burdened than CRI scientists (46.1%). At the other end of the scale, university personnel (33.7%) reported spending less than 20% of their work time in this way compared to 30% for CRI personnel. To some degree this is not surprising, given the larger budget authority of CRI scientists shown above.

Time estimates made by respondents are certainly not hard core data, but responses to this question, as with almost all of the others, become more useful with more iterations of the survey. The responses to this question form a good base for future surveys.

Professional participation (Q. 21)

Scientists contribute to the vigour and stability of their professions by participating in affairs of scientific societies such as meetings of Member Bodies of the Royal Society of New Zealand, programmes sponsored by the New Zealand Association of Scientists, or in organisations specific to disciplines. More than three-quarters of the survey respondents (77.4%) indicated they had attended meetings of, or have otherwise been active in, such societies. It is in the sense of support for more general aims of science, represented by these organisations, that fosters a productive environment for scientists.

Figure 8: Percentage of time spent on administration and compliance as opposed to research.



Attitudes and opinions

General concerns of scientists

The major issues facing scientists and technologists (Q. 23) *(Q. 14)*

The 2008 Survey repeated seven important issues identified in the 1996 Survey. In 1996 the top five issues accounted for nearly three-quarters *(73.1%)* of the responses and in 2008 they accounted for 88.1%. These issues were chosen based on focus group discussions with members of the New Zealand science community. A category of 'Other' (2.3%) *(6.0%)* was provided for individuals to identify issues of importance not shown on the list.

> *Which two issues do you consider to be most important at the current time?*

The ranked answers were combined (Table 8). The most important issue selected was 'Interruptions in research funding' (25.4%) *(18.0%),* and 'Bureaucratic accountability, management, and red tape' (24.0%) *(20.1%)* was second, followed by 'Emphasis on funding applied research over basic research' (15.8%) *(11.8%)*. Concern for 'Decline of student interest in S&T' (11.9%) *(8.7%)* moved up, and 'Lack of public understanding of science and technology' (11.0%) *(14.4%)* edged out 'Over-politicisation of research' (8.6%) *(8.8%)* for fifth place.

Table 8: Major issues facing science.

Lack of public understanding of science and technology	11.0%
Interruptions in research funding	25.4%
Over-politicisation of research	8.6%
Decline of student interest in science and technology	11.9%
Bureaucratic accountability, management, and red tape	24.0%
Emphasis on funding applied research over basic research	15.8%
Fraudulent development of data and its use by scientists	1.1%
Other	2.3%

Between 1996 and 2008 the ranking of issues changed slightly, but the important feature to note is the intensification of concern in the top three issues, which jumped 15.3%. Concern for interruptions in research funding and for bureaucratic management is particularly acute, accounting for nearly half of the responses (49.4%).

Men and women scientists displayed little difference in their choices, with the exception that women (18.3%) felt the issue of funding applied research over basic research to be of more concern than did men (13.6%). Men felt more strongly about bureaucratic management and red tape (22.6%) compared to women (17.3%). There was little change from 1996 from the gender point of view.

In some instances, certain of the fields of science made significantly different choices. On the key issue of 'interruptions in funding', three fields expressed severe angst: Agriculture & Soil sciences (58.1%) *(25.7%)*, Physical sciences (*42.9%*) *(11.4%)*, and Biological sciences (40.9%) *(20.5%)*. Engineering & Applied scientists (18.4%) *(14.3%)* and Mathematics & Computer scientists (19.2%) *(17.1%)* were the least concerned with this issue.

Concerning bureaucracy and red tape, there is an interesting split among fields: Agriculture & Soil scientists (29.0%) *(30.0%)* and Health scientists (28.6%) *(12.5%)* show more concern about this issue than do Mathematics & Computer scientists (15.4%) *(13.4%)* and Engineers (13.2%) *(14.3%)*. Social & Behavioural scientists (24.1%) *(11.4%)*, like Health scientists, experienced a very substantial increase in concern over this issue between the two surveys.

Mathematics & Computer scientists are more inclined (19.2%) *(14.6%)* to worry over the 'lack of public understanding of science and technology' than do others.

Physical scientists are modestly more concerned (17.9%) *(19.0%)* with the emphasis on funding applied research over basic research.

On the issue of 'over-politicisation of research' Engineering & Applied scientists (15.8%) *(8.9%),* followed by Social & Behavioural scientists (12.1%) *(15.0%)* registered the greatest concern.

Both Engineers & Applied scientists (28.9%) *(8.9%)* and Mathematics & Computer scientists (26.9%) *(24.4%)* were substantially more concerned with the decline of student interest than the other fields.

Comparisons between university scientists and CRI scientists are similar on most issues, with the exception of one major difference: CRI scientists (49.3%) *(24.2%)* were twice as likely to cite interruptions in funding than university scientists (24.2%) *(17.5%)*. This difference is great enough to signal its importance for further discussion and analysis. Universities and CRIs diverge on two other questions: university scientists are more concerned (19.7%) *(14.8%)* than CRI scientists (10.6%) *(9.3%)* on the issue of the emphasis on funding applied research over basic research, and not surprisingly, university scientists (12.9%) *(8.6%)* are also more concerned than CRI scientists (4.2%) *(6.9%)* on the matter of the decline of student interest in S&T. Between 1996 and 2008, opinions of CRI scientists (21.8%) *(27.5%)* converged with those of university scientists (19.7%) *(13.5%)* on the issue of 'bureaucratic accountability, management, and red tape.'

Necessary conditions for a strong scientific workforce (Q. 32)

The following are said to be necessary for a strong, motivated, and productive scientific workforce that contributes to the welfare of the Nation. Please select TWO conditions you believe to be most important.

In an effort to identify what are the conditions necessary for a dynamic scientific workforce an NZAS-organised focus group suggested six choices of which a Most important and Next most important could be chosen. The two most important were 'A productive research environment that is compatible with the requirements of the research endeavour' (28.3%) closely followed by 'A climate in which scientists feel valued and trusted' (26.0%). Employment security was also an important consideration at 15.8%.

Earth & Environmental scientists identified a climate in which they would be valued and trusted (40.0%) as a necessary condition; Social & Behavioural scientists (39.7%) focused on having a research environment compatible with the research endeavour; Agricultural & Soil sciences was the field most concerned about employment security; and Mathematics & Computer scientists were more concerned than other fields with the question of the advancement of S&T careers. On the choice of a national science strategy to which researchers contribute significantly both Agriculture & Soil scientists (22.6%) and Physical scientists (21.4%) selected this significantly more than the other fields. The interesting feature of this result is the contrast between the relatively small variance in the aggregate choice shown in Table 9 and the separate spikes of interest by different fields on individual choices.

Age does not play a great role in these choices although the 65 and over cohort chose the issue of a climate of value and trust (48.0%) more than the other cohorts and the under 35 cohort chose research environment compatibility with the research endeavour (37.8%).

The only item of interest with respect to gender was on the research environment compatibility, where the choice by women (39.4%) was greater than that of men (23.7%); otherwise the responses were relatively homogenous.

With respect to work environment, only the issue of employment served to differentiate CRIs and universities; CRI scientists (21.8%) were twice as likely as university scientists (10.7%) to make this choice.

Issues of job satisfaction and job security are explored in more depth in Questions 70 and 71 later in this section.

The nexus of concern among scientists, as shown above, relates to the struggle to secure and sustain research funds in the face of what seem to be mounting reporting and accounting requirements that attend the award of public support. A substantial part of the individual researcher's work time is spent meeting these requirements and writing proposals for support or, by contrast, serving as a reviewer of other's proposals. Evaluation of these proposals by funding agencies is fundamental to the S&T system, some through peer review and others by agency committees that increasingly lean towards 'negotiated' contracts. These evaluation processes are stressful for many, in part because the outcome determines much of one's career success, and because a deep well of suspicion exists about the review processes. This was quite obvious from the results of the 1996 Survey and is repeated in the 2008 Survey. The following suite of questions explores this area of concern.

Table 9: Basis for a strong scientific workforce.

	Most important	Second importance
Climate in which scientists feel valued and trusted	26.0%	20.5%
Productive research environment compatible with research endeavour	28.3%	19.9%
Employment security commensurate with research activity	15.8%	17.2%
Career advancement in science and technology	9.1%	12.2%
A national science strategy to which scientists contribute	14.1%	8.6%
A transparent decision-making system based on evidence and guidelines	8.0%	15.5%

Funding concerns

Peer-reviewing experience (Q. 64)

During the past five years I have served as a peer-reviewer of a bid for science and/or technology funding in New Zealand.

For the 2008 Survey this question was introduced simply to find out who has had experience as a peer reviewer and then to ascertain if that made any difference in their perception of the entire awards process. Moreover, the issue of peer review tends to be sensitive because it relates to who influences the course of scientific research and in which directions. In the relatively small scientific community in New Zealand, it is difficult to manage a peer-review process for the award of grants without creating the appearance, if not the reality, of a conflict of interest among specialist reviewers, and the sensitivities attending this issue are increased when only one-quarter (26.6%) of the scientists served as a peer-reviewer during the past five years. Even with the use of off-shore reviewers some researchers are concerned that potential competitors for funding will unduly influence award decisions.

This said, it may be of real interest to see how closely the responses to the 2008 Survey map those to the 1996 Survey and even to the 1988 Survey in the USA (shown below in bold italics). The order of issues is virtually identical.

The 2008 Survey question was broadened from the more narrow perspective of 'peer review' to 'award process' to account for some more recent mechanisms for awards but it continued to be focused on the experience of individuals with the FRST, HRC, and Marsden Fund. The Foundation for Research Science and Technology, as reported above has, by far, the widest participation of awardees and the largest number of respondents to the 2008 Survey (315). The Health Research Council was subject to the responses of 231 individuals, despite the fact that only a dozen scientists (3.9%) received their principal research funding from that organisation and just 28 received any funding. Nevertheless, both of the survey results are shown in brackets. Because the Marsden Fund was created in 1994 and experience was so limited, there was nothing of significance to report in the 1996 Survey; therefore no 1996 results are shown here. By 2008 the question generated 303 responses, even though only 22 individuals (6.1%) received their principal research funds over the past five years from the Marsden Fund and just 54 had received any funding from this source. The other two main sources of funding are reported separately. As with previous questions involving ranking first and second choices, these choices are combined as a single value in the Table 10. When cross tabulations with other variables are presented they relate solely to the first choice.

FRST-funded research (Q. 61) *(Q. 39) (1988 US Survey)*

When asked what the two greatest concerns they had with respect to the FRST award process the opportunity to respond positively was purposely placed first so that individuals could choose 'Award process works well and I have no major concern.' If this option was chosen, the respondent could move to the next question. This option was selected first by (10.2%) *(7.6%)* ***(8%)***. In descending order, the negative responses were: Reviews are marred by cronyism, old boys' networks, and insider politics (26.2%) *(18.7%)* ***(32%)***; Original, non-mainstream ideas are unlikely to be funded (22.0%) *(16.0%)* ***(27%)***; Reviews are perfunctory, cursory, or non-substantive (13.9%) *(7.9%)* ***(9%)***; Reviews are not given sufficient weight in award decisions (6.6%) *(11.4%)* ***(5%)***; Reviews are conflicting (4.8%) *(13.2%)* ***(5%)***; Original ideas are sometimes 'appropriated' or 'leaked' by a reviewer or program officer (0.3%) *(3.4%)* ***(5%)***; Other (16.0%) *(6.4%)* ***(1%)***. The bump-up in 'Other' is likely related to the elimination of the option 'Reviewers are not expert in applicant's field' *(15.3%)* ***(8%)*** from the 2008 Survey, an hypothesis supported by individual invited narrative comments.

In the 1996 Survey more than one-third *(36.8%)* of the respondents declined to react to this question. This may have been because of lack of experience with the FRST system, but in 2008, only 9.7% chose not to respond. By 2008, almost half of the respondents had received FRST funding during the past five years, so it is reasonable to assume that a substantially greater percentage would have received funding, or at least made bids for support over their entire careers.

Even though this survey shows evidence of improvement in the way respondents view the FRST grant award process, from *7.6%* in 1996 to 10.2% in 2008, the issue remains that 9 out of 10 scientists indicate that they have a concern with the way the award process works.

Persistence of the two most frequently cited issues by those who perceive problems in the award process are particularly troubling because they have also increased from *34.7%* of the responses to 48.2%. The top two concerns, 'Reviews are marred by cronyism, old boys' networks, and insider politics' and 'Original, non-mainstream ideas are unlikely to be funded' can be considered as **fundamental** concerns. Add to this the 0.3% who cited 'Original ideas are sometimes 'appropriated' or 'leaked' by a reviewer or programme officer' and these concerns total nearly half of the responses. These three concerns can be compared to the **technical** concerns of the review process represented by the other three reasons (25.3%). Even if the 'Other' category (16.0%) is taken to be entirely 'technical' the preponderance of the concerns expressed are 'fundamental' in nature.

With few exceptions, the uniformity of concern among scientists regarding these rankings is striking. The only exception is that men identified the issue of reviews being cursory and non-substantive substantially more (17.4%) than women (4.4%).

The most positive age group was the youngest; scientists under 35 gave FRST the highest marks (14.3%), but scientists 35–44 years old (8.4%) and those 65 and older (3.7%) were at least inclined to agree that the FRST review process works well. Concern about cronyism was diminished among older scientists.

University scientists (10.8%) *(9.2%)* are more supportive of FRST reviews than are CRI scientists (9.8%) *(6.9%)* but the 'signature' of concern differs. In 2008, 'Cronyism' was the primary concern for university scientists (31.9%) *(20.3%)* compared to 1996, when university scientists ranked cronyism behind their primary concern, that original ideas go unfunded *(19.2%)* (21.7%). CRI scientists shared these top two concerns with university scientists but switched their positions: their greatest concern was that original ideas go unfunded (20.3%) *(9.1%)* and cronyism was second (18.8%) *(21.5%)*.

Each of the fields of science have specialised concerns too extensive to report in full, but some of these concerns can be highlighted. Earth & Environmental scientists (18.8%) *(10.1%)* and Mathematics & Computer scientists (15.4%) *(2.8%)* are more favorably impressed with FRST reviews than other fields, particularly Engineers & Applied scientists (2.7%) *(9.3%)* and Biological scientists (6.7%) *(12.1%)*. Moreover, Engineers & Applied scientists registered an intense concern on the issue of cronyism (51.4%) *(14.6%),* more than 20% greater than Social & Behavioural sciences (29.4%) *(31.0%)*, whose was the next highest response. These represent substantial changes in opinion over the decade that merit a level of investigation not included in this document.

Table 10: Concerns about FRST award process.

	2008 Survey	1996 Survey	1988 Survey
Award process works well and I have no major concern	10.2%	7.6%	8.0%
Reviews are marred by cronyism, old boys' networks, and insider politics	26.2%	18.7%	32.0%
Original, non-mainstream, ideas are unlikely to be funded	22.0%	16.0%	27.0%
Reviews are perfunctory, cursory, or non-substantive	13.9%	7.9%	9.0%
Reviews not given sufficient weight in award decisions	6.6%	11.4%	5.0%
Reviews are conflicting	4.8%	13.2%	5.0%
Original ideas are leaked or stolen	0.3%	3.4%	5.0%
Other	16.0%	6.4%	1.0%

Table 11: Award process concerns compared.

	FRST		HRC		Marsden	
	2008	1996	2008	1996	2008	1996
Award process works well and I have no major concern	10.2%	7.6%	15.2%	16.9%	14.9%	16.9%
Reviews are marred by cronyism, old boys' networks, and insider politics	26.2%	18.7%	16.9%	20.9%	28.7%	26.2%
Original, non-mainstream ideas are unlikely to be funded	22.0%	16.0%	9.1%	20.9%	9.1%	11.5%
Reviews are perfunctory, cursory, or non-substantive	13.9%	7.9%	3.7%	8.0%	6.4%	6.9%
Reviews not given sufficient weight in award decisions	6.6%	11.4%	2.9%	8.0%	12.6%	6.9%
Reviews are conflicting	4.8%	13.2%	2.5%	10.0%	6.1%	2.3%
Original ideas are leaked or stolen	0.3%	3.4%	0.4%	3.0%	0.3%	2.3%
Other	16.0%	6.4%	49.4%	5.5%	21.9%	7.7%

In addition to the two main concerns shared by all fields Agriculture & Soil scientists are especially concerned with perfunctory reviews (20.0%) *(6.6%)* and with conflicting reviews (13.3%) *(20.9%)*. Medical & Health scientists also expressed concern (19.4%) *(10.0%)* on the issue of perfunctory reviews.

Some of the concerns expressed in 1996 remained remarkably consistent through the years: Biological scientists express a greater degree of concern (24.4%) *(23.7%)* over cronyism; Environmental scientists are especially concerned that original ideas go unfunded (15.6%) *(20.3%)*, as are Mathematics & Computer scientists (23.1%) *(25.0%)*. Social & Behavioural scientists remain less concerned (3.9%) *(6.0%)* than most other fields about conflicting reviews.

Health Research Council award process (Q. 63) *(Q. 39)*

The two greatest concerns for the Health Research Council (HRC) award process are the same as those with FRST: Reviews are marred by cronyism, old boys' networks, and insider politics (16.9%) *(20.9%)* ***(32%)***, and Original, non-mainstream ideas are unlikely to be funded (9.1%) *(20.9%)* ***(27%)***. Respondents gave the award process a higher rating for working well (15.2%) *(16.9%)* ***(8%)*** than for either FRST or the Marsden Fund (see Table 11). Of the remaining responses: Reviews are perfunctory, cursory, or non-substantive (3.7%) *(8.0%)* ***(9%)***; Reviews are not given sufficient weight in award decisions (2.9%) *(8.0%)* ***(5%)***; Reviews are conflicting (2.5%) *(10.0%)* ***(5%)***; Original ideas are sometimes 'appropriated' or 'leaked' by a reviewer or programme officer (0.4%) *(3.0%)* ***(5%)***; and Other (49.4%) *(5.5%)* ***(1%)***.

The very large choice of 'Other' is, perhaps, a reflection that far fewer individuals experienced with that award process responded to the HRC question than to either FRST or Marsden. This may also be a reflection of the more specialised nature of the health research grants and elimination of the choice of 'Reviewers are not expert in applicant's field' *(7.0%)* ***(8%)***. In 1996, the majority of respondents to the HRC question were from the Health sciences, but in 2008 only about one-fifth were in this field, a fact that also raises a question about the success of the 2008 Survey's database development in Medical & Health sciences. For these reasons the HRC award process responses should be treated with some care.

It should be noted that women and men responded very similarly on all but two questions. Ironically, women were less concerned with cronyism and old boys' networks than men, 21.7% to 31.2%, but more concerned with the unlikelihood that non-mainstream ideas would be funded, 13.0% to 7.6%.

Marsden Fund award process (Q. 62)

Marsden Fund award processes were seen to work well by 14.9% *(16.9%)* of respondents, substantially greater than for FRST (10.2%), but the remainder of the responses differed in several respects (Table 11). The greatest concern expressed was that reviews are marred by cronyism (28.7%) *(26.2%)*, followed by reviews are not given sufficient weight in award decisions (12.6%) *(6.9%)*, and the unlikely prospect for non-mainstream ideas to be funded (9.1%) *(11.5%)* ranked third. Reviews are perfunctory, cursory and non-substantive (6.4%) *(6.9%)* ranked next, and conflicting reviews (6.1%) *(2.3%)* after that. Original ideas are leaked or stolen (0.3%) *(2.3%)* ranked last. The category of Other (21.9%) *(7.7%)* is substantial, but close checking of the narrative responses attending the question indicate that this response is a product of the low frequency of actual experience with the Fund.

Women were less concerned (21.7%) with old boys' networks than were men (31.2%) and modestly more concerned (13.0%) than men (7.6%) over the unlikelihood of original ideas being funded.

University scientists were more concerned (15.9%) than CRI scientists that reviews are not given sufficient weight in the Marsden decision process, but otherwise there is little to distinguish differences between scientists' views in these two institutional settings.

Agricultural & Soil scientists (46.2%) and Engineers & Applied scientists (51.4%) were far more concerned with the influence of cronyism and old boys' networks than Mathematics & Computer scientists (34.5%), the next highest.

Age is not a factor in differentiating views on the Marsden award process.

Science managers of the major funding agencies now have some specific information on how science providers have viewed an integral part of the entire research process. As long as there is a granting process there will be criticism of its implementation, just as there would be criticism of alternative means of funding scientific and technological research. This truism is not an excuse to ignore the information provided here; rather it suggests that there should be some vigorous experimentation with science funding mechanisms to address the more difficult issues. It is obvious that science managers will wish to improve the percentage of individuals who have no major concerns with the funding process.

Knowledge of FRST portfolios and bidding process (Q. 54)

> *I regard myself as sufficiently informed on FRST's portfolio schemes to formulate coherent bids for science funding.*

In focus group meetings and in casual conversation, scientists have remarked that the portfolio schemes framed by FRST make the bidding process confusing. This question was framed in straightforward terms to elicit information on the subject. The results are interesting and, in some respects, counterintuitive. Asked whether they felt sufficiently informed on FRST's portfolio schemes to formulate coherent bids for science funding, 63.4% said they did not and 36.0% said that they did. This in itself is not surprising, but when the population of those who had received FRST funding was isolated, this group responded as follows: 45.8% did not think they were sufficiently informed and 54.2% thought they were! Almost half of the awardees had succeeded in spite of themselves – a veritable 'shot-in-the-dark'!

Gender played no role in the response to this question.

There were some significant differences among the fields of science. Engineers & Applied scientists were far-and-away the most confident of their ability to make an informed bid (60.5%), followed distantly by Earth & Environmental scientists (42.9%). The least confident in the degree that they are sufficiently informed are the Mathematics & Computer scientists (26.9%) and Social & Behavioural scientists (27.6%). Those in the Medical & Health sciences ranked low (28.6%) but that is to be expected given their orientation towards the HRC.

University scientists (68.0%) were less confident that they were sufficiently informed of FRST award processes than were CRI scientists (54.2%).

What these results mean is something that should be discussed by the science managers at FRST, but the data may suggest that the serial reformulation of goals and objectives under different rubrics, such as 'roadmaps,' and shifting sets of priorities has been more confusing than illuminating. Such confusion may have contributed to interruptions in research funding already identified as the greatest concern of scientists in 2008.

A lottery as an alternative funding method (Q. 65)

Apart from a few exceptional bids at the top and a few obviously unfundable bids at the bottom, the great majority of bids for government research funding are so tightly grouped that a lottery for this middle group would deliver a more fair result than current practices. Agree emphatically (7.2%) Agree in substance (29.6%) Neither agree nor disagree (38.8%) Disagree in substance (20.5%) Disagree emphatically (3.0%).

Sensing the dismay of many scientists with the award process, as expressed in the 1996 Survey, subsequent focus groups with research scientists emphasised the importance of personal connections (the 'old boys' network' identified previously) and sheer luck as keys to success in receiving an award. Discussions with science managers at FRST and Marsden often focused on their inability to distinguish between many good proposals and frustration over rising rejection rates. These sentiments are not unique to New Zealand scientists or science managers, and different funding methods are being widely discussed in other countries, such as the increased use of prizes to reward accomplishments rather than grants to underwrite promises. It is in the spirit of exploration that this question was framed.

It is not surprising, without further specification of how a lottery would work, that 38.8% were undecided, but it is interesting that, of the remaining respondents, 36.8% agreed with the

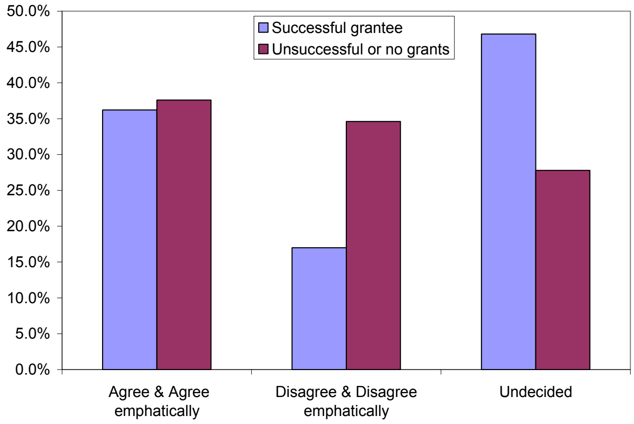


Figure 9: A lottery as a funding method.

statement compared to 23.5% who disagreed. Moreover, more than twice as many were in emphatic agreement than those who emphatically disagreed.

As one would expect among the group of individuals who had succeeded in getting grant support, the response was more negative (34.6%) than among those who had not received grant support (17.0%). What is intriguing is that the response in favour of a lottery from successful awardees (36.2%) is virtually the same as that from those who have been unsuccessful in the award process (37.6%).

University scientists are more supportive of the idea of a lottery (40.5%) and less negative (19.6%) than are CRI scientists (33.1% and 28.1%, respectively).

Employment concerns

Job security (Q. 70) *(Q. 45)*

I feel that my job is reasonably secure for the next five years. Agree emphatically (15.5%) *(16.0%)* Agree in substance (45.4%) *(35.3%)* Neither agree nor disagree (10.0%) *(8.3%)* Disagree in substance (15.5%) *(15.5%)* Disagree emphatically (8.6%) *(22.5%).*

Three-fifths (60.9%) of the respondents agree that their job is reasonably secure. This is a significant increase since 1996, when *51.3%* registered a positive response. The nature of the shift is also notable as the percentage of individuals who were emphatic in their disagreement dropped precipitously. The general average masks differences in perception among different groups. As one might expect, job security increases with age, at least until one becomes 65. A surprising outlier is the under 35-year-old group, which agrees with this statement more than any other age cohort, and the difference between 2008 and 1996 is stunning (70.3%) *(35.4%)*. The 35- to 44-year-old group (who were under 35 in the 1996 Survey) increased its agreement with the question to 51.9%, still substantially below the average for all. Men are slightly more concerned than women about job security, and although the difference is not significant, it does represent a reversal of the 1996 results.

Once stark, the differences between scientists in CRIs and in universities on this issue have moderated greatly. Fewer university scientists now disagree with the statement (20.8%) (*24.4%)* and far fewer CRI scientists disagree with it (30.3%), down from *54.6%* in 1996. Further, only 12.7% *(30.6%)* of the CRI scientists disagree emphatically. These data portray a scientific community much more secure in their employment than it was a decade ago. The change is particularly dramatic at the CRIs, reflecting positive government initiatives in this area in recent years.

Table 12: Job is secure in near future.

	1996 Survey	2008 Survey
Disagree emphatically	22.5%	8.6%
Disagree in substance	15.5%	15.5%
Neither agree nor disagree	8.3%	10.0%
Agree in substance	35.3%	45.4%
Agree emphatically	16.0%	15.5%
Other	2.5%	5.0%

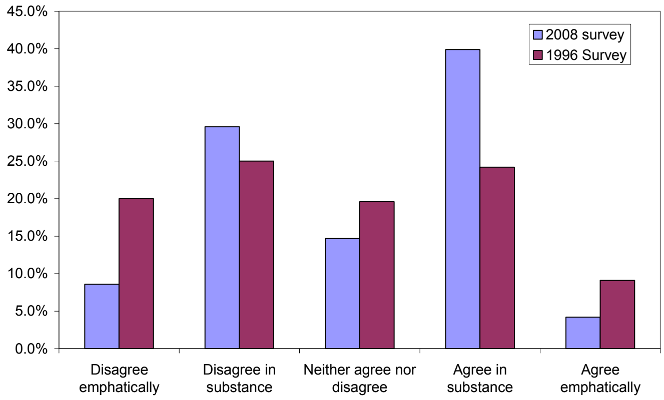


Figure 10: Job satisfaction has risen, differences between surveys.

At least half of the scientists in each of the eight fields agree with this statement. Differences remain between the different fields, but they are not as pronounced as they were in 1996. Social & Behavioural scientists (72.5%) *(74.2%)* remained the most secure in their jobs and Agriculture & Soil scientists (51.6%) *(32.9%)* remained among the least secure. Only Physical scientists (50%) *(55.2%)* felt less secure. Earth & Environmental scientists agreed with the statement (68.6%) *(59.7%)* even more than they did in 1996.

There is no question that a greater sense of job security prevails in 2008 than it did a decade earlier, but the question remains whether individuals enjoy a sense of satisfaction in their work.

Job satisfaction (Q. 71) *(Q. 46)*

> *During the past five (two) years my job satisfaction has risen.* Agree emphatically (4.2%) *(9.1%)* Agree in substance (39.9%) *(24.2%)* Neither agree nor disagree (14.7%) *(19.6%)* Disagree in substance (29.6%) *(25.0%)* Disagree emphatically (8.6%) *(20.0%).*

Satisfaction with one's job is roughly balanced but tipped slightly toward the positive side as emphatic views moderated. This is a reversal of the slightly negative views in 1996. There are differences among groups. Women (50.9%) *(37.7%)* became more satisfied with their jobs than men (41.2%) *(32.2%)* and scientists under 35 years old were most in agreement with the statement (64.9%) *(44.8%)*. In 1996, older scientists, specifically those in the 55 to 64 age bracket recorded the most negative response, with more than half *(50.6%)* (38.4%) disagreeing with the statement and more than half of those *(26.9%)* emphatically. The 1996 Survey's 55-64 age cohort became 65 years old and above by 2008 and expressed a change of heart: nearly half (48%) *(35.7%)* agreed with the statement compared to 28% *(21.4%)* who did not. The only age cohort that disagreed more (45.1%) *(49.5%)* than it agreed (40.2%) *(32.5%)* were scientists between 45 and 54 years old.

Since 1996 the views of university and CRI scientists have converged. In 1996 more than half of the scientists in CRIs *(52.3%)* disagreed with the statement compared to *41.1%* of the university scientists, but by 2008, 44.4% of CRI scientists disagreed and 37.4% of university scientists disagreed. CRI scientists remain less satisfied with their jobs than university scientists, but in both institutional settings there was a rising level of job satisfaction.

Among the different fields of science, a dramatic difference in levels of job satisfaction is recorded: Agriculture & Soil scientists continue to render the most negative response to the question (48.4%) *(61.5%)*. On the brighter side, more than three-fifths (62.8%) *(40.7%)* of individuals in the Medical & Health sciences felt that their job satisfaction had increased over the past five *(two)* years.

State of New Zealand science

Is New Zealand science headed in the right direction? (Q. 74)

> *All things considered, science in New Zealand is headed in the right direction.* Agree emphatically (0.8%) Agree in substance (25.5%) Neither agree nor disagree (33.0%) Disagree in substance (31.0%) Disagree emphatically (7.8%).

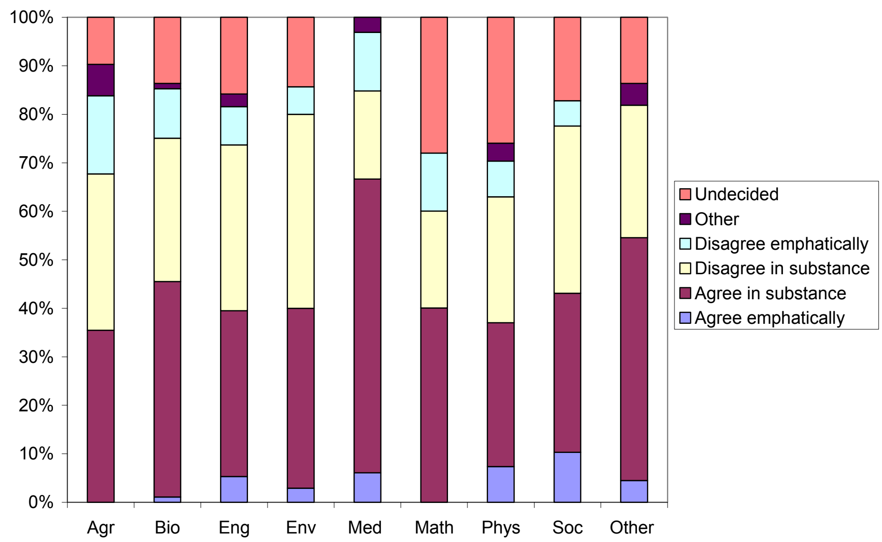
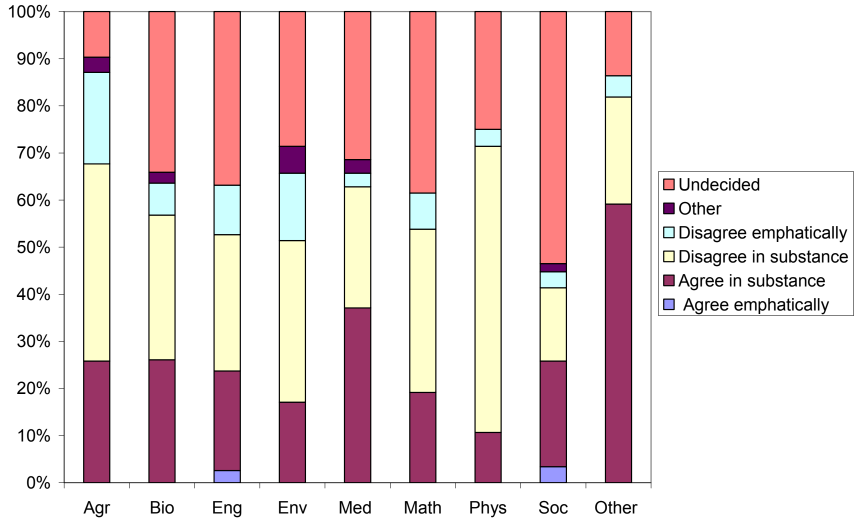


Figure 11: Job satisfaction in 2008 among different fields of science.

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.

Figure 12: Is New Zealand science headed in the right direction?

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.



The concluding question in the 2008 Survey is another bellwether inquiry meant to capture a general summation of the state of New Zealand science. When asked to opine on the statement individuals responded as follows: 26.3% agreed, 38.8% disagreed, and 33.0% were undecided. Within this response less than one per cent emphatically agreed whereas 7.8% emphatically disagreed. Although the responses are not particularly encouraging it must be noted this question was not asked in 1996. Therefore the results are only a snapshot of views at one point in time.

By peeling back underlying differences on important dimensions of the survey the value of the question is revealed. From the point of view of the different fields of science we can see dramatically varied perspectives. Only those in Medical & Health sciences actually agreed with the statement (37.1%) more than the mean and disagreed with it less (28.6%). Social & Behavioural scientists were very close to the mean in agreement (26.1%) and far below the mean in disagreement (18.9%). A very different response is given by Physical scientists: 10.7% agreed with the statement and 64.3% disagreed. Earth &Environmental scientists were 17.1% in agreement while 48.6% disagreed. Mathematics & Computer scientists responded by agreeing 19.2% and disagreeing 42.3%. Agriculture & Soil scientists were more optimistic at 25.8% agreement but they were also highly pessimistic with 61.3% disagreeing. If we consider 'level of conviction' the Agricultural & Soil scientists stand out: less than ten per cent (9.7%) were undecided compared to more than half of the Social & Behavioural scientists (53.4%) and 19.4% of the Agricultural & Soil scientists were in emphatic disagreement compared to 3.4% emphatic agreement by Social & Behavioural scientists.

Work location also reveals striking differences between scientists at universities and those at Crown Research Institutes. University scientists are roughly divided into thirds in their viewpoint: 29.8% agree with the statement, 30.9% disagree and 36.5% are undecided. CRI scientists are markedly less optimistic: 23.2% agree, 53.5% disagree, and 22.5% are undecided.

Women were evenly split in their assessment of the direction of New Zealand science with 30.7% believing it is headed in the right direction and 28.9% disagreed while 37.5% were undecided. Not so with the men. Only 24.5% agreed with the statement and 42.8% disagreed while 31.1% remained undecided.

Only scientists 65 years and older agreed (36.0%) with the statement more than they disagreed (32.3%) with it. The least supportive were individuals 55 to 64 years old, with 41.9% disagreeing and 24.5% agreeing. It will be interesting, five years hence, to see if this cohort mellows with age.

Science, values, and government

In most science communities there is a tension with respect to the proper role of government in the process of knowledge creation. Governments have been the preponderant source of finance of the sciences, yet scientists seek to preserve the essential independence of a truth-regarding process. Because the New Zealand Government's role in science is so great, the reactions of scientists to its role are important to ascertain. The questions in this section are aimed to explore the way New Zealand scientists perceive the role of government in the direction of national science and technology and how they view their own responsibility to society. Specific issues of 'scary science' are broached so that the public and policy makers may become aware of the opinions of the scientific community on contentious issues at the nexus of science and society.

Responsibilities of scientists

Responsible to science and citizens (Q. 31) *(Q. 1)*

> *In my professional capacity, I feel responsible first to science and the creation of new knowledge or products, and then to the concerns of citizens.* Agree emphatically (2.8%) *(5.6%)* Agree in substance (25.2%) *(34.4%)* Neither agree nor disagree (8.6%) *(14.4%)* Disagree in substance (48.2%) *(31.8%)* Disagree emphatically (11.9%) *(11.7%)*

A solid majority (60.1%) *(43.5%)* of scientists expressing an opinion on this issue disagree. This sentiment is observed among university and CRI scientists, all age groups, and by both women and men. Women (67.3%) disagreed more than men (57.2%). Medical & Health scientists (71.4%) and Engineers & Applied scientists disagreed more strongly (71.1%) *(60.7%)* than those in other fields. In 1996 no other field of science registered more than 50% disagreement but by 2008 Social & Behavioural scientists (46.5%) was the only field that failed to reach this level. Scientist's sense of social responsibility, already strong, strengthened over the past decade.

The 1996 Survey asked two other questions concerned with this issue that were not repeated in 2008 because their lop-sided results indicated a small likelihood of developing further useful information. The survey asked if the respondent felt a responsibility for improving the general public understanding of the long term value of basic/fundamental research, to which the response was an overwhelming yes. A question on whether the scientist considered the potential uses of her/his research or products derived from it before undertaking the research revealed the New Zealand scientist felt strongly obligated to consider the implications of the research that they pursue. Responses to both of these questions showed the great majority of scientists, regardless of gender, field, age, and other characteristics, uniformly support these views.

New Zealand should be prime beneficiary (Q. 34)

> *New Zealand should be the prime beneficiary of scientific advances funded by New Zealand taxpayers.* Agree emphatically (12.5%) Agree in substance (44.6%) Neither agree nor disagree (13.0%) Disagree in substance (24.4%) Disagree emphatically (3.9%).

This question replaced a suite of three questions asked in 1996 to ascertain dimensions of scientists' attitudes on science as a transcendent activity versus local obligation to the nation. The 1996 results of these three questions are shown in the box below to illustrate how significantly different wording of a question on the same issue can result in quite different responses.

One can certainly hold that New Zealand taxpayers should be the prime beneficiaries of the science they fund but how would this square with strongly expressed prior attitudes against restrictions on the outflow of research from the Nation and in support of the idea that such restrictions would have a negative consequence for science and engineering everywhere?

The results from 2008 (Figure 13) appear to indicate movement by the scientific community towards a more nation-based

1996 questions:

> *Science transcends national concerns*
>
> *I believe that pursuit of scientific knowledge transcends national concerns. Agree emphatically (27.6%) Agree in substance (39.0%) Neither agree nor disagree (9.4%) Disagree in substance (16.4%) Disagree emphatically (6.1%).*
>
> *Governments should restrict outflow of research*
>
> *I believe the government should do more to restrict the outflow of research results which might help other countries become more 'competitive' with New Zealand. Agree emphatically (4.2%) Agree in substance (7.9%) Neither agree nor disagree (17.2%) Disagree in substance (37.2%) Disagree emphatically (32.8%).*
>
> *Keeping science within national borders*
>
> *Any attempts to confine research results to a particular country will diminish the progress of science and engineering in that country as well as elsewhere. Agree emphatically (44.9%) Agree in substance (43.2%) Neither agree nor disagree (5.4%) Disagree in substance (4.5%) Disagree emphatically (1.6%).*

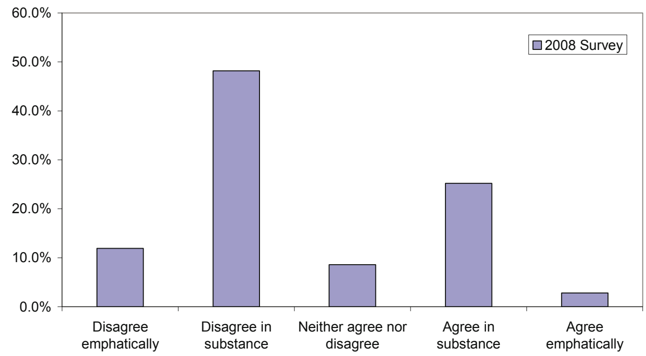


Figure 13: Responsible to science before citizens?

view of science and technology and away from the transcendent status expressed in the 1996 Survey. Age and gender show no divergence from this tendency. A substantial difference exists in the views of CRI scientists (73.2%) and university scientists (42.7%), a difference captured in the extreme positions of primarily CRI-based Agriculture & Soil scientists (90.3%) and primarily university-based Social & Behavioural scientists (34.5%). Mathematics & Computer scientists (42.3%) and Physical scientists (46.4%), also predominantly university-based, are substantially below the average response.

This question, and one or two of the 1996 questions discussed here should be repeated in future surveys to continue to monitor this interesting and important dimension of global versus local contexts for science and technology.

Responsibilities of government

Government should define the research agenda (Q. 35) *(Q. 16)*

> *It is the proper role for government with regard to the funding of science to define broadly what should be investigated, thereby providing scientists with a 'research agenda'.* Agree emphatically (1.7%) *(5.2%)* Agree in substance (31.9%) *(31.3%)* Neither agree nor disagree (7.5%) *(15.6%)* Disagree in substance (38.2%) *(31.3%)* Disagree emphatically (17.5%) *(15.2%)*

The New Zealand scientific community reacted negatively to this assertion (55.7% versus 33.6%) and by a wider margin than in 1996 *(46.5% versus 36.5%)* but the intensity of this difference should be noted: scientists responded ten *(three)* times more frequently that they disagreed emphatically than they agreed emphatically. More interesting are differences by gender, location of the scientist in a university or CRI, and the field of science. Age plays very little role except to note that the under 35 cohort agreed more (37.8%) *(42.7%)* and disagreed less (45.9%) *(57.3%)* than any other cohort.

Women disagreed much more vociferously than men, (65.4%) *(63.8%)* to (51.7%) *(41.3%)*, while men surpassed women in agreement with the assertion, (38.5%) *(40.6%)* to (21.2%) *(23.0%)*. These differences, which have moderated slightly over the years still echo the 1988 American survey.

A vast gulf between the views of university scientists and CRI scientists on the proper role of government continues: (68.5%) *(61.2%)* of university scientists disagreed with the assertion compared to (37.3%) *(30.5%)* of CRI scientists. Only (21.2%) *(23.8%)* of university scientists agreed with it compared to (52.8%) *(48.6%)* of CRI scientists.

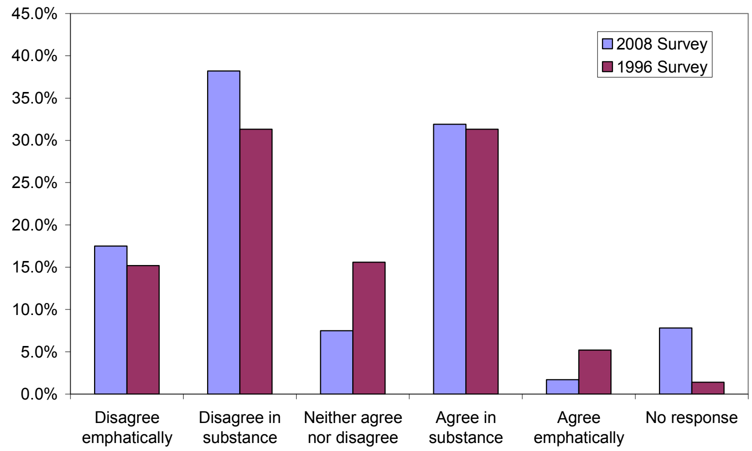


Figure 14: Government should set research agendas.

Table 13: Government should set research agendas, responses according to work location.

	Univ.	CRI
Disagree emphatically	24.7%	7.7%
Disagree in substance	43.8%	29.6%
Neither agree nor disagree	7.9%	5.6%
Agree in substance	19.1%	50.0%
Agree emphatically	1.1%	2.8%

Among fields of science the most outstanding feature once again is the widely different reaction of the Agriculture & Soil scientists, who agreed (58.0%) *(31.5%)* compared to the Social & Behavioural scientists (10.3%) *(22.8%)* and who gave the most negative response (81.0%) *(64.9%)*.

Government research agendas are political (Q. 36) *(Q. 17)*

> *When government sets research agendas it is responding more to political priorities than it is to potential for scientific advance.* Agree emphatically (23.8%) *(25.9%)* Agree in substance (54.8%) *(48.1%)* Neither agree nor disagree (11.9%) *(15.1%)* Disagree in substance (7.2%) *(8.7%)* Disagree emphatically (0.0%) *(0.9%).*

Fewer than 1 in 13 (7.2%) *(9.6%)* of the respondents disagreed with this statement, whereas more than 3 in 4 (78.6%) *(73.0%)* agreed. Unlike the previous question, there is little difference among the other variables, so these views may be thought of as generally held throughout the community. The exceptions to this comment are Earth & Environmental scientists (91.4%) and Physical scientists (89.3%) mainly in agreement, and in the case of the latter there was no disagreement registered.

Given the primary influence of government in New Zealand science and the skeptical attitudes voiced by scientists toward government's reasons for, and role in agenda setting, there continues to be much that should be debated among purchasers and providers.

Sustainable development and the precautionary principle (Q. 37)

> *The New Zealand government's Sustainable Development Programme of Action establishes a set of principles that require government to address risk and uncertainty when making choices, taking a precautionary approach to funding science and technology. I think these constraints are more detrimental to the advancement of science than they are helpful. Agree emphatically (3.6%) Agree in substance (36.6%) Neither agree nor disagree (37.7%) Disagree in substance (13.6%) Disagree emphatically (1.4%).*

This rather awkward question is derived almost directly from a Ministry of Research, Science and Technology (MoRST) document, 'Science for New Zealand: an Overview of the RS&T System 2006' (page 12). The responses are meant to be a direct source of information about science policy for those who formulate and manage policy. In effect, it can be considered a surrogate voice for those scientists who have not been part of the consultation process by government (see Questions 41 and 42) as well as an indicator of scientists' awareness of government science objectives.

Apart from the general agreement (40.2%) being significantly greater than disagreement (15.0%) the salient feature of the response is the high percentage of individuals who chose neither to agree or disagree (37.7%). Responses to questions about specific government programmes, for example Question 55 on Technology New Zealand, generated a heavy loading on Neither agree nor disagree signifying that the individual did not have enough information to decide positively or negatively. This information is valuable in its own right for those who develop programmes with the hope of engaging the entire scientific community.

Detailed response with respect to age, gender, and place of employment revealed no major differences, but when considering field of science Earth & Environmental scientists (48.6%) and Biologists (46.6%) stood out in their agreement with the statement.

Payoff for basic research (Q. 39) *(Q. 20)*

> *When the taxpayers fund basic/fundamental research, their government representatives should not (cannot) require a specific payoff because no scientist can guarantee a result in advance of doing the research.* Agree emphatically (33.8%) *(45.6%)* Agree in substance (46.8%) *(38.3%)* Neither agree nor disagree (4.2%) *(6.6%)* Disagree in substance (9.1%) *(6.8%)* Disagree emphatically (1.4%) *(0.7%).*

and

Basic research should be supported (Q. 40)

> *Even if it brings no immediate benefits, scientific research that advances the frontier of knowledge is necessary and should be supported by the New Zealand Government.* Agree emphatically (53.2%) Agree in substance (42.4%) Neither agree nor disagree (1.7%) Disagree in substance (1.4%) Disagree emphatically (0.8%).

Two questions remain from a 1996 battery of questions around the nexus of basic versus applied research. Questions 39 and 40 continue to ask the scientist to distinguish the difference between research modes and to attach value to them. Neither question yielded important information on differences between young and old, female or male, CRI or university employee or by field of science. On the contrary, responses were uniform with the exception of two outliers: Mathematics & Computer scientists (96.2%) agreed with Question 39 more than others and Medical & Health scientists were one-hundred per cent in agreement with Question 40. Four-fifths (80.6%) *(83.9%)* agreed with the statement in Question 39 and 95.6% agreed with the statement in Question 40.

Scientists understand clearly that basic research explores the unknown whereas applied research has an established goal in mind that can, in principle, be reached. The implication that scientists draw from this is well specified in Question 39: no matter how much science policy experts and science managers want to have guarantees of results from 'blue sky' basic research the scientist cannot agree to provide them. Eight out of nine scientists agreed with the statement. In 1996 the following question dealing with the radical uncertainty of basic research was asked and the responses are shown below:

> *1996 Question 19: It is the nature of basic/fundamental research that its results cannot be pre-determined. Agree emphatically (46.8%) Agree in substance (34.9%) Neither agree nor disagree (9.8%) Disagree in substance (6.8%) Disagree emphatically (1.4%).*

Two important follow-on questions asked in 1996 had to be abandoned in 2008 to keep the survey within manageable length. One question asked 'if government policy stipulates near term and measurable returns on public investment in science, then government should fund only applied research,' to which scientists responded negatively (55.1%). A second question stated that 'in general, applied research should not be funded by government because if it is sufficiently valuable it will be supported through private investment,' to which scientists also responded negatively (74.1%).

There continues to be some intriguing issues to explore for those concerned with the public understanding of science and technology. Should scientists, who are so overwhelmingly aware of the uncertainties inherent in basic/fundamental research depend on government support even though they are unlikely to deliver the results demanded? Why do scientists continue to believe that science policy makers have a better understanding of societal demands for science and technology than does the market place?

Scary issues

The general public is confronted daily with perplexing or frightening issues seemingly requiring advanced scientific knowledge in order to know how to cope. Scientists are regarded as authoritative sources of information by the public but scientists often feel that their views are not well reported by the media (see Question 30). Even with the best of intentions sometimes the print and electronic journalistic media exaggerate the potential risk of these issues, or simply miss the subtleties of scientific evidence altogether. The suite of questions in this segment asks scientists about selected widely reported science-based issues. Their opinions, while more expertly informed than those of the general public, are opinions based on the current understanding of the science behind the issues not universal and enduring truths.

Development of dangerous technology (Q. 24) *(Q. 3)*

> *I think that the development of potentially dangerous technology should be decided, primarily, within the scientific and engineering community.* Agree emphatically (2.8%) *(4.2%)* Agree in substance (23.3%) *(16.9%)* Neither agree nor disagree (5.8%) *(13.6%)* Disagree in substance (40.4%) *(37.6%)* Disagree emphatically (14.1%) *(26.3%).*

Only 1 in 4 (26.1) *(21.1%)* of the respondents agreed with this assertion whereas more than half (54.5%) *(63.9%)* disagreed with it. These data represent a slight movement toward greater decision authority within the science community even though the preponderance of the responses are negative. Women and men responded roughly the same with respect to agreement but men disagreed (58.4%) more than women (45.2%). Similarly, CRI scientists (61.3%) disagreed with the statement more than university scientists (50.5%) even though both had the same levels of agreement. Engineers & Applied scientists had the highest level of agreement (36.8%) and Social & Behavioural scientists the least (18.9%). These data, once again, represent a strong inclination toward societal responsibility and citizen involvement over strict expertise. A follow up question concerning the implementation rather than the development of dangerous technology asked in 1996 *(Question 4)* evoked responses consistent with responses to Question 24. These results show the New Zealand scientists' continuing sense of responsibility to society at large, and reveal a professional community that is trusting of the societal processes within which science is embedded.

Five current issues that have captivated news organisations and engaged the scientific community both in serious research and contentious debate are genetic modification, genetically engineered foods, embryonic stem cell research, nuclear power, and global warming. The public and its policy makers as well as many scientists are informed by the print and electronic media, so it is important to understand how the science community views these information sources. This section begins with a question on media reporting of science and then considers these five issues so widely exposed by newspapers and television.

Media reporting on science (Q. 30)

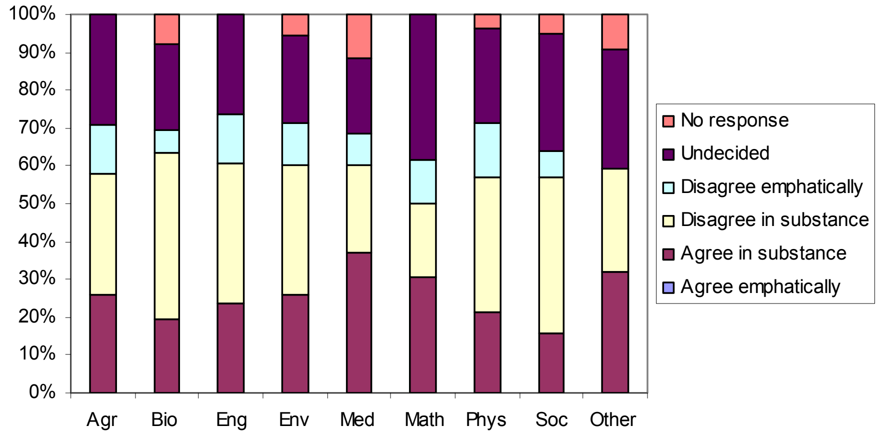
> *Newspaper and television reporting on science issues in New Zealand is generally accurate and unbiased.* Agree emphatically (0.0%) Agree in substance (23.8%) Neither agree nor disagree (26.6%) Disagree in substance (35.5%) Disagree emphatically (8.9%)

The 2000 and 2007 Panelist Surveys of New Zealand Scientists and Technologists asked this question. These surveys assessed the views of a cohort of approximately 170 participants in the 1996 Survey who agreed to become part of a panel group to be resurveyed periodically. This question was introduced in 2000 and asked again in 2007. The moderating responses from this panel group were sufficiently interesting that the question was incorporated in the 2008 Survey. In 2000, 66.7% disagreed; in 2007, disagreement dropped to 49.4% for the same individuals. The 2008 Survey respondents, an entirely different group, registered 44.4% disagreement compared with 23.8% agreement. Although disagreement with this statement prevails, it may be the case that coverage of science-based issues is improving in the estimation of the science and technology community.

Medical & Health scientists (37.1%) agreed more than scientists in other fields, most notably Social & Behavioural scientists (15.5%) and Biologists (19.3%). Those fields of science most negative in their assessment were Biologists,

Figure 15: Media reporting on science is generally accurate.

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.



Engineers & Applied scientists, and Physical scientists, all at 50.0%. Men (28.0%) agreed with the statement by more than twice the agreement by women (13.5%).

Genetic modification as ecosystem threat (Q. 25)

> *My understanding of the science of genetic modification of organisms leads me to believe they pose sufficient threat to the ecosystem to warrant suspension of research endeavours.* Agree emphatically (1.9%) Agree in substance (10.8%) Neither agree nor disagree (21.9%) Disagree in substance (39.9%) Disagree emphatically (20.2%)

Three-fifths of the scientists (60.1%) disagreed with this statement compared to 12.7% who agreed. Other, more nuanced versions of this question were considered, but it was decided to present the statement as plainly as possible.

Earth & Environmental scientists and Mathematics & Computer scientists agreed the most, 20.0% and 26.9% respectively, whereas Agricultural & Soil scientists (3.2%), Medical & Health scientists (8.6%), and Biologists (9.1%) agreed the least. More than four-fifths of the Agricultural & Soil scientists (80.7%) disagreed with the statement. There was no distinction in viewpoints with respect to age and gender, but university scientists (14.6%) agreed more than CRI scientists (9.9%).

Organic foods v. genetically engineered foods (Q. 38)

> *Government should invest as much in research on 'organic' foods' as it does on genetically engineered foods.* Agree emphatically (15.2%) Agree in substance (31.0%) Neither agree nor disagree (26.0%) Disagree in substance (19.1%) Disagree emphatically (3.3%)

New Zealand's historically strong agricultural base is a source of pride for most Kiwis and the issue of genetically engineered organisms, particularly foodstuffs, has stirred lively debate. There is a wide gap in the views of scientists in different fields: Earth & Environmental scientists (60.0%) and Social & Behavioural scientists (62.1%) registered the strongest agreement with this statement. Both of these fields had the lowest disagreement (8.6%). Engineers & Applied scientists (31.6%) responded with the least agreement. Interestingly, those in the field of science with a large stake in the discussion, Agricultural & Soil sciences, had a more middle of the road response, as 45.2% agreed with the statement and 35.5% disagreed. Moreover, this group of scientists was the least undecided (16.1%) by a large margin over other fields. This result suggests some polarisation within this community.

Embryonic stem cell research (Q. 26)

> *I believe that embryonic stem cell research should be suspended while other stem cell sources are researched.* Agree emphatically (3.6%) Agree in substance (10.2%) Neither agree nor disagree (18.8%) Disagree in substance (42.9%) Disagree emphatically (19.7%)

Although three-fifths of the respondents (62.6%) disagreed with the idea that embryonic stem cell research should be suspended, further breakdown of the data reveal which groups hold the strongest opinions. Scientists under 35 years old were less in agreement (8.1%) than older scientists. Men were slightly less in agreement (12.8%) than women (16.4%). Whether one is at a CRI or a university made little difference, but with respect to fields of science there were substantial differences. Earth & Environmental scientists agreed the least (5.8%) and Physical scientists the most (21.4%). Biologists were most closely aligned with the Earth & Environmental scientists. Medical & Health scientists showed some of the strongest agreement (17.2%) and disagreement (71.4%), an oddity made possible by the fact that they had the smallest proportion of undecided (8.6%) compared to the average of 18.8%.

Reconsidering nuclear power (Q. 27)

> *In my view, New Zealand should reconsider its prohibition of nuclear power sources.* Agree emphatically (10.5%) Agree in substance (29.4%) Neither agree nor disagree (14.1%) Disagree in substance (25.2%) Disagree emphatically (19.1%)

The aggregate response to this issue is more evenly divided than are the other 'scary' issues, with 39.9% agreeing and 44.3% disagreeing with the statement. Age and work location showed no significant differences with the aggregate numbers, but men were more in agreement (44.4%) than were women (28.9%) and less in disagreement, (41.3%) and (51.9%) respectively. Earth & Environmental scientists, with 45.7% both agreeing and disagreeing, and Medical & Health scientists displaying almost the same split with 48.6% in agreement and 45.7% disagreeing, are very different from the Social & Behavioural scientists. The latter agree only 13.8% and disagree 69.0 %.

Humans are main cause of global warming (Q. 28)

I think that over the last century human activities have contributed more to global temperature increase than have solar cycles or other natural phenomena. Agree emphatically (27.1%) Agree in substance (42.4%) Neither agree nor disagree (18.6%) Disagree in substance (5.0%) Disagree emphatically (4.2%)

New Zealand scientists placed themselves squarely in the camp of the orthodox interpretation of global warming being a consequence of human activities by nearly 7 in 10 (69.5%) agreeing with the statement compared to 1 in 11 (9.2%) who disagreed. For some, Social & Behavioural scientists for example, their belief approaches certainty with only 1.7% disagreeing.

Acceptance of this statement declined with age with the exception of a spike upwards among the small group of scientists over 65 years of age. Women and men shared roughly the same level of agreement, but men disagreed (10.8%) more than twice as much as women (4.8%). CRI scientists (76.1%) were more in agreement than university scientists (64.6%) but the main differences emerged among the fields of science. Agricultural & Soil scientists (80.6%) and Earth & Environmental scientists (82.8%) agreed the most while Mathematics & Computer scientists (53.8%) and Engineers & Applied scientists (55.2%) agreed the least, although both were nearly twice as 'undecided' as the remainder of the fields.

This will be a particularly interesting issue to consider in subsequent surveys as actual physical measurements of global temperature phenomena continue to be weighed against the output of computer models.

Climate change information sources (Q. 29)

Sources of information on the science of climate change are given in Table 14.

Table 14: Scientists' information sources on climate change.

Scientific journals	24.4%
Newspapers	18.3%
Internet	16.3%
Colleagues who are climate scientists	12.5%
Colleagues who are environmental experts	11.1%
Television	8.3%
Public lectures	5.5%
My own research	2.8%
Other	0.8%

Some may be surprised that scientist's reliance on newspapers and television (26.6%) is roughly equivalent to the combined sources of their own research and that of colleagues expert on the environment and climate itself (26.4%). This is especially interesting in light of the responses given to Question 30 on media reporting of science issues. The results of Question 29 highlight the reality that scientists are busy professionals who cannot be expert on all scientific matters no matter how current or fractious the issue may be. They must cope with conflicting information as does the rest of the citizenry. Scientific journals (24.4%) play a role nearly equal to each of the above combinations and the internet is a vast supplementary source from which information may be plucked by those who are doing research on climate change as well as those who may want to probe more deeply than the journalistic media.

Suppress unorthodox science (Q. 33)

It is in the public interest to discourage the dissemination of the views of scientists who do not agree with reigning orthodoxies in scientific issues. Agree emphatically (0.3%) Agree in substance (2.8%) Neither agree nor disagree (7.8%) Disagree in substance (47.1%) Disagree emphatically (38.2%)

It is a valuable insight for the public at large, and for individuals in policy positions, to understand that scientists know the difference between scientific opinions they hold securely and the necessity of entertaining other, possibly contrary, opinions. The history of science is replete with accounts of orthodoxies that were sustained by an overwhelming consensus only to be overturned as the burden of contrary evidence upended them: continental drift among earth scientists and, of course, the heliocentric universe among astronomers are just two examples. The results of this question point to the profound respect that New Zealand scientists have for open dialogue on controversial issues. Only three in one-hundred scientists agreed with this statement while 85.3% disagreed. There was virtually no support among any group defined by age, gender, work location or field of science, although two minor points of divergence may be identified: university scientists (4.5%) were twice as likely as CRI scientists (2.1%) to agree with the statement, and agreement by Engineers & Applied scientists (10.5%) was anomalous among fields of science.

Scientific inquiry and education

This section explores issues in the development of the human resource base of New Zealand science and technology and characterises the views of the scientific community on the nature of scientific inquiry and on perplexing aspects of the work of those who have chosen this career. The consistency of the reasons for becoming a scientist and the estimation of the weaknesses of young scientists entering their profession can be contrasted with changes that have occurred in support for the encouragement of women and Māori into science and technology education.

Developing human resources of science

Reasons to become a scientist (Q. 44) *(Q. 31)*

If you had to select just TWO reasons, which TWO of the following would you choose as your most important reasons for becoming a professional in your field?

The most frequently cited reasons for becoming a scientist have varied little since the 1996 Survey. The primary reason then and now is 'intrigue with the search for truth and knowledge or straightforward curiosity' (34.9%) *(32.9%)*. The second choice was 'desire to contribute to the improvement of the material and intellectual conditions of humanity' (23.8%) *(18.7%)*. These two reasons were selected as first or second choice by nearly three-fifths of the respondents. The next most frequently cited reason was: 'expectations of a sense of accomplishment by becoming an expert in my field' (16.0%) *(17.4%)*. Least cited reasons include: 'the potential to become famous for my research' and 'the potential to achieve greater wealth than possible through other careers.' These two choices total less than two per cent of the choices. What is remarkable is the stability in the rankings of this question, a near perfect match, between the two surveys (see Table 15 below). Moreover, it was noted in the report of the 1996 Survey that the results to this question mimicked those of the 1986 Sigma Xi survey in both order and percentage of choice (Jackson 1987). One might speculate that these results lend credence to the thought that there exists a culture of science that extends across time and space and is not confined to methodologies or techniques.

Table 15: Reasons to become a scientist.

	1996	2008
Intrigue with the search for truth and knowledge	32.9%	34.9%
Desire to contribute to the improvement	18.7%	23.8%
Expectation of a sense of accomplishment	17.4%	16.0%
Influence of an older scientist	8.5%	8.7%
My chosen field was easier and more fun for me	14.4%	7.8%
Desire to achieve a comfortable lifestyle	2.7%	3.4%
Other	1.7%	1.7%
Desire to follow in the footsteps of great thinkers	0.9%	1.4%
Expectations of other persons	1.4%	1.0%
Potential to become famous for my research	0.6%	0.9%
Potential to achieve greater wealth	0.6%	0.7%

Cross-tabulations of the data reveal that there were no significant differences with respect to age, gender, or work location in a university or CRI. There were some interesting differences with respect to field of science. Earth & Environmental scientists (65.7%) had the strongest response to 'intrigue with the search for truth.' On the second most popular choice concerning the 'desire to improve conditions for humanity', it may not be surprising that Medical & Health scientists would make this their highest choice (42.9%), whereas Engineers & Applied scientists ranked it lower (13.2%). Mathematics & Computer scientists were up-front in choosing to become a professional in their field because it was easier and more fun (19.2%), and that was three times greater than the nearest other field.

Weaknesses of young scientists (Q. 46)

I think the two greatest weaknesses of young scientists entering my field of science are:

The respondents to this survey represent a professional cadre that has a stake in the future of science and technology in general and in their own fields and institutions in particular. Much casual discussion about the qualities of new entrants into the profession dwells on their inadequacies so a new question was formulated to identify the principal weaknesses of young scientists. Focus group discussion contributed to the specification of a limited set of eight choices. Table 16 displays the combined first and second choices. Subsequent cross-tabular information refers only to the first choice.

Table 16: Weaknessses of young scientists.

Poor at written expression	14.4%
Lack of rigour in research methodologies	14.3%
Superficial understanding of the subject matter	12.8%
Too narrowly focused	12.2%
Unable to form an independent research agenda	11.1%
Lack of curiosity	9.0%
Poor grasp of maths	7.8%
Unwillingness to work hard	6.1%
Other	5.4%

The aggregate data reveals that there are no dominant complaints. Weakness seems to be spread across all of the choices. The category of 'Other' was the smallest and invited narrative comments yielded no special insights or suggestions of other weaknesses that might have been listed. But what of the results when disaggregated by age, gender, work location and field of science?

The age of the respondent made little difference in their response except for one major exception and one minor exception. The youngest cohort, under 35, was the most critical of young scientists over the perceived lack of rigour in research methodologies (32.4%) and poor grasp of maths (18.9%). The three oldest cohorts were more inclined to be critical of the narrow focus of young scientists

Analysis of gender revealed that women and men scientists have no important differences on the weaknesses of young scientists.

Minor differences occur with respect to work location in a CRI or a university. Worth noting is that CRI scientists (18.3%) are more concerned about the narrow focus of young scientists than are university scientists (10.1%). On the other hand, university scientists (12.4%) think that young scientists suffer from a lack of curiosity, but CRI scientists are more demure (5.6%) on this point.

Field of science analysis yields a few differences. Unsurprisingly, Mathematics & Computer scientists (23.1%) seize on 'poor grasp of maths' and are joined by Physical scientists (21.4%). Agricultural & Soil scientists (19.4%) and Biologists (19.3%) cite poor written expression as the main weaknesses. Other than these, the only other interesting differences are at the other end of the scale: Agricultural & Soil scientists (3.2%) and Physical scientists (3.6%) are far less inclined to cite 'lack of curiosity' as a weakness, and Agricultural & Soil scientists (3.2%) do not see the inability to form an independent research agenda as an issue. Do these low values indicate a lack of concern by Agricultural & Soil scientists, for example, for 'curiosity' and the ability 'to form independent research agendas' or do they indicate that the young scientists entering this field are particularly strong in these areas?

What to make of the results for the entire question is unclear. One is tempted to think that complaining about the younger generation is an occupational pathology.

Prepared for other work (Q. 50)

My education and training as a scientist has prepared me for productive work outside scientific research. Agree emphatically (16.3%) Agree in substance (59.3%) Neither agree nor disagree (13.0%) Disagree (9.1%) Disagree emphatically (0.6%).

During a period of global economic uncertainty and constantly shifting government priorities for science funding many New Zealand scientists have had to evaluate the nature of their education and experience with respect to opportunities to begin new careers. How well does their education and training in science translate into capability to perform in other jobs? Evidently the respondents to the survey are sufficiently confident in their education and training that they have the luxury of security in preparedness for other work outside science that does not exist in all professions. More than three-quarters affirmed this confidence (75.6%) and only 9.7% did not. But is this high confidence evident throughout the scientific community?

In terms of age, confidence in the value of one's education and training increases as one grows older. This trend is not dramatic but it is clear.

Gender analysis offers no insight whatsoever.

University scientists (79.8%) are more confident than CRI scientists (66.9%) in their employment flexibility.

Consideration of field of science found that Engineers & Applied scientists (92.1%) essentially expressed no doubts about their education and training. Physical scientists (57.2%) viewed themselves as having had the least flexibility conferred on them by their education and training.

Special efforts to attract women (Q. 47) *(Q. 32)*

> *Special efforts should be made to attract women into (undergraduate) science, maths and engineering postgraduate studies.* Agree emphatically (13.3%) *(15.3%)* Agree in substance (42.9%) *(37.0%)* Neither agree nor disagree (16.6%) *(27.8%)* Disagree in substance (19.9%) *(11.1%)* Disagree emphatically (3.9%) *(7.1%).*

This 2008 version of the question turned the focus from undergraduate to postgraduate studies and the results are similar to those of 1996 although not strictly comparable. Differences among fields of science are manifested in responses to this statement. In strong support are Social & Behavioural scientists (74.2%) *(67.3%)*, Engineers & Applied scientists (60.6%) *(62.5%)*. Agreeing least are Biological scientists (45.4%) *(37.1%)*, and Agricultural & Soil scientists (48.4%) *(45.1%).*

Individuals under 35 years of age favoured the statement less than other age groups in 2008 but more than any other age group in 1996. Women, as a group, agreed with the statement more strongly (69.2%) *(61.4%)* than did men (51.2%) *(49.8%).* University scientists (65.8%) *(56.5%)* agreed with the statement more than CRI scientists (45.0%) *(46.1%).*

Special efforts to attract Māori (Q. 48) *(Q. 33)*

> *Special efforts should be made to attract Māori into undergraduate science, maths and engineering studies.* Agree emphatically (13.6%) *(17.4%)* Agree in substance (48.5%) *(32.3%)* Neither agree nor disagree (15.2%) *(28.3%)* Disagree in substance (15.5%) *(13.0%)* Disagree emphatically (4.2%) *(7.3%).*

Māori make up less than two per cent of the S&T population in New Zealand who qualified for this survey, far less than their proportion in the population at large. As an under-represented minority they, like women, are a source of opportunity for those concerned with keeping a flow of New Zealand scientists entering the workforce. New Zealand scientists who expressed an opinion on this issue are more than three to one in favour of special efforts to attract more Māori into undergraduate science studies. Agreement on this issue increased substantially between the two surveys.

Agreement with the statement increased slightly with age. Women agreed more strongly (69.2%) *(56.8%)* than did men (59.1%) *(48.1%)*, and university scientists were more supportive (79.8%) *(54.4%)* than their CRI counterparts (66.9%) *(43.6%).* On both of these key variables the support for the statement has increased greatly.

It is interesting to note wide differences among fields of science. Strongly agreeing with the statement are the Social & Behavioural scientists (77.6%) *(65.6%)* but no others are close to this level. Agreeing least are Physical scientists (50.0%) *(41.1%)*, and the Mathematics & Computer scientists (53.8%) *(71.5%)*, and both of these fields expressed nearly double the average disagreement. It is puzzling why Mathematics & Computer scientists would go from being one of the most supportive fields in 1996 to one of the least in 2008. Apart from this last datum, there exists a much more encouraging atmosphere for greater Māori participation in undergraduate science studies.

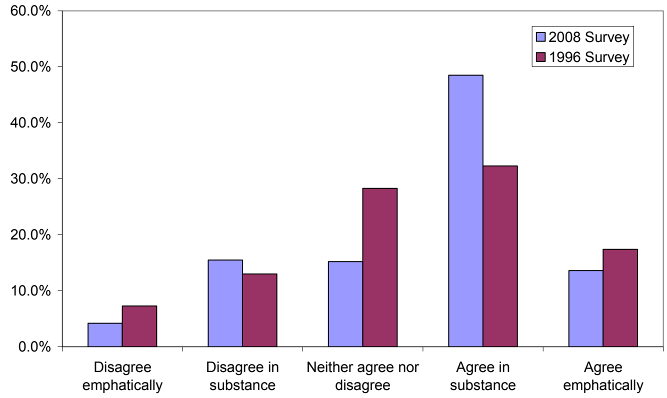


Figure 16: Special efforts needed to attract Māori.

On the nature of scientific inquiry

How do New Zealand scientists conceive science and the best ways to proceed with their research? Five questions were asked in this segment to try to gain perspective on the issues. The responses may surprise some science managers.

Scientific knowledge and Matauranga Māori (Q. 43) *(Q. 9)*

> *In my view Māori claims to scientific knowledge derived from Matauranga Māori (traditional knowledge) deserve serious attention and public funding.* Agree emphatically (4.7%) *(4.2%)* Agree in substance (30.2%) *(19.5%)* Neither agree nor disagree (24.7%) *(32.2%)* Disagree in substance (26.9%) *(24.2%)* Disagree emphatically (7.5%) *(16.4%)*

Almost one-fourth of those queried sat on the sidelines, neither agreeing nor disagreeing, but 34.9% *(23.7%)* agreed compared to 34.4% *(48.6%)* who disagreed. Women scientists were much more sympathetic to the assertion, with 49.1% *(35.6%)* agreeing and 18.3% *(28.7%)* disagreeing. This contrasts with men, who agreed only 29.2% *(20.1%*) and disagreed 40.8 % *(43.9%)*.

In 1996, university and CRI scientists did not differ markedly in their responses to this assertion but in 2008 some separation emerged as CRI scientists agreed more (38.0%) than university scientists (32.5%) and disagreed less (28.8%) to (36.6%).

Social & Behavioural scientists registered the strongest agreement (55.2%) *(50.0%)*, compared to those in Physical sciences (14.3%) *(13.9%)* and Mathematics & Computer sciences (19.2%) *(14.3%)*. Physical scientists recorded the strongest

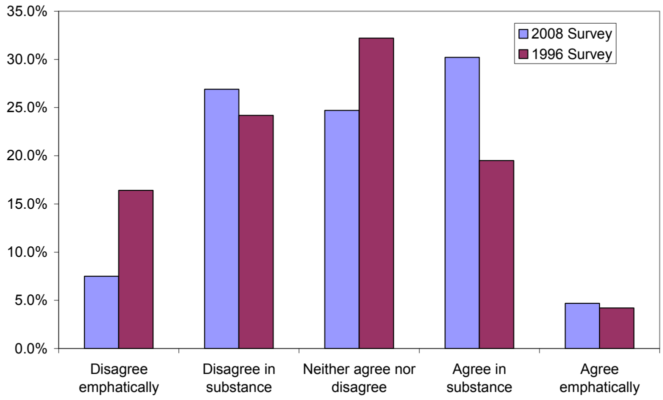


Figure 17: Scientific validity of Matauranga Māori.

disagreement (53.6%) *(49.4%)*. Although deep divides remain within the scientific community over the scientific validity of Matauranga Māori, the arrow of acceptance is pointed upward in all instances. Nowhere is this more evident than in the Health & Medical sciences, which were strongly in the negative camp in 1996, with only *14.5%* in agreement with the statement, whereas in 2008 this group of scientists became much more positive (48.6%).

This question is a useful benchmark of changing attitudes for future surveys, and the responses reported here can be the basis for lively discussion within the different professions. One might contrast the eagerness to encourage Māori to study science at university with the more muted support for the acceptance of Matauranga Māori and wonder if subsequent surveys will reveal a continued convergence on these issues.

Scientific discovery and serendipity (Q. 45) *(Q. 18)*

> *From what I know of scientific discovery, it is more a result of insight and circumstance than it is of textbook methodological treatment of a subject area.* Agree emphatically (10.0%) *(19.2%)* Agree in substance (39.9%) *(42.3%)* Neither agree nor disagree (18.3%) *(20.3%)* Disagree in substance (23.5%) *(13.1%)* Disagree emphatically (2.2%) *(3.5%).*

Is scientific discovery the result of a flash of insight that may, or may not, relate to research in which the scientist is engaged or is it a consequence of carefully planned methodological application of standard scientific procedures? Many scientists who are credited with important scientific discoveries claim their discovery was incidental to the research in which they were engaged. Some of the respondents who chose ‘Neither agree nor disagree’ restated the truism that discoveries happen more often for the trained mind but they did not argue that faithful application of scientific procedures alone would lead to discoveries. The implications of the results are something that the managers and planners of the scientific enterprise should consider carefully.

Approximately half (49.9%) *(61.5%)* of respondents providing an opinion agreed that scientific discovery is more a result of insight and circumstance than textbook methodological treatment. This recognition of discovery as a creative act appears to increase with age; where 48.6% *(52.0%)* of scientists under 35 concur with this notion the percentage of respondents agreeing increases for each age group 45 and over until we observe that 57.1% *(70.9%)* of scientists between 55 and 64, and 84% *(73.3%)* 65 years of age and over support the idea. Men (53.7%) *(65.1%)* are more likely to agree with this assertion than women (40.4%) *(50.4%)*. These responses correspond with those given by American scientists in 1988. Earth & Environmental scientists (60.0%) *(71.1%)* and Physical scientists (57.1%) *(71.0%)* showed the highest levels of agreement.

It is apparent that support for this statement has declined since the 1996 Survey, possibly indicating that the goal-driven results orientation of government science policy has had an effect on scientists’ perception of the discovery process.

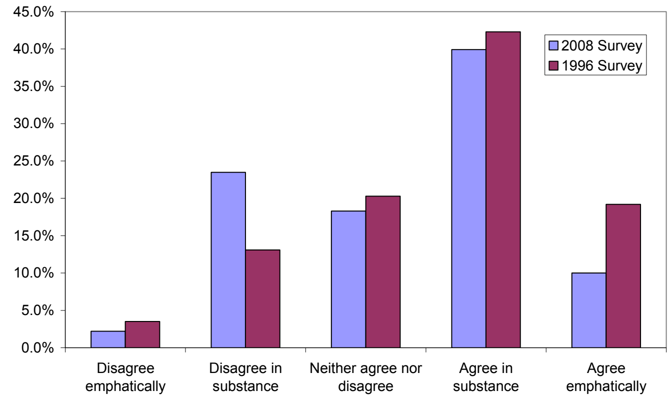


Figure 18: Scientific discovery and serendipity.

Team research versus the lone researcher (Q. 49)

> *Scientific advances are more likely to derive from team research than from the insights of an individual.* Agree emphatically (14.1%) Agree in substance (37.1%) Neither agree nor disagree (20.5%) Disagree in substance (20.2%) Disagree emphatically (3.3%)

As a corollary to the question of serendipity and the implicit inspiration of the individual researcher, this explicit question addresses the individual versus team approach to research. It is commonplace to hear that the role of the lone researcher has been eclipsed by team research. The aggregate data support this view (51.2% versus 23.5%), but how does it stand up with respect to age of the respondent, and is it uniformly viewed that way by those in different fields of science?

Age is an influential factor on this question: more than three-fifths of the scientists under 45 years old agree that team research prevails over the individual researcher whereas just over two-fifths of those 45 years and older concurred.

Women, who make up a relatively larger segment of the younger scientists, agreed more than the average (57.7%) and disagreed less (19.2%). Men, who are a relatively greater proportion of the older cohorts, agreed less (48.6%) and disagreed more (25.3%).

Agreement between CRI and university scientists was almost the same, but university scientists (27.0%) disagreed with the statement more than those in CRIs (18.0%).

Between fields of science there are some significant differences, with Agricultural & Soil scientists with the greatest agreement (64.6%) and the least disagreement (16.1%) and Social & Behavioural scientists at the other end of the distribution, with agreement of 39.7% and disagreement of 31.1%. Earth & Environmental scientists and Biologists are closely aligned with Agricultural & Soil scientists, whereas Physical scientists and Mathematics & Computer scientists are grouped tightly with the Social & Behavioural scientists.

Social and physical scientist collaboration (Q. 67) *(Q. 38)*

> *During the past five (two) years I have participated in or directly witnessed effective research collaboration between social scientists and physical scientists.* Yes (40.2%) No (59.6%). *In 1996 the response was as follows: Agree emphatically (7.4%) Agree in substance (10.7%) Neither agree nor disagree (17.4%) Disagree in substance (16.3%) Disagree emphatically (43.3%).*

The 2008 Survey added three years to the period of observation and changed the question to a simple 'yes' or 'no' response as it should have been formulated originally. No fence-sitting option was offered in 2008 as it was in 1996. The response to the question is not strictly comparable but aggregate information is shown above for both surveys. This is a question of some interest for science managers because fostering interdisciplinary collaborations has been a policy goal for government; in neither survey is the question answered in a very encouraging way. In both surveys three in five scientists (59.6%) responded negatively to the assertion. The persistence of negative responses indicates long-term difficulties for collaborative efforts, yet there seems to be a more positive estimation of collaboration in some areas of science.

Women and men share views on this issue close to the aggregate totals, as do individuals in universities and in CRIs. Apart from the under 35 cohort, which gave 70.3% 'No' response, the remaining age groups did not have a large variation. Keep in mind that many in the under 35 year old group have not had five years in which to make observations.

There is a very interesting difference with respect to fields of science. Earth & Environmental scientists (60.0%) and Agricultural & Soil scientists (51.6%) have taken part in or witnessed far more successful collaborations than any other scientists. This elevated level of agreement may, in part, be a consequence of a regulatory environment that requires interactions on issues related to natural hazards. On the other side are the Physical scientists (25.0%) and Biological scientists (29.5%), who were much less likely to have taken part in or witnessed a successful collaboration.

Table 17: Collaboration among scientists.

	Yes	No
Agriculture & Soil sciences	51.6%	48.4%
Biological sciences	29.5%	70.5%
Engineering & Applied sciences & technologies	36.8%	63.2%
Earth & Environmental sci. and Natural resources	60.0%	40.0%
Medical & Health sciences	48.6%	51.4%
Mathematics & Computer sciences	38.5%	61.5%
Physical sciences	25.0%	75.0%
Social & Behavioural sciences	41.4%	58.6%

Cross-institutional collaboration (Q. 68) *(Q. 51)*

> *Over the past five years the opportunities for cross-institutional collaborative research have greatly improved.* Agree emphatically (3.6%) Agree in substance (38.5%) Neither agree nor disagree (29.6%) Disagree in substance (19.9%) Disagree emphatically (5.0%).

> *1996 Question 51: My freedom to collaborate with scientists outside my own institution has increased since the restructuring. Agree emphatically (3.4%) Agree in substance (12.0%) Neither agree nor disagree (45.6%) Disagree in substance (19.3%) Disagree emphatically (12.0%).*

This question was derived from focus group discussions in 1995 and revised and revalidated in 2007. It asks directly about another persistent goal of New Zealand science policy makers. The question is sufficiently different in content that the 1996 data should be treated as background information rather than used for valid comparisons; however, one can infer that there has been greater affirmation of the opportunity to collaborate. Respondents in 2008 are more certain of their response than those in 1996.

Among the key variables there was no important difference with respect to work at a CRI or a university. Women were slightly more positive than men on this question. The under 35 cohort once again registered the lowest support for the statement (29.7%), probably due to their lack of time on the job. The age group 45–54 were the most positive (48.0%)

Agriculture & Soil scientists (51.6%) were the most positive discipline, an oddity considering that they registered the greatest disagreement in 1996. The lowest agreement was posted by Mathematics & Computer scientists (23.1%), and they led the other fields of science in disagreement (38.5%).

On freedom of expression

Along with job security and remuneration for services performed scientists value greatly freedom of inquiry, and freedom of expression in writing and speaking. Four questions in this section explore this dimension of the environment of science.

Pressure to commercialise (Q. 57)

> *During the past five years I have experienced increased pressure to direct my research toward commercial outcomes.* Agree emphatically (17.5%) Agree in substance (44.3%) Neither agree nor disagree (6.4%) Disagree in substance (22.2%) Disagree emphatically (3.9%).

One can see from the responses to Question 23 (see page 15) concerning the most important issues facing science that 'emphasis on funding applied research over basic research' ranked a strong third after interruptions in funding and bureaucratic accountability. A common complaint of scientists is the amount of 'outside interference' in their quest to satisfy their intrigue with the search for truth and knowledge, their principal reason for becoming a scientist, as expressed in Question 44 (see page 26).

Pressure to commercialise one's research is generally experienced by most groups of scientists: men are only slightly more in agreement with the statement than women, but three other categories yield much stronger distinctions. That CRI scientists (70.4%) feel the pressure to commercialise research more acutely than university scientists (57.9%) is not unexpected given the Statements of Corporate Intent of some Crown companies and the traditions of universities, but the sharp divide between scientists under 55 years of age and those 55 and older is striking. Two-thirds of the younger scientists agreed with the statement compared to half of the older scientists.

Differences between fields of science are substantial. Agricultural & Soil scientists (77.4%), Engineers & Applied scientists (76.3%) and Biologists (68.2%) feel these pressures much more than Medical & Health (57.1%), Earth & Environmental (51.4%) or Social & Behavioural scientists (51.7%).

Able to submit research for publication (Q. 72) *(Q. 48)*

> *I am able freely to submit my research results for publication without prior approval from my employer.* Agree emphatically (31.0%) *(48.5%)* Agree in substance (31.3%) *(32.4%)* Neither agree nor disagree (2.8%) *(6.7%)* Disagree in substance (18.6%) *(8.6%)* Disagree emphatically (12.7%) *(2.5%).*

The clause 'without prior approval from my employer' was added to the statement in 2008 to make explicit its context. New Zealand scientists feel that they are able to submit research for publication, a pattern that holds with respect to one's gender. Age is a different matter, as scientists under 35 years old are half as supportive of the statement (29.7%) as are any of the other cohorts. A distinction should be made in future surveys between normal processes of internal peer review in organisations to assure quality and organisational strictures aimed to suppress politically awkward information or interpretations of scientific issues.

Something dramatic has happened with respect to CRIs in the past decade. In 1996 agreement was substantial in CRIs *(70.7%)* but by 2008 this agreement had shrunk to 20.4%. Scientists in universities (93.2%) *(92.2%)* continued to agree with this issue much more than those in CRIs. Overwhelming agreement was expressed by Social & Behavioural sciences (87.9%) *(87.9%),* Mathematics & Computer scientists (84.6%) *(74.3%)* and Medical & Health scientists (82.8%) *(90.8%).* Disagreement with this statement is far greater among Agriculture & Soil scientists (61.3%) *(20.0%)* compared, for example, to Social & Behavioural scientists (8.6%) (6.9%).

Table 18: Free to publish without prior approval?

	2008	1996
Disagree emphatically	12.7%	2.5%
Disagree in substance	18.6%	8.6%
Neither agree nor disagree	2.8%	6.7%
Agree in substance	31.3%	32.4%
Agree emphatically	31.0%	48.5%

May speak freely on public policy issues (Q. 73) *(Q. 50)*

> *I am able to speak freely on public policy issues within my particular area of expertise without prior approval from my employer (1996: where I have particular expertise without fear of reprisals from management).* Agree emphatically (20.5%) *(22.2%)* Agree in substance (34.9%) *(24.7%)* Neither agree nor disagree (8.3%) *(21.3%)* Disagree in substance (23.3%) *(19.2%)* Disagree emphatically (10.0%) *(9.3%).*

Although the difference between those who agree and those who disagree with this statement may not appear great in the aggregate, the averages for the entire set of respondents mask some enormous differences among groups. In this question and in the preceding question a clear pattern of polarisation appears. The percentage of individuals who 'neither agreed nor disagreed' dropped significantly between surveys and the respondents moved resolutely toward the negative on these important issues of freedom of publication and speech. For the scientist, freedom of expression is an important issue, central to the canons of science. It is, therefore, a crucial matter for the quality of life of the scientist which must be noted by those in management roles. Exploration of the gulf of differences between key groups increases the urgency for understanding the underlying issues.

Table 19: Free to speak on public policy issues?

	2008	1996
Disagree emphatically	10.0%	9.3%
Disagree in substance	23.3%	19.2%
Neither agree nor disagree	8.3%	21.3%
Agree in substance	34.9%	24.7%
Agree emphatically	20.5%	22.2%

Agreement with the statement jumps dramatically with age: (29.7%) *(30.5%)* of those in the under 35 group agree compared to 84.0% (64.3%) in the 65 and over group. One might attribute this difference to individuals who have not yet established themselves in their position but the job security information in Question 70 (see page 19) does not bear this out. Women *(41.5%)* agreed somewhat more than men *(27.2%)* in 1996, but by 2008 both women (61.4%) and men (52.9%) increased their agreement substantially.

There is great variation between fields of science. Social & Behavioural scientists continued their lead in agreement with the statement (84.5%) *(71.9%)*, far more than those in other fields. Agriculture & Soil scientists recorded the lowest level of agreement (19.3%) *(31.9%),* nearly half that of the next lowest level of agreement, found among Biologists (36.4%) *(39.5%)*. There is an astonishing difference in levels of disagreement too, as Agricultural & Soil scientists registered 67.7% *(35.9%)* compared to Social & Behavioural scientists 8.6% *(22.8%)*. One is led to speculate on institutional setting as an influence on these data.

Responses to this statement offer insight into the personal concerns of scientists, and how these differ by institutional setting. One clearly prefers that a greater proportion of the scientific community would feel free to express an opinion and the aggregate response of the entire scientific community appears to affirm this hope. In fact, the aggregate response papers over some truly significant differences. It is in the difference, for example, between CRI scientists and university scientists where a measure of this aspect of the quality of professional life may be pondered. Only 23.2% *(23.3%)* of the CRI scientists agreed with this statement and 63.3% *(45.3%)* disagreed. Agreement by university scientists declined radically to 29.8% *(67.4%)* while disagreement was 30.9% *(11.7%).*

Direct knowledge of fraud (Q. 66) *(Q. 11)*

> *Excluding gross stupidities and/or minor slip-ups that can be charitably dismissed (but not condoned), I have direct, personal knowledge of fraud (e.g. falsifying data, misreporting results, plagiarism) on the part of a professional scientist during the past five (1996: two) years.* Yes (10.5%) No (88.9%). *1996: Agree emphatically (4.7%) Agree in substance (4.2%) Neither agree nor disagree (8.0%) Disagree in substance (13.3%) Disagree emphatically (67.4%)*

This question was converted to a more direct Yes/No format, and to cover five years instead of two. The responses between 1996 and 2008 are not strictly comparable but they are very nearly the same nonetheless. Only about 1 in 10 scientists have personal knowledge of fraud, and it must be remembered that a single act of fraud may have been recognised by many individuals rather than a unique instance witnessed by each observer. One would not expect the witnessing of fraud to be affected by age or gender, and they were not. Institutional setting provided no significant information either. Differences did appear when field of science was considered. Agricultural & Soil scientists (19.6%), Mathematics & Computer scientists (19.2%), and Engineers & Applied scientists (18.4%) bore witness nearly double the rest of the fields except Medical & Health scientists (2.9%).

A question concerning the responsibility of the scientist to expose fraud on the part of another was asked in 1996 but not in 2008 because the response was so overwhelmingly positive that it seemed unlikely to yield much useful information.

Performance of the S&T system

In this final section of the report we focus directly on how the individual scientist views the operation of the New Zealand science and technology system over the past few years and compares those views with survey responses of 1996. In 1996 much of the survey was focused on how scientists viewed various aspects of restructuring of the system that were put in place at the beginning of the decade. Nearly two decades later a number of different initiatives have been launched by those in science managerial positions and the science community has had more time to adjust to these initiatives. Much of what is reported in the preceding sections provides insights about some of these initiatives, but this section focuses on some specific performance measures.

The first two questions in this section ask for information on the evaluation of the openness and inclusiveness of the decision making system and then on the actual role individuals have had in the deliberative processes of science and technology policy. These are followed by three questions about changes in the access to quality equipment and technical support for research endeavours. Three more questions ask about specific policy initiatives to determine the extent of knowledge about the initiatives and opinions about their efficacy.

Lastly, two grand summary questions are analysed both for their current content and for the changes they reveal in the viewpoints of the science and technology community. These two questions, along with Questions 23 and 74 (pages 15 and 20) evoke expressions of deeply held judgments on the state of the system and should act as bellwethers for the public, policy makers and science managers. To ignore the signals given in these answers is to court folly in the management of science and technology in New Zealand.

Science policy is open and inclusive (Q. 42)

> *Government science strategy development is open and inclusive of a large segment of New Zealand scientists.* Agree emphatically (0.0%) Agree in substance (13.6%) Neither agree nor disagree (35.7%) Disagree in substance (34.9%) Disagree emphatically (13.6%).

When organisations make policy decisions with little input or participation from their employees, the morale of these employees is negatively affected. This observation applies to the New Zealand science and technology system, where policies are announced from top government decision makers, ostensibly with input from the science community but with little actual participation. Such input undoubtedly occurs, but the perception of how open these decision makers are to the advice of scientists and how inclusive they are in seeking such advice is open to question. The pervasive sense of an 'old boys' network', evident in the responses to Questions 61–63 (pages 17–18), may be a concern among the wider population of scientists and technologists. The aggregate response makes an obvious statement of disagreement with the proposition. Only 13.6% of the respondents agreed, and none of them did so emphatically. Nearly half (48.5%) disagreed and the emphatic disagreement (13.6%) matched the entire level of agreement.

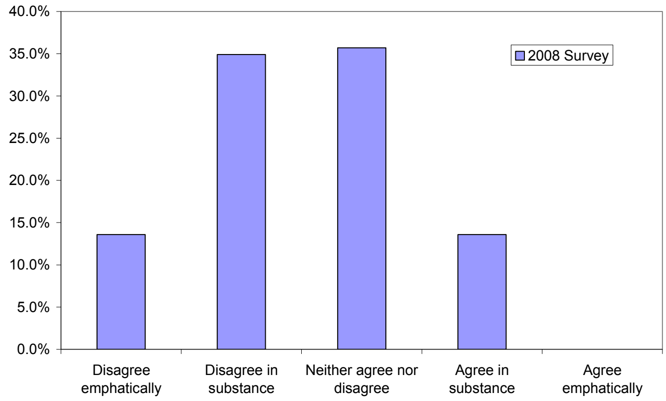


Figure 19: Open and inclusive policy dialogue?

The disaggregated analysis points to an increase in agreement with the statement with age, certainly a result of reflecting the reality that more established scientists are also 'survivors' in the system. Scientists under 35 years old exhibited both a low level of agreement (8.1%) and a low level of disagreement (32.4%) but a very high level of neither agreement nor disagreement (56.8%). Percentages of those who neither agreed nor disagreed declined monotonically across the age cohorts to 20% for those 65 and older.

Women and men report different levels of agreement, with women (7.7%) agreeing half as much as men (16.0%). A much larger proportion of the female respondents (51.0%) reported that they could neither agree nor disagree compared to 29.6% of men. The large proportion of women in the under 35 age cohort is reflected in this response.

Work location made little difference in outlook although those in CRIs were slightly more in agreement and in disagreement than those in universities.

Within the different fields of science there is some wide variation, with Earth & Environmental scientists (20.0%) and Mathematics & Computer scientists (23.1%) in greatest agreement, while Agricultural & Soil scientists (6.5%) and Social & Behavioural scientists (5.2%) recorded the least agreement. The latter pair was joined by Physical scientists (10.7%), but this field also recorded a level of disagreement much more elevated than any other (67.8%) and the lowest level of neither agreeing nor disagreeing (17.9%). Social & Behavioural scientists had the highest proportion of respondents who neither agreed nor disagreed (51.7%).

Government advisory experience (Q. 41)

> *During the past five years I have been solicited for scientific advice or evidence by a government agency to inform policy making.* Yes (39.9%) No (59.9%)

The previous question explored the perceptions of scientists about the process of science policy decision making. This question is a straightforward request to find out who has been included in the policy process: two-fifths have been solicited in the past five years and three-fifths have not. This question was not asked in 1996 so we do not have a comparison, but the responses here establish a baseline for future surveys.

It is not surprising that the under 35 age group, at 18.9 % agreement, and the 35–44 cohort, at 28.8% agreement, were solicited about half as much as the remaining age groups, because it takes time for an individual to establish a scientific identity and a research programme. For this reason one might gain an understanding of the different response of women and men. Women agreed 31.7 % compared to men 43.2% and disagreed 68.3% to 56.0% for men. As a group proportionally more women are in early stages of their careers than men.

Biologists (34.1%), Mathematics & Computer scientists (26.9%) and Physical scientists (25.0%) showed the lowest level of solicitation by government, whereas Earth & Environmental scientists (62.9%) and Medical & Health scientists (57.1%) reported the highest levels. It is curious that Mathematics & Computer scientists had the highest level of agreement in the previous question concerned with the perception of openness and inclusion yet was near the bottom of those actually solicited by government. On the other hand, Earth & Environmental scientists and Physical scientists demonstrated a consistency between questions: the former exhibited the highest level of solicitation in Question 41 and second highest level of agreement in Question 42, and the Physical scientists experienced the lowest level of solicitation in Question 41 and the greatest disagreement in Question 42.

Availability of state-of-the-art equipment (Q. 53)

> *I think access to state-of-the-art equipment is better now than five years ago.* Agree emphatically (3.9%) Agree in substance (42.7%) Neither agree nor disagree (28.5%) Disagree in substance (13.6%) Disagree emphatically (2.9%).

Even though respondents to the 1996 Survey did not think that 'most of the really interesting research questions today require expensive state-of-the-art equipment to answer them' by a two to one margin, it was decided that a useful measure of material development of the S&T system could be constructed by asking about access to such equipment. In this first edition of the question, respondents were nearly three to one (46.6% to 16.5%) in agreement.

Women (39.4%) agreed less than men (49.4%) and scientists in CRIs (50.7%) agreed more than those in universities (42.1%). Age-related responses showed no great differences, but the field of science revealed some of importance.

Agricultural & Soil scientists were in greater agreement (64.5%) than other scientists and Engineers & Applied scientists were at the other end of the distribution, with only 34.2% agreement.

Sufficient access to equipment and supplies (Q. 58) *(Q. 34)*

> *I have access to equipment and other scientific supplies sufficient to do my research.* Agree emphatically (8.9%) Agree in substance (60.7%) Neither agree nor disagree (3.9%) Disagree in substance (18.0%) Disagree emphatically (3.9%).

> *1996 Question 34: The restructuring of NZ science has improved my access to equipment and other scientific research supplies. Agree emphatically (2.6%) Agree in substance (11.0%) Neither agree nor disagree (30.7%) Disagree in substance (24.9%) Disagree emphatically (25.6%).*

Access to equipment and supplies is important for most scientific research, and commitment to its replacement or enhancement is fundamental to the sustainability of research programmes. In 1996, as shown above, our concern was with the immediate impact of the new restructuring process. More than half (50.5%) disagreed that their access to equipment and supplies had improved. After a dozen years does the New Zealand science community think its access is sufficient to do their research? Recognising that the 2008 and the 1996 questions are different, one still must conclude that there has been a general improvement in access to equipment and supplies. Nearly seven in ten (69.6%) agree with the statement. Of course, more differentiation is found in the disaggregated data.

Men and women scientists responded alike in terms of agreement but men disagreed (24.2%) more than women (16.3%). Age was not a factor in the responses.

Only a small difference exists between CRI and university scientists on this question: CRI scientists (72.5%) agreed with the statement more than university scientists (66.3%).

Variation among scientific fields on this issue was not great. Engineering and Applied scientists (34.2%), and Physical scientists (28.5%) recorded the strongest disagreement. Mathematics & Computer scientists (80.8%) were in greatest agreement.

Satisfactory staff and technical support (Q. 59) *(Q. 37)*

> *During the past five years technical and other staff support for my scientific research has been satisfactory.* Agree emphatically (6.1%) Agree in substance (41.8%) Neither agree nor disagree (5.8%) Disagree in substance (35.2%) Disagree emphatically (6.9%).

> *1996 Question 37: The restructuring of NZ science has resulted in an increase in staff support for my scientific research. Agree emphatically (1.4%) Agree in substance (8.2%) Neither agree nor disagree (24.7%) Disagree in substance (23.2%) Disagree emphatically (34.7%).*

As in the previous question the 2008 and 1996 versions differ sufficiently that they can only be contextually comparable, but staff support, like equipment, is crucial to the maintenance of continuity in research programmes. Estimates of improvements in technical and staff support for scientific research are much more divided than those for equipment: slightly more respondents (47.9%) agree compared to 42.1% who disagree.

Again, age has no role in these choices. Fewer women agreed (42.3%) than men (50.2%), but their level of disagreement was almost identical.

CRI scientists agreed (54.9%) with the statement more than university scientists (43.9%) and their disagreement on this issue is also of the same differential: CRI scientists (35.9%) and university scientists (46.8%).

Earth & Environmental scientists (62.9%) and Mathematics & Computer scientists (61.5%) thought that technical and staff support had been satisfactory, but Social & Behavioural scientists (36.2%) thought otherwise.

Technology New Zealand scheme (Q. 55)

> *In my view Government's Technology New Zealand scheme has been effective in aiding the movement of ideas from the laboratory to the market place.* Agree emphatically (1.1%) Agree in substance (16.3%) Neither agree nor disagree (52.6%) Disagree in substance (14.1%) Disagree emphatically (3.0%) Other (9.7%).

This question and the two that follow are focused on the policy designs of government, and the salient features of each of these are the choices of 'Neither agree nor disagree,' 'Other,' and those who skipped the question entirely. In the case of Technology New Zealand there is little awareness of the programme, a point fortified by the response to Question 18 (page 13) that showed that only 9.1% had received funding directly from this source and an additional 2.9% received some commingled with other funding programmes. This is surprising given the specific interest of government to expedite the commercialisation of ideas, and it may be taken as an indication of lack of knowledge about the programme. More than half of women and men, CRI scientists and university scientists and all but one age cohort chose to neither agree nor disagree. Physical scientists and Mathematics & Computer scientists chose this option more than 70 per cent of the time. The only field of science that differed significantly from this trend was Engineers & Applied scientists, who agreed 31.5%, disagreed 26.4%, and were undecided one way or the other 31.6%.

This survey, already quite long, might well have explored some of the other major government initiatives to gain a greater understanding of how these initiatives engage (or fail to engage) a wide base of the science community.

New Zealand's S&T investment (Q. 56)

> *I think New Zealand public agencies that fund or invest in RS&T support the retention and development of research capability needed by existing sectors and industries.* Agree emphatically (4.7%) Agree in substance (32.1%) Neither agree nor disagree (31.3%) Disagree in substance (21.9%) Disagree emphatically (5.8%).

Apart from the fact that only just over one-third (36.8%) of the respondents agreed with this statement it is noteworthy that the disaggregated responses followed the aggregate response so closely. Gender and work location showed no distinctive trends away from the aggregate averages. The under 35 age group agreed with the statement (56.8%), much more than any other cohort, as did Engineers & Applied scientists (57.9%). The only other scientific field that strayed away from the aggregate averages more than five percentage points was Social & Behavioural sciences, which recorded 27.6% agreement.

Performance-Based Research Fund (Q. 60)

> *On balance, Performance-Based Research Fund (PBRF) monies are fairly allocated to those university scientists most likely to perform excellent research.* Agree emphatically (1.7%) Agree in substance (16.1%) Neither agree nor disagree (36.0%) Disagree in substance (21.3%) Disagree emphatically (11.4%).

The large percentage of those who neither agreed nor disagreed is no mystery because PBRF monies are directed through university administrators to university-based researchers. These funds are not generally available to those in CRIs or other organisations. If it is somewhat surprising that disagreement (32.7%) is virtually double agreement (17.8%) in the aggregate, it is more surprising that only 22.4% of university scientists agree with the statement while 56.2% do not! Moreover only 1.1% of university scientists neither agreed nor disagreed, an indication that their views are very strongly held. This is surely an issue to be addressed by government science managers and university administrators.

Men disagree (55.4%) with the statement more compared to women (30.8%). Mathematics & Computer scientists and Medical & Health scientists hold divergent views on this issue, the former agreeing 15.3% and disagreeing 57.7% compared to the latter's 45.8% and 28.5%.

Management systems are appropriate for research advancement (Q. 52) ***(Q. 49)***

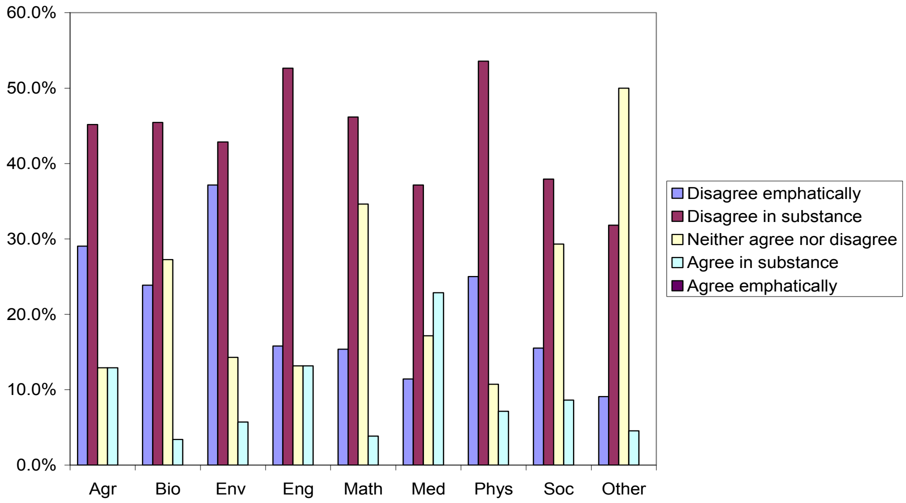
> *The management systems in New Zealand science are appropriate for the effective advancement of research.* Agree emphatically (0.0%) *(1.6%)* Agree in substance (8.6%) *(9.5%)* Neither agree nor disagree (23.3%) *(31.3%)* Disagree in substance (43.8%) *(30.9%)* Disagree emphatically (20.8) *(22.3%)*.

The restructuring of New Zealand science over the past two decades continues to be a work in progress. During these years since the abandonment of the Department of Scientific and Industrial Research (DSIR) and the establishment of CRIs and their subsequent consolidation, there have been a number of initiatives to direct scientific research towards problems and opportunities defined by science policy makers. An important new source of support for the preservation of fundamental research emerged with the creation of the Marsden Fund, but much of the search for a combination of vibrant programmes to meet the priorities set by government for public science has appeared frenetic, or even frantic. Scientists have been heard to complain that more resources are spent on new and clever names for initiatives and their attendant stunning charts and diagrams than on the basics of making a system run effectively and consistently. With all of this motion is there progress? Do scientists think that the ever-new management systems are effective for the advancement of scientific research? Question 52 seeks an evaluative opinion of the scientific community about the guidance systems put in place to manage science.

The answer to this crucial question of appropriateness is no. Nearly two-thirds (64.6%) *(53.2%)* disagree with the statement compared to 8.6% *(11.1%)* who agree with it. Thus, for every New Zealand scientist who thinks that management structures with potential for success are operational, there are seven who do

Figure 20: Management systems are appropriate for research.

Agr = Agriculture & Soil sciences; Bio = Biological sciences; Eng = Engineering sciences and Applied sciences & technologies; Env = Earth & Environmental sciences, and Natural Resources; Med = Medical & Health sciences; Math = Mathematics & Computer sciences; Phys = Physical sciences; Soc = Social & Behavioural sciences.



not. Since the 1996 Survey the needle on this monitoring device has moved into more negative territory. Overcoming this negative assessment was an obvious challenge for those in science management positions in 1996, and it remains a challenge for the future. Monitoring future responses to this question becomes an imperative for those who seek a consistent indicator of the performance of the New Zealand S&T system.

Table 20: Management systems are appropriate for research.

	2008	1996
Disagree emphatically	20.8%	22.3%
Disagree in substance	43.8%	30.9%
Neither agree nor disagree	23.3%	31.3%
Agree in substance	8.6%	9.5%
Agree emphatically	0.0%	1.6%

Age provided no special insights for this question.

CRI scientists (70.5%) *(96.0%)* disagreed with this statement somewhat more than university scientists (61.2%) *(78.7%)*.

Male scientists disagreed (68.9%) *(55.7%)* more than female scientists (53.8%) *(43.4%)*.

Earth & Environmental scientists disagreed the most (80.0%) *(50.0%)*, followed by Physical scientists (78.6%) *(60.2%)* and Agricultural & Soil scientists (74.2%) *(65.7%)*. Medical & Health scientists disagreed the least (48.6%) *(42.7%)* and agreed the most (22.9%) *(5.3%)*. Agricultural & Soil scientists were the only other group to record double-digit agreement (12.9%) *(10.0%)*.

Recommending science as a career (Q. 51) *(Q. 42)*

This bellwether question simply states:

> *The way things are going with scientific and engineering careers in New Zealand today, I would recommend such careers to New Zealand youth.* The aggregate response was: Agree emphatically (3.6%) *(6.6%)* Agree in substance (33.2%) *(28.6%)* Neither agree nor disagree (18.8%) *(18.2%)* Disagree in substance (32.1%) *(31.1%)* Disagree emphatically (9.1%) *(14.7%)*.

The aggregate response of 41.2% *(45.8%)* disagreeing, either somewhat or emphatically, while 36.8 % *(35.2%)* agree and 18.8% *(18.2%)* don't know is interesting in that a slight improvement has occurred over the decade. The fact that disagreement remains greater than agreement is disturbing in its own right, but when considering the comparison between the sentiments of university and CRI scientists an even more troubled picture emerges. CRI scientists are much less optimistic than their university counterparts: 59.2% *(56%)* disagree with the statement while only 26.7% *(24.7%)* agree. The numbers for the university scientists are 28.7% *(37%)* who disagree while 43.8% *(44.8%)* agree.

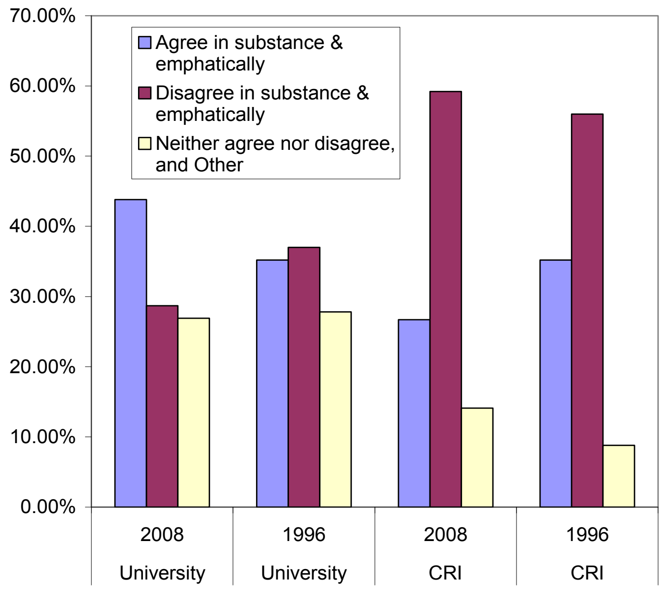


Figure 21: Recommending science as a career, comparing universities and CRIs.

Table 21: Recommending science as a career, aggregate in 2008 compared with 1996.

	2008	1996
Disagree emphatically	9.1%	14.7%
Disagree in substance	32.1%	31.1%
Neither agree nor disagree	18.8%	18.2%
Agree in substance	33.2%	28.6%
Agree emphatically	3.6%	6.6%

Women and men have very different opinions on this issue, signalling a change from 1996, when their views were virtually identical. Agreement among women is 43.3% *(38%)* compared to men (31.2%) *(34.0%)* and disagreement is almost a direct switch, with women disagreeing 31.8% *(46.0%)* and men 45.1% *(46.0%)*. Scientists over 65 and under 35 were the most positive in their responses, whereas mid-career scientists were less inclined to support the statement.

Social & Behavioural scientists agree with this statement more than any other group (51.7%) *(39.7%)* followed closely by Health scientists (48.6%) *(38.2%)*. Even more striking is the reduced vehemence of the sentiments of Health scientists expressed in the form of emphatic disagreement (from *19.7%* to 2.9%). On the opposite side are the Agricultural & Soil scientists (22.6%) *(26.7%)* and Biological scientists, who report only 25% *(24.4%)* agreement. Biological scientists also recorded 17% *(19.5%)* emphatic disagreement, and other groups recording emphatic disagreement with the statement are Agricultural & Soil sciences 16.1% *(19.7%)* and Mathematics and Computer sciences 15.4% *(5.0%)*.

The responses to this question across all categories do show a very modest improvement. However, the persistent discontent of those in the Agricultural & Soil sciences and in the Biological sciences should be cause for alarm, especially in light of the fact that nearly one-fifth (19.1%) of all scientists in the under 35 age cohort are in the Biological sciences.

Postscript

Results presented here robustly support the four functions of the survey articulated at the beginning of this report, and they establish the second datapoint in an anticipated series of surveys to be continued in the future. A single survey may produce some intriguing surprises, but the succession of surveys yields trends that can foster hypotheses and research endeavours of greater depth.

A voice for the community of scientists and technologists has been amplified in several important ways. First, it has been given a temporal dimension in which echoes from the 1996 Survey are heard in 2008 through which an appreciation may be gained for how attitudes and opinions change or remain stable under different conditions. Second, the specific voices of age, gender, field of science, and job location are isolated amidst the cacophony of data, thereby permitting one to peer into important differentiation within the aggregate responses. This disaggregated information helps to make specific what are the unvarnished concerns of the science and technology community. The respondents have been randomly selected to give their views rather than chosen to represent those of government or other parties.

This 'voice,' combined with data on the attributes of the S&T community, produces a rich source of unbiased information for development of science policies. Science policy is often thought to be the province of government, but that is not accurate – firms, foundations, educational institutions, scientific societies and other organisations also formulate policies to guide their own development. Information from these surveys can help the managers of these entities to shape decision making.

In the case of government, which is the dominant entity in New Zealand's science and technology activity, the survey results do provide some direct performance measures. Some of the questions were formulated in 1995 to develop outcome measures of goals stated in the discussion document preceding publication of *RS & T 2010* (MoRST 1996). Others were developed to capture the impact of policies on the morale of the S&T community. Results from the 1996 Survey caused anxiety among policy makers despite the fact that the survey was only a 'snapshot' of one point in time, and a time then regarded as turbulent. Now that a second survey has been completed, science managers should begin to wonder if trends are being established or if past perceived issues are being resolved, persist, or have intensified. If the period in which the 2008 Survey was conducted is also regarded as turbulent one might wonder whether this is the 'normal' state of affairs and if so, why?

The remaining important function of the survey is to open to the public at large a greater understanding of science and technology, its practitioners, and the management issues that emerge from the complex relationships that exist in the political economy of New Zealand. Greater public understanding of and engagement with the S&T community will promote the emergence of a milieu in which debate of issues can proceed with greater clarity. Instrumental in this process are the print and electronic media. Solid journalism, using these results to inform their own questions and their reports, can contribute immeasurably to an informed public.

It is fitting to bring this report to a close by sharing the actual voices of individual scientists who offered their thoughts on the issues raised by the survey questions. One-hundred and sixty respondents wrote narrative comments, many with similar themes, so only a few can be quoted here. A few of the comments were virtual essays on the state of New Zealand science so in some cases a relevant passage has been extracted for our purposes. The individuals have given permission to use their remarks and many have waived the offer of anonymity. The author has chosen to provide information on the background of the individual rather than using their name.

The overwhelmingly popular theme in the respondent remarks is that of lack of sufficient funds for research. This is seen to contribute to related issues of interruptions in funding and over-specification of research objectives by individuals who are seen not to be knowledgeable of the canons of science in general and of the practice of scientific research in particular. Their narratives also express great concern over the respondents' perception of pressure to point research toward commercial objectives. Job security is a third important theme. It would be a mistake to interpret this outcry as a kind of self-pleading. The respondents have, for the most part, taken a synoptic view of conditions and have rendered their sober analyses. All respondents are New Zealand citizens who have a PhD degree unless otherwise noted.

Budget for science

#1 **A 46 year old male physical scientist at a university. He has worked in New Zealand science for 5–10 years and has received his main funding from Marsden. His annual research budget is between $50,000 and $99,999**. The main issue – the lack of funding – has not been addressed properly in this survey. A success rate of only 7% in Marsden because of lack of funds is just not good enough. Excellent research does not get funded often. If Marsden were tripled then we would be at the level of our competitors in other countries. I have not yet sought to leave NZ but can imagine a scenario in which this might occur. I was lucky enough to have Marsden funding for 3 years but have had better proposals turned down because the number of grants awarded is so few and have been without funds for the past 2 years. There is an 'it's not his turn' sort of mentality given the limited amount of money on the table. The only reason my job satisfaction has increased is because of strides I have been making in my research - due to chance factors and individual insights - in spite of the lack of funds. Getting young people interested in science is vital as well; I did not list this as my greatest concern in a relevant box because it does not impact directly on research in the way that lack of money does but clearly it is important too. I am all for more outreach.

#67 **A 54 year old male physical scientist at a CRI. He is a resident of New Zealand who has worked in New Zealand science for less than five years. His budget of $100,000-249,999 comes from CRI sources.** It is a sad state of affairs when I as a scientist must discourage my children from training in a scientific career unless they intend to leave New Zealand after graduation. When educational requirements pay and job stability are considered they would be much better off as tradesmen.

#150 **This 47 year old male university scientist is in mathematics and computer science. He has worked in New Zealand science for 11–15 years and his main source of funding comes from New Zealand university sources. He has essentially no research budget**. It is my view that world-wide the principal benefits universities can deliver to society have been significantly eroded and undermined primarily through over-management by non-academics --- specifically from misguided attempts by government agencies to control and manipulate those benefits. This could be fixed by making it easier/simpler for many more (particularly younger) academics to get small research grants ($10,000–$25,000) to use as they see fit rather than investing/gambling great sums on fewer large-scale projects selected through a complex, ambiguous and time-consuming process. I am happy for my views to be published and attributed.

#158 **This 32 year old physical scientist is employed at a CRI and has been working in New Zealand science for less than 5 years. His funding is from FRST and his annual research budget is between $100,000 and $249,999.** Permission is given to use the following comment: Working in a CRI in New Zealand I find the most negative aspect to be the non-indexing of FRST funding. Every year funding of our core research programmes decreases (in relative terms), resulting in constant reduction of objectives and staff. While new money does arrive, it is usually government-targeted for a specific area and obviously unpredictable, thus reducing the security and satisfaction of a science career in New Zealand. This 'boom or bust' approach is difficult for recruitment and retention of scientists within a particular field.

#57 **A male in engineering and applied science is 65 years old and has worked in New Zealand science for 31–35 years. He is at a university and his main funding is from FRST. His annual research budget is $25,000–49,999.** I think the most important issue facing scientists is the lack of effective leadership at government level. We do not have politicians committed to promoting science and technology development and securing sufficient funds to ensure NZ's science and technology enterprise is conducted on a scale large enough to have a significant effect on society and the economy.

#123 **A 57 year old male in the biological sciences employed at a CRI. He has worked in New Zealand science for 31–35 years and his annual research budget is $100,000–249,999.** As a lucky 'survivor' scientist in the CRI system I have survived for the last 16 years entirely off grants while many of my colleagues have not. As a top priority, some sort of PBRF equivalent for CRIs is essential if this type of career in applied research is to become attractive. Job security is a major issue for young CRI scientists. [*Author's Note:Q. 70 results contradict this observation*.] A question that should have been in this survey: Should a PBRF equivalent fund be in place for CRI scientists? My answer is STRONGLY AGREE.

#281 **A 44 year old female in agriculture and soil sciences who works for a CRI and has worked in New Zealand science for 16–20 years. Her annual research budget is derived primarily from FRST and is $250,000–499,999.** Just a note about Marsden fund is that it is a great idea but grossly underfunded – novel new ideas should be fostered much more. Just coming back from Europe it is clear that RS&T are not a high priority in NZ. This is reflected right from attitudes of an average New Zealander to the resulting lack of emphasis based on funding RS&T. It is not an easy task to change these attitudes stemming from the culture of doers not thinkers which was so important in the early history of NZ. Hopefully things will improve for my children's generation.

Foibles of the funding system

#24 **A 52 year old male biological scientist with a CRI. He has 21–25 years' experience in New Zealand science and derives his $250,000–499,999 research budget from commercial contracts.** FRST has become a surreal system in the Kafka mould with values and objectives that act against the operation of good science. When asked I counsel young people 'to steer clear of science careers in New Zealand.'

#79 **This 55 year old male engineer and applied scientist is employed at a university and has been working in New Zealand science for 31–35 years. His research budget of $50,000–99,999 is derived from a government department**. The FRST funding system in particular is inefficient, overly bureaucratic, and prone to capture by those with 'grantsmanship' skills as opposed to those with strong research capabilities. I recently witnessed a colleague in a CRI saying that he had more money than he knew what to do with while other bright prospects in his field are starved for research funds. I have no faith at all in FRST. Its 'foresight' process and reinvention of the English language as a substitute for real insights into potential research gains are jokes worthy of Fawlty Towers. It would be laughable if it was not so damaging to science in New Zealand. Let's return to independent funding of each CRI and university and get rid of all this phoney 'contestability' that consumes so much time and money for negative gains.

#120 **A 50 year old male biological scientist employed in a CRI. He has been engaged in New Zealand science for 16–20 years and derives his $250,000–499,999 research budget from FRST.** My strong impression of FRST-funded science is that it is far more important to be seen to be working on the 'right' areas than to achieve anything useful. Failure to achieve anything useful in a politically correct research area gains more recognition and reward than real progress in an 'incorrect' area. I give permission to quote this comment.

#141 **This 51 year old female biological scientist is employed by a university. She has worked in New Zealand for 5–10 years. Her research budget of less than $25,000 comes from university resources**. I have found that mainstream ideas get funded by FRST. New and original ideas are not favourably looked at. The funding seems to be controlled through 'old boys' networks'. The outputs seem to be mediocre in comparison to funding levels and an obvious trickling of funds towards unidentified sources of wastage seems to occur. Small businesses struggle and substantial funding is not directed towards these businesses. The availability of funding is more apparent than real. On the whole, New Zealand does not inspire confidence as becoming a leader in the advancement of science and technology.

#255 **A 47 year old male engineer and applied scientist who works at a university. He has worked in New Zealand science for 5–10 years and has essentially no research budget.** My greatest concern (Q61) and the thing that prevents me from absolutely loving my work is that CRIs are forced to enter the FRST granting process to ensure the continuation of their existence. For us scientists at the pointy end of this it is about retention of our jobs and those of our team-mates. I have personal experience of the major hoops we have to jump through with the FRST portfolio criteria, with the blunt and quite questionable interpretation of this by FRST staff (who to my mind have very little if any actual research experience), with the ever-changing rules (especially what's 'in' this time and what's 'out' – this changes from round to round and it definitely affects skilled people), and with the effect that non-inflation-proofed funding systems have and will continue to have on the progress of research and on the development of careers. (I've been in the 'system' for 25 years and in the years since the CRIs and FRST/MoRST were established it's just gone from one scary scenario to another). The inevitable effect of non-inflation-proofed funding (and lack of stability of salary funding, hence your job security in a CRI) is that, as a programme manager, you try to support your staff and cut down on operating $s to make things 'fit' until you really do have to lose positions (and hence lose the ability to progress the research). 'Negotiated' programmes with FRST are NOT as they are described to provide stability of funding and support of expertise. The minister and FRST just don't seem to get it. You are bidding for the SAME amount of money that supported a programme at inception (often 4–6 years ago) and this is to last you for another 4–8 years. We can all do that maths! The funding mechanism for CRIs just has to be overhauled – we absolutely need to have stability of funding to ensure that valuable staff have a reasonable outlook for a career – the bidding process should be for programme operational funding not to keep the organisation afloat. Government needs to provide the foundational funds to ensure the institutes can run. Lastly (sorry!), I am so sick of this requirement that commercial funding must be part of a research programme. NZ is too small for small commercial companies to be putting up valuable dollars, and to make FRST funding contingent on this is horrifying. In our institute there is the expectation we will find commercial contracts to 'fill the gaps' as well. I do love being a scientist – but we are in a very black period for science in NZ at the moment. Fifty years ago our scientists found out stuff that has since been developed into ways to make our economy tick (and those guys had fun doing it too). I think in time we will look back and regret the funding models and set-ups we have today. I appreciate being able to add on to the survey like this – thanks.

#272 **This 42 year old university-based biological scientist is a resident of New Zealand who has worked in New Zealand science for 5–10 years. His main research funds come from university sources and his annual average budget is $25,000–49,999.** I think science funding is too small in NZ. PBRF is OK, but low-research-output staff that have high teaching loads end up getting exploited by high-research-output staff who shirk teaching responsibilities. It can be a vicious circle. The requirement for Māori consultation is an impediment to native plant research (pure research, I mean). It amounts to extra bureaucracy and they usually aren't interested anyway unless politics is involved. MAF and ERMA red tape is terrible too. Seems like we waste time working out how to work within new rules when things have worked fine for a hundred years without regulations.

#320 **A 51 year old male earth and environmental scientist who is Māori and has been employed in science in the country for 21–25 years. He holds a Masters degree, is employed at a CRI and derives his $500,000–1,000,000 annual research budget from FRST**. NZ science and research has lost about 15–20yrs of where it could have been because of the present 'inflexible' & overly 'bureaucratic' tight competitive funding system introduced in the early 1990s and lack of attention to RS&T as a priority and strategy area for growth innovation sustainability and wellbeing in NZ – by politicians, private industry, and the NZ public alike. We have only just started to collaborate and think again post-2004! NZ as a whole has suffered detrimentally because of this ignorance and it has been a major contributing factor to the current lack of interest and pride in RS&T in NZ (e.g. schools, universities). Our science illiterate politicians have resigned us – in NZ – to increasingly buying RS&T in from overseas for years to come (e.g. medicine, health, environment, engineering, industry, IT) and therefore being dependent on knowledge creation innovation and technology from elsewhere at increasingly high cost. A well funded RS&T sector should have established our NZ identity, our culture, competitive advantage and economic resilience in the world.

A more optimistic note

#181 **A male university-based medical and health scientist who is 43 years old and who has been working in New Zealand science for less than 5 years. He receives $500,000–1,000,000 from the HRC for his annual research budget.** Having recently returned to NZ after 10 years working in science overseas, NZ science looks to me to actually be in fairly good shape compared to some other countries. That said, basic biomedical research in NZ is entering a deepening funding crisis.

#335 **A 45 year old male earth and environmental scientist who works at a CRI. He has been working in New Zealand science for less than 5 years and his annual research budget of $25,000–49,999 comes from FRST.** I recently moved to NZ from the USA to work as a research scientist. This may influence the interpretation of my responses to the first few questions which are probably aimed at established scientists in NZ considering a move abroad. For me it is the opposite; I am happy to be here!

#324 **A female social and behavioural scientist with a Masters degree who is 43 years old and who is employed at a polytechnic. She has worked in New Zealand science for 5–10 years and, although she has essentially no research budget, she gets some support from overseas.** I like the research focus of the Labour government and I think it is starting to influence political decision making more keenly than in the past.

#82 **A female social and behavioural scientist at a university who is 40 years old and who has worked in New Zealand science for less than 5 years. Her annual research budget of less than $25,000 comes from university sources.** I am one of those rare breeds of NZ academics who has actually returned to this country. It may say more about the university I was based at in Australia than the system as a whole, but I have much greater support and time for research now than I did in the Australian system and much greater job satisfaction despite a 30% decrease in pay.

#354 **This 49 year old medical and health scientist has worked in New Zealand science for 21–25 years. He has an annual research budget of $500,000–999,999 supported by the HRC.** PBRF in particular has had an empowering effect on university-based researchers particularly at University of Otago Christchurch (formerly Christchurch School of Medicine) where I work. In the past week, five new full-time confirmation path research positions at senior/associate professor level have been awarded. These are funded by the university and were awarded to five researchers (myself included) currently funded by the HRC. This has had a major positive effect on these individuals and will have a trickle-down effect for other researchers (for example this transfer from HRC- to university-funded salaries probably means an additional 3–4 HRC grants will get funded in the next round. The government and TEC are to be congratulated on this initiative, which has significantly improved our research environment. Other burning issues: we need to increase HRC and Marsden funding! These are our innovation engines, and so much excellent research is not being funded. I know – I've chaired an HRC assessing panel for 5 years and am gutted every year when only about 5 or 6 of 40 grants in my committee get funded. The recent large increase in HRC funding has been effectively lost to overhead and salary increases, so it has really only been about keeping pace. The current career 'valley of death' in my field (biomedical research/genetics) seems to be after the postdoc stage, perhaps 4–5 years out. We need more early- to mid-career fellowships to give outstanding emerging researchers a stronger career path. I sat on two NHMRC panels (Australia) recently and one of the major differences was the lack of PI and senior research salaries on NHMRC grants. Australia has many more institutional ARC, NHMRC, etc. fellowships at all levels. Doubling the number of Charles Hercus Fellowships would be a great start in this direction! I have appreciated having two RS&T Top Achiever PhD Scholars in my lab (over the past 4 years) and one RS&T Postdoctoral Fellow. These are excellent schemes and should be retained and strengthened if possible. The recent CoRE process was a major debacle and embarassment. To mobilise so many people and waste so much time and effort in order to identify $n = 1$ new CoRE was an utter disgrace. The lack of science detail and strong administrative/political themes required in the applications was perturbing and left one with little confidence in the value of the assessment process. If government really believed in CoREs as a way ahead they should have dumped in a decent amount of money and picked up 3 or 4 new ones. It is nice to know someone is researching science and science careers in this country. Keep up the good work!

#236 **A 39 year old biological scientist who has worked in the New Zealand science system for 5–10 years at a CRI. His $250,000–499,999 budget is derived from FRST.** Overall I believe science in New Zealand is headed in the right direction. My first major concern, however, is the lack of stability and bureaucracy associated with government sources of funding, particularly the FRST system. I do not think that the competitive model (CRI v. CRI, university v. CRI) is beneficial – it instead creates inefficiencies, a lack of job security, and a lack of cooperation between science groups that should be collaborating not competing. Efforts to reduce the level of competition are welcome. The procedures used to allocate funds could be simplified and the money saved spent on funding research. Less pretending by government bureaucrats that they can 'invest' in predictable outcomes and less time wasted by scientists pretending they can calculate the monetary value of their work for the country in 5 or 10 years' time would save a lot of money. Fund good quality applications by scientists or groups with a good track record of quality science outputs. My second concern is around the lack of new graduates choosing a career in science particularly biological science. Some of this is undoubtedly the result of the perceived lack of job security and low rates of pay experienced by research scientists.

Future surveys must continue to seek a balance between new questions that address current issues and those that are refined and repeated so that trend analyses can be enhanced. There is no question that the survey instrument can be improved to reduce or remove ambiguity in some questions, some of which was noted by sharp-eyed respondents whose critique is much appreciated. The categories of 'field of science' must be expanded to conform to developing international standards. The question of electronic survey versus alternative methods must be revisited and resolved in light of database development.

Supporting the entire process must be a commitment to improved and continuous database development rather than viewing it as an episodic event. Support for data development has been a stated goal of Government in official documents and MoRST was generous in underwriting some of the costs of the database for this survey. However, it is critical that support be continued and increased to permit a completely validated database of New Zealand scientists and technologists to be established and sustained. The returns to New Zealand science and technology will far outweigh the costs.

The survey process itself should be institutionalised in a widely respected organisation outside of government to ensure that the results of surveys will be understood to be independent. This is a discussion that should begin immediately if the surveys are to occur on a five year schedule.

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