MINISTRY OF RESEARCH, SCIENCE & TECHNOLOGY
TE MANATŪ PŪTAIAO

COMMONSENSE, TRUST AND SCIENCE

HOW PATTERNS OF BELIEFS AND ATTITUDES TO SCIENCE POSE CHALLENGES FOR EFFECTIVE COMMUNICATION

RESEARCH CARRIED OUT FOR THE MINISTRY OF RESEARCH SCIENCE AND TECHNOLOGY BY THE NEW ZEALAND COUNCIL FOR EDUCATIONAL RESEARCH IN ASSOCIATION WITH ACNIELSEN

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SUMMARY

INTRODUCTION

This research was undertaken for the Ministry of Research Science and Technology (MoRST) by the New Zealand Council for Educational Research (NZCER) in association with ACNielsen. The research provides insights into what the public knows, thinks, and feels about science.

The methodology employed builds on similar research carried out in the United Kingdom (OST/Wellcome Trust, 2000 and 2001). The UK researchers reported that communication activities may effectively inform the public about a science issue but still fail to allay mistrust of scientists. For this research, we proposed as a tentative hypothesis that such continuing distrust might partly result from a lack of broad understanding of how science ideas are investigated, debated, and resolved within the science community itself. That is, aspects of the *nature of science* are as important to science communication as are the relevant science concepts. This tentative hypothesis was used to frame some of the questions in the telephone survey that formed the quantitative component of the research, and it also informed the shaping of the material for discussion in the focus groups that formed the qualitative component of the research.

The two components, together with related insights from the literature on the public understanding of science, provide a robust body of findings that should be useful for those who make decisions about *communication* between scientists and the public. This is a difference of emphasis from previous similar research carried out in New Zealand which was intended to inform the *promotion* of a positive image of science to the public (CM Research 2000).

SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

The summary integrates findings from both quantitative and qualitative components of the research. The interconnections between these two components are fully elaborated in the body of the report.

General attitudes to science

A majority of New Zealanders are interested in at least some aspects of science and technology, with interest highest in those areas where personal and societal benefits are most evident. A majority of New Zealanders are personally confident that they can engage with new ideas in science, although they prefer to do so on their own terms and when they choose.

Population segments

Six segments of New Zealand society were identified, each with a distinctive profile of attitudes and beliefs about science. The profiles of most of these segments showed similarities to those identified in previous research in the UK. The six New Zealand segments are:

- *Confident Science Believers* - the most highly educated and renumerated group, with a high level of intrinsic interest in science, and an appreciation of the benefits it brings to society. Their theoretical understanding of science is somewhat better than that of other segments. They are a gender-balanced group and comprise a quarter of the population.

- *Educated Cynics* - similar demographically to Confident Science Believers, but with a small male bias. They are likely to be in business roles, and nearly a quarter of the group have had formal science training. Despite this their theoretical understandings of science match the average. They show less interest in science and a lower level of expressed appreciation of the benefits of science and technology than other segments. They do not see a need for government control of science, nor do they see a strong need for scientists to have to justify and explain their research to the public.
- *Concerned Science Supporters* - are interested in and appreciate the benefits of science and technology, but are concerned about its consequences and consider it important that the government keep control on science. With average levels of education, their view of science is somewhat naïve. The group shows a small female bias.
- *Confused and Suspicious* - believe that science is out of control, and that the government needs to keep control. They do not have a strong appreciation of science's role in achieving economic success. They put faith in common sense, which can be a barrier to understanding the complexities of the scientific world. This group has a small female bias and lower levels of income.
- *Uninformed Individualists* - a younger segment, with a male bias. Students and those in semiskilled occupations predominate. Despite an interest in new technologies, their understanding of science is relatively unsophisticated. They are less likely to see a need for control over scientists, nor the need for scientists to be independent of business interests.
- *Left Behind* - older than the average, less well educated and with the lowest levels of Internet access. They do not understand the complexities of new science and technology areas, nor are they interested in learning about them. They strongly disagree with anything that interferes with nature, such as cloning. There is a strong female bias in this group and many are retired.

Understandings about science

Most New Zealanders hold strongly realist views of science. A significant proportion of the population appears to hold the view that 'seeing is believing' and they are not inclined to take scientific claims on trust. This can be an unhelpful attitude to bring to decision making about socio-scientific issues of concern, particularly as most people make 'common sense' judgements about the plausibility of scientific research. For many New Zealanders everyday/common sense judgements about science appear to be naively empiricist – they are likely to judge research as irrelevant or unconvincing if they do not understand the research methods and/or the meaning of evidence is not immediately apparent. In part, this appears to be related to the seeming invisibility of links between scientific theory and investigative methods. The 'invisibility' of the role of science theory in research methodology has also been reported in recent research literature elsewhere.

To the limited degree that this was investigated, many New Zealanders do appear to have gaps in their understandings of basic science theory in areas that underpin contemporary research and debate. When basic principles are misunderstood misleading views of the nature and significance of research can develop.

Risk and the regulation of scientific research

On the whole, people recognise that new developments in science and technology are important to New Zealand's economy. However some segments of the population show a high level of concern about the consequences of new developments in science and technology. This appears to be partly related to personal values positions, although more research is needed to clarify this.

Concern may be exacerbated by a conflation of science and business interests by those segments of the population who do not have direct contact with professional science. Across different segments, there appears to be a high level of awareness about past dishonesties in science internationally, particularly in relation to the reporting of health effects of smoking. Public relations approaches to socio-scientific issues are, accordingly, treated with circumspection or outright suspicion.

Older people appear more able to accept uncertainty and to appreciate that 'answers' may not be straightforward. This is probably related to their more extensive life experiences, and an appreciation of the complexities of heath related issues. Some New Zealanders see openness about uncertainty as evidence of honesty on the part of scientists. Pitched at an appropriate level of detail, an open accounting of areas of uncertainty and new questions would appear to be preferable to bland assurances of safety and/or predictability.

Concerns about the consequences of science are frequently balanced by a desire not to unduly hamper the advancement of knowledge likely to be of benefit. Health and environmental issues are both areas of high interest to many New Zealanders. A small majority see a role for the government in funding basic research, and there is a significant level of desire for government control over scientists, and accountability of scientists to the public.

Preferred information sources

Most people would prefer to have discretionary access to impartial science information, and they are discriminating of the sources they will trust. Professionals are trusted above all media sources. Politicians and lobby groups are the least trusted sources of information about science issues.

Information about science activities should be presented in clear straightforward language and should, where possible, communicate how issues will affect people in their daily lives. However science should not be misrepresented as 'common-sense'. It is important to introduce the relevant theoretical ideas at an appropriate level of simplicity. Research methods need thoughtful elucidation but there is a tension between the provision of validating detail and the necessity to retain interest and engagement of a non-science audience.

Visual images create powerful impressions and in some cases appear to be taken at face value. In instances where this could be an issue (for example where lobby groups provide deliberately misleading images) it would be helpful to provide information that raises awareness of various imaging techniques and explains how to 'read' the significance of their products.

All except the ‘left behind’ segment have 65 percent or greater access to the Internet and access is highest amongst the group with the most active interest in science. Although there is some suspicion about the trustworthiness of the Internet, better use could be made of this communication channel by those trusted to inform the public about science.

SECTION ONE: INTRODUCTION TO THE RESEARCH

BACKGROUND

Previous research related to New Zealanders' attitudes to science and technology has been used to inform *promotional* activities and strategies. In line with current thinking in the 'public understanding of science' research literature, the focus of this project has been on *communication*, and the goal of informing the development of 'two way dialogue of specialists and non-specialists' (OST/Wellcome Trust, 2001, p. 315). The Ministry of Research Science and Technology has sought a robust body of research to elucidate the challenges of developing such two way communication between scientists and members of the public who are interested and/or concerned about science research and associated technological developments.

This research was commissioned by the Ministry of Research Science and Technology from the New Zealand Council for Educational Research (NZCER), in association with ACNielsen Ltd.

RESEARCH OBJECTIVES

The research seeks to describe:

- what New Zealanders think about science in general;
- identifiable clusters in thoughts, feelings, and attitudes, and the significant factors that shape these;
- patterns of similarity/change in opinions with respect to previous similar surveys; and
- the role New Zealanders see themselves playing in the scientific process.

RESEARCHERS

Members of the research team are:

NZCER

Rosemary Hipkins, Senior Researcher: Project leader
Rachel Bolstad, Researcher: Qualitative project manager
Robyn Baker, Director: Literature review and critique
Cathy Wylie, Principal Researcher: Peer review

ACNielsen

Wendy Stockwell, Director, Research: Quantitative project leader
Sanchia Patchett, Research Executive: Project manager
Hugh Butcher, MIS Director: Multivariate analysis of quantitative data

STRUCTURE OF THE REPORT

The report is divided into six sections. Following the introduction to the research in section one, section two reports the quantitative research undertaken, and section three presents the cluster analysis of this data. Section four draws comparisons between the findings of this research and those of similar previous surveys carried out in New Zealand and in the United Kingdom. Following that, section five reports on the qualitative focus group research and section six provides overall implications of the findings, including recommendations for effective communication between scientists and the wider New Zealand public.

THE RESEARCH DESIGN

The research utilised a combination of qualitative and quantitative methods:

The Quantitative Component

A national telephone survey sought to establish broad patterns in understandings of, interest in, and feelings about scientific research and associated technological applications.

The Qualitative Component

The use of a reconvened focus group methodology engaged four small groups of the New Zealand public in discussion about a scientific issue that has been the focus of recent debate.

THE RELATIONSHIP BETWEEN THE RESEARCH COMPONENTS

The approach taken in this research has been informed by literature drawn from the wider ‘science for public understanding’ field. Such literature suggests strong links between attitudes and feelings towards science/scientists and beliefs about the nature of science. It is possible that beliefs about science may well relate to stereotypes or myths and may or may not align to aspects of science valued by scientists themselves. Thus, in the quantitative stage, the research sought to identify more general patterns of beliefs, and in the qualitative stage, to seek individual responses that could provide more fine-grained illumination of these broad patterns.

The research sought to compare patterns of beliefs about science with those that have been identified in previous similar studies. However, the data-gathering instruments were modified from similar instruments that have been used previously, in order to provide contemporary New Zealand contexts for the research.

Time constraints on the overall project meant that both parts of the research were carried out at the same time. Thus, while the research instruments were designed to complement each other, it was not possible to use actual findings from either one to inform and fine-tune the questions that shaped the other part of the research.

ANALYSIS OF THE OVERALL RESEARCH FINDINGS

The Telephone Survey

The extensive survey data were analysed using cross-tabulations, and factor analysis undertaken using a 'k means' cluster analysis method. Details are provided at the beginning of section three. This analysis identified six groups of respondents who hold broadly similar attitudinal patterns towards science and technology.

The Focus Group Data

Transcriptions of the focus group discussions, excerpts from diaries kept by participants, and individual written responses to some questions were searched for patterns that would deepen understanding of beliefs and attitudes towards science and technology held by a small diverse sample of the New Zealand public.

The Synthesis

To arrive at a shared understanding of interrelationships between the qualitative and quantitative components of the research, members of both participating companies (NZCER and ACNielsen) met regularly throughout the research process, including the final analysis and reporting stage.

Analysis of the focus group data began as the findings from the quantitative telephone survey were being shaped into a completed report. Thus, the more general findings from the survey research were available to inform the themes that emerged during the analysis of the focus group transcripts. However, these emergent themes were also able to inform the final stages of the analysis of the trends and patterns identified from the telephone survey research.

The extent of public mistrust of science became evident at a relatively early stage of the survey research, when coding decisions were made with respect to the open response questions. Since trust is an essential element of open communication, the more detailed and context-bound qualitative data was searched for deeper insights into the substance of the distrust of science and/or scientists. The synthesis of this analysis of the quantitative and qualitative components of the project is reported in section six. Some recommendations for more effective communication between science professionals and different groups of the New Zealand public are also outlined in section six of the report.

SECTION TWO: THE QUANTITATIVE RESEARCH

THE RESEARCH DESIGN

The telephone survey was conducted using ACNielsen's Wellington and Auckland-based CATI (Computer Assisted Telephone Interviewing) facilities. Fieldwork was conducted from 28 January to 25 February 2002 during evenings and weekends.

Sample

The total sample was 801 people. The sample was a fully national one, which was representative of New Zealand's main urban, secondary urban, and rural urban populations. To be eligible, people had to be 18 years and over. Where there was more than one eligible person per household, the 'next birthday' method was used to randomise respondent selection. Telecom's Electronic White Pages provided the sample frame.

Response Rates

- The response rate (based on interviews achieved versus number refused) was 29 percent.
- The response rate (based on total eligible numbers, including refused, no answer, engaged, people unavailable during survey period, language barriers etc.) was 15 percent.

Response rates for telephone surveys vary according to the survey topic and its intrinsic interest level, and according to the questionnaire length. The length of this questionnaire was relatively long for a telephone survey (average interview length was 18 minutes). The response rate achieved was an average one for a survey of this length.

Four call-backs were made to each household selected for interview to help boost response rates.

Questionnaire Development

The questionnaire was developed principally by the New Zealand Council for Educational Research, drawing on the UK Office of Science and Technology/Wellcome Trust's (2000) research report *Science and the Public: A Review of Science Communication and Public Attitudes to Science in Britain*, and the findings of relevant public understanding of science literature. A rationale for each question is provided at the start of the report of the findings for that question. The full questionnaire is included as appendix one.

Question Trialing

ACNielsen pre-tested several versions of the draft questionnaire in late 2001, to ensure that the attitudinal statements were easily understood, measuring something meaningful, and not biased in any way. A full pilot was conducted in mid-January 2002.

Notes to the Report

1. The level of sampling error on a yes/no question for a sample of 800 people is +/- 3.5 percent.

2. The report comments on differences between subgroups. While some of these differences are not statistically significant, they do highlight emerging trends.
3. Responses to some open-ended questions total more than 100 percent. Respondents could provide more than one reason for their answer.
4. '*' appearing in a table indicates a percentage of less than 0.5 percent.

Opinion Statement

ACNielsen certifies that the information contained in this report has been compiled in accordance with sound market research methods and principles. ACNielsen believes that this report represents a fair, accurate, and comprehensive analysis of the information collected, with all sampled information subject to normal statistical variance.

INTEREST IN AND BENEFITS ARISING FROM SCIENCE AND TECHNOLOGY

Introduction

Respondents were first asked about their level of interest in a range of topical scientific and technological areas and then asked to rate the level of benefit they consider each area has offered or is likely to offer to humanity.

These questions allowed correlation of people's interest in a given area with their perceptions of the benefits that science research in this area could bring. They also provided a context for respondents to consider later questions.

The statements within each of these questions were modified from those used in the OST/Wellcome Trust (2000) research to reflect New Zealand's research interests. A statement about space research was retained even though it is not a prominent professional science research area in New Zealand. This was done because of the widespread perception that this is one area with the potential to capture the public imagination and 'hook' people in to discussions about science and technology, and because a number of New Zealanders are known to be keen amateur astronomers.

Interest in Different Science Areas

As the chart on page 12 shows, different areas trigger different interest levels. Three broad groupings emerged, with greatest interest shown in areas that directly affect people's personal lives, or that are easy to relate to and understand.

People have the greatest level of interest in *new medical techniques and treatments* (82 percent interest), the area of science that directly affects their lives, and this is the science area they consider has the greatest benefit for their lives (93 percent beneficial).

People also claim a high level of interest in *saving endangered species* (81 percent interest), which may reflect the high level of media attention in New Zealand to saving native bird species such as kiwis, penguins, kakapo, etc.

A second tier of scientific and technology topics emerged, with between half and two-thirds of the sample claiming interest in each one. This group contained a mix of physical sciences, electronic technologies, and engineering sciences. It included improving the quality of agriculture and horticultural products (66 percent), genetic testing for human disorders (64 percent), computing and the Internet (63 percent), understanding earthquakes and making buildings safe (60 percent), new methods of transport (56 percent), and research into climate change (56 percent).

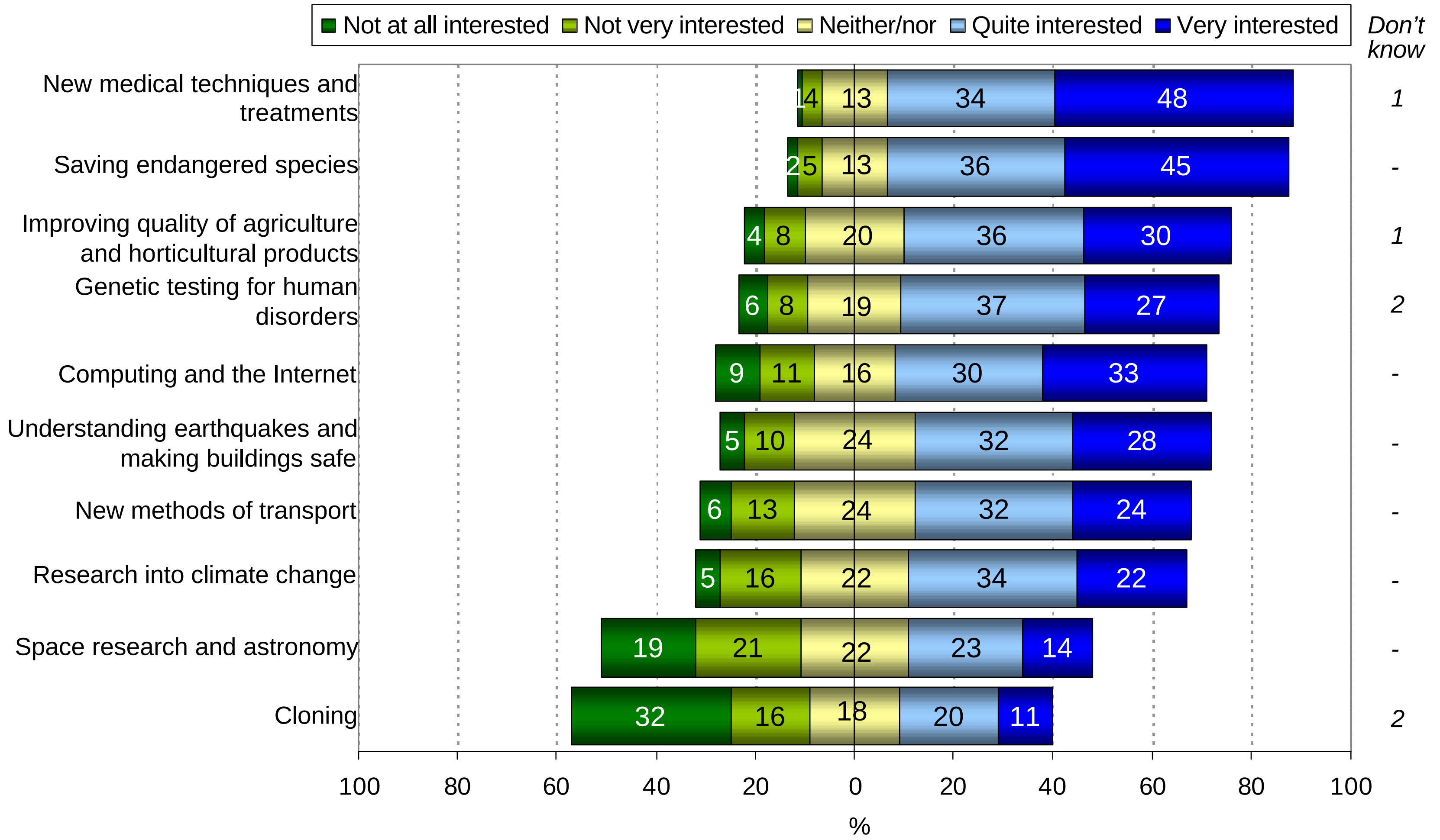
Despite the perception that it might provide a good 'hook', interest was much lower in space research and astronomy (37 percent). Interest in cloning was also significantly lower (31 percent). These are areas that are remote from people's daily lives and where there are perceived to be fewer societal benefits from such research: space research and astronomy (39 percent) and cloning (26 percent). Cloning is known from UK research to be ethically unacceptable to a large sector of society (Wellcome Trust 1998).

Subgroup Differences

Some general trends in interest levels emerge, along with trends specific to the type of science.

- Generally, people with formal training in science claimed greater interest in the topics than did those with no formal science training.
- People who said they try to keep up with new technologies claimed greater interest levels than those who do not make an effort.
- People who find science and technology too specialised to understand typically claimed lower levels of interest than others.
- Interest in science topics such as new transport methods was reasonably consistent across all demographics.
- Some areas appealed differently to men and women. Men showed greater interest in high technology areas such as space research (49 percent) than women (27 percent), while women showed greater interest than men in topics like genetic testing for medical disorders (70 percent compared with 60 percent), saving endangered species (86 percent compared with 74 percent), and new medical techniques (87 percent compared with 76 percent).
- Under-35-year-olds claimed very high interest in some new technologies: 48 percent interest in space research and astronomy, and 71 percent interest in computing and the Internet.
- Interest increased with age for science topics like genetic testing for disorders, and new medical techniques, improving the quality of agriculture and horticultural products, understanding earthquakes, and research into climate change. These age-related differences are likely to reflect the impact of life experiences on interests.
- Some ethnic differences were apparent, although these should be read with caution in view of the small Asian sub-samples. Asian respondents expressed greater than average levels of interest in new methods of transport, computing and the Internet, and cloning, and lower than average interest in saving endangered species and climate change. These differences may indicate values-based differences, but they are more likely to reflect age-related differences, as the Asian sub-sample had a younger than average age profile.

Level of Interest in Scientific and Technological Issues



Benefits of Science and Technology

Generally, the science and technology areas presented to respondents were thought to be beneficial to humanity, but there were broad groupings, with different levels of perceived benefit. These groupings are shown in the chart on the next page.

Not surprisingly, given their relevance to people's own health, new medical techniques and treatments were considered to be most beneficial (with 93 percent considering them so, and only a small minority seeing no benefit in these).

More than three in four people rated four diverse areas as beneficial. These included improving the quality of agriculture and horticultural products (80 percent beneficial), understanding earthquakes and making buildings safe (80 percent beneficial), saving endangered species (79 percent beneficial), and genetic testing for human disorders (73 percent beneficial).

About two-thirds of people rated research into climate change (68 percent), new methods of transport (66 percent beneficial), and computing and the Internet as beneficial (65 percent beneficial).

Two less accessible and/or acceptable areas of science were not considered particularly beneficial to humanity. While views were mixed about the benefits of space research and astronomy (39 percent beneficial versus 30 percent not beneficial), negative opinion about the benefits of cloning outweighed favourable opinion (50 percent not beneficial versus 26 percent beneficial).

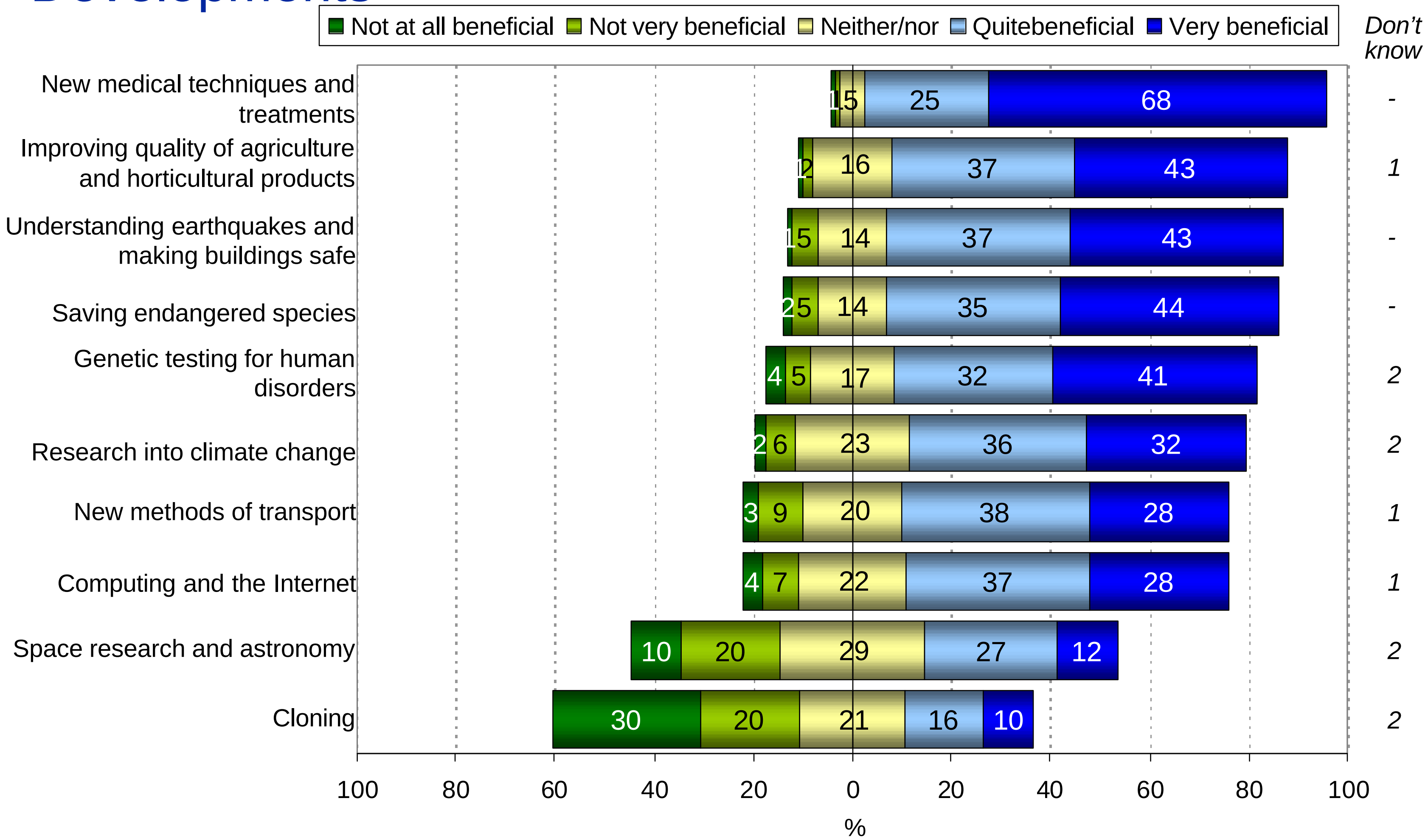
Subgroup Differences

Patterns of response were generally similar to those for levels of interest in science areas.

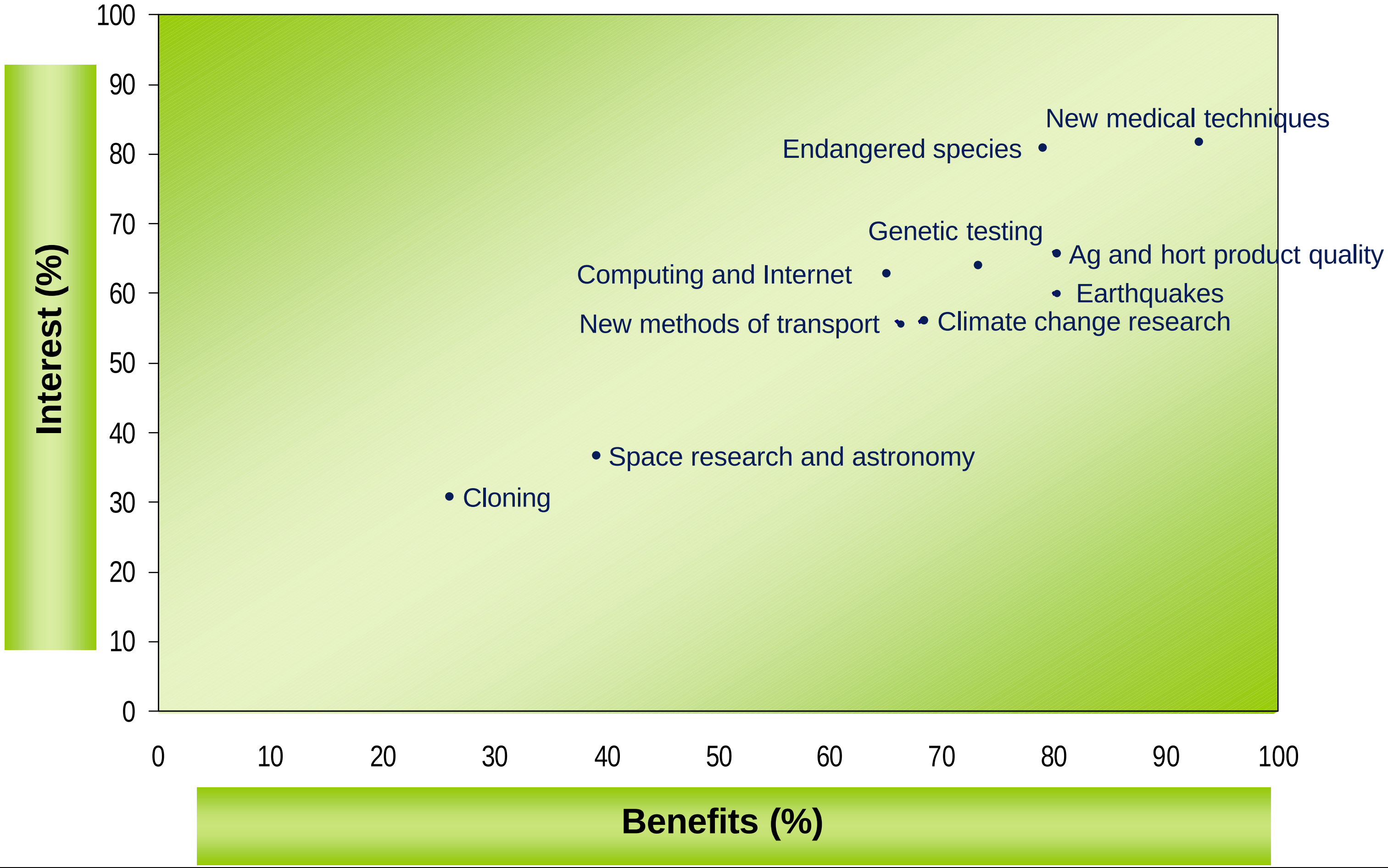
Relationship Between Interest and Benefits

The chart on page 15 plots the relationship between declared interest in and perceived benefits associated with the areas of science and technology. It shows that interest in an area of scientific research is strongly related to perceptions of benefits from that research. This pattern has also been found in research carried out in the UK (OST/Wellcome Trust 2000).

Benefits Associated with Scientific and Technological Developments



Relationship Between Benefits and Interest



INTEREST IN SCIENCE AND LEARNING

Introduction

Statements in this question aimed to find out about people's personal orientation towards and interest in science and technology and in learning generally.

The statements were shaped to potentially make links between the quantitative and qualitative aspects of this research project. They were designed to focus on two domains that have previously been identified as important in shaping personal responses to science-related issues (Alsop & Watts 1997). The two domains are:

conative: people's sense of how they could use their own knowledge, whether they trust their understanding of the issues; and

self esteem: each respondent's image of self as a successful and autonomous learner

Interest in Science Learning

As the chart on page 17 shows, people have a positive view both of the importance of learning new skills and knowing about science, and of their own interest in engaging with science:

- 90 percent consider it is important for them to keep on learning new skills;
- 66 percent acknowledge the importance of knowing about science in their daily lives;
- 73 percent say they enjoy finding out about new ideas in science; and
- 67 percent say they try to keep up with new technologies that could be useful in their daily life.

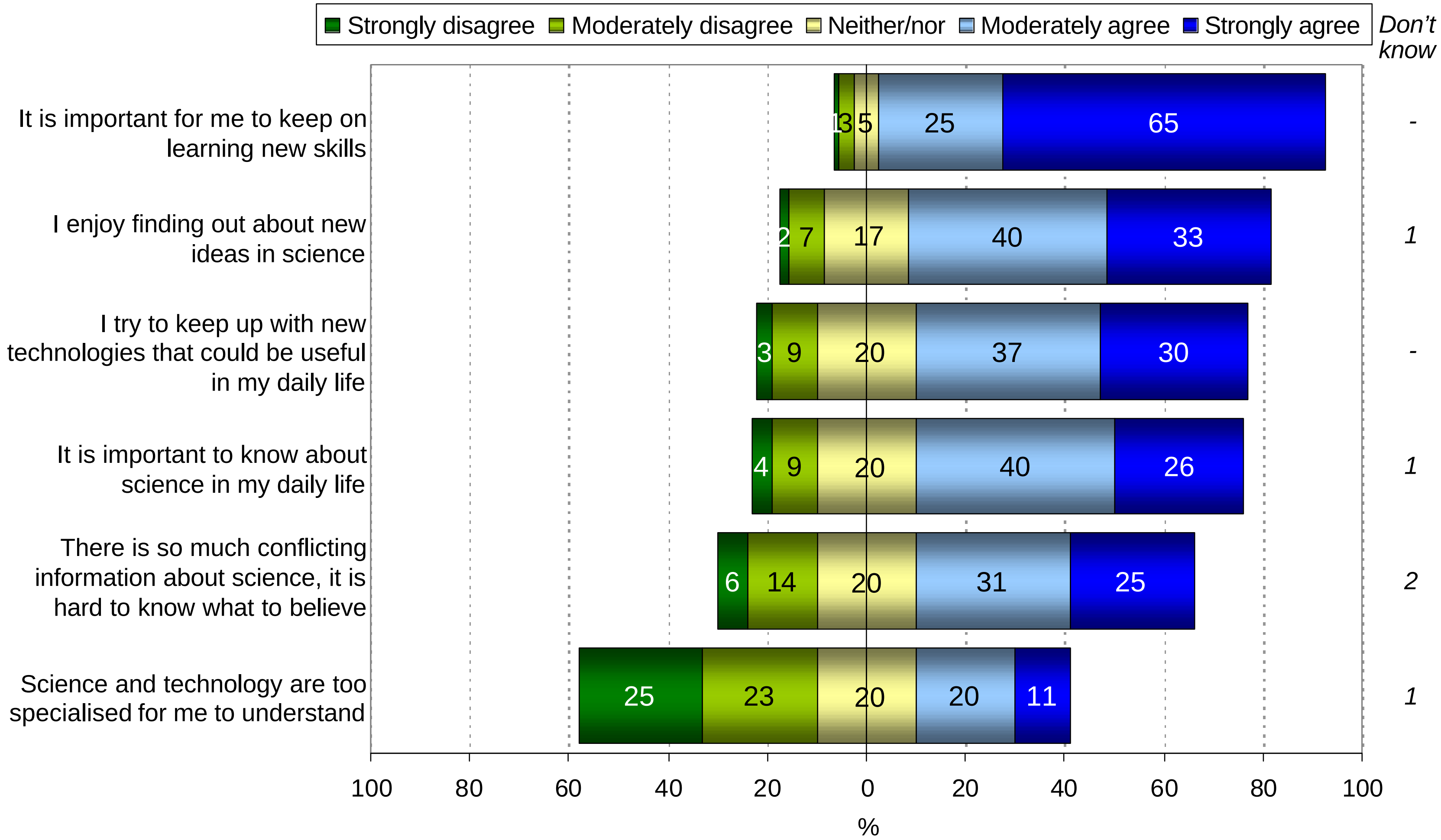
People tend to disagree that science and technology are too specialised for them to understand (48 percent disagree that this is so, while 31 percent agree). There is, however, reasonable agreement (56 percent agreement) that there is so much conflicting information about science that it is hard to know what to believe.

Subgroup Differences

Some demographic differences were apparent in the views expressed:

- The importance of learning new skills is widely appreciated across all demographics, but does decline among the over-65 age group.
- Those with formal science training attach greater importance to knowing about science in their daily lives (83 percent) than those without formal science training (61 percent).
- Enjoyment of finding out about new science ideas and keeping up with new technologies are both greater than average among men, those with formal science training, those with tertiary education (a wider subset than those with formal science training), and, related to this, those in professional and managerial roles. Enjoyment of finding out about new science ideas and the desire to keep up with new technologies are not age linked.
- Those who tend to find science and technology too specialised to understand and those who find it hard to know what to believe tend to be older people (over 55, but particularly over 65), female, those with no tertiary training, and those with no formal science training.

Interest in Science and Learning



Relationships Between Science and Technology, and the Economy

Introduction

Statements in this question assess perceptions of the role science and technology play in the economy. They also discuss attitudes towards the need for control over science. They combine questions drawn from the OST/Wellcome Trust (2000) survey with issues raised by New Zealand research on Genetic Modification (Harsant & Kalafatelis 2001).

Science and Technology, and the Economy

The contribution of science and technology for New Zealand is recognised both in economic and environmental terms. More than three in four agree that science and technology are important and have a role to play in preserving our New Zealand environment (82 percent agreement) and to enhance our international competitiveness (77 percent).

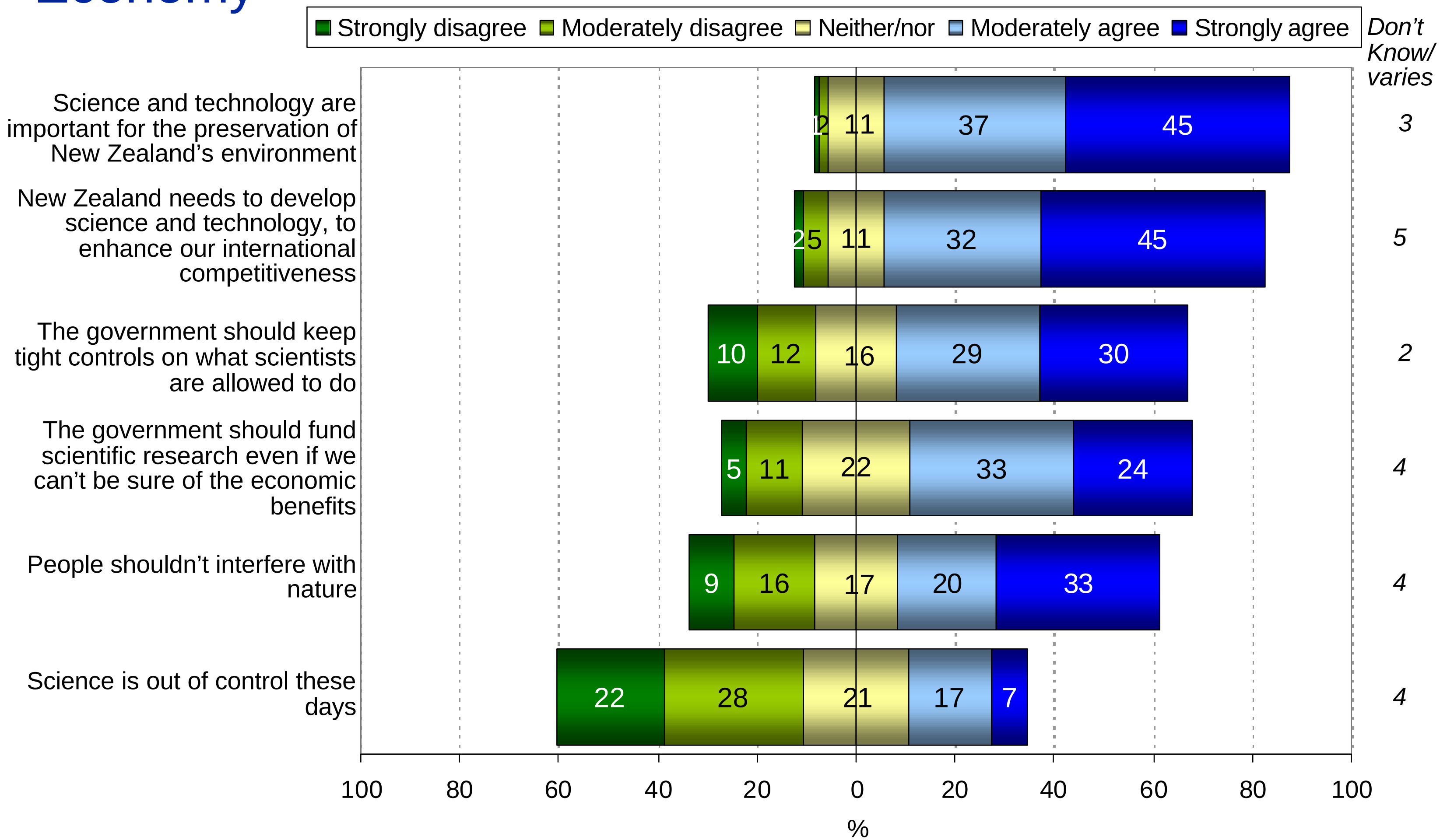
In line with these views, there is a perception that the government should fund scientific research even if we can't be sure of the economic benefits (57 percent agreement) with a relatively low rate of disagreement (16 percent). One in five people (22 percent) hold a neutral view.

It is encouraging to note that disagreement with the statement 'science is out of control these days' outweighs agreement by two to one (50 percent disagreement as opposed to 24 percent agreement), although one in five hold a neutral view (21 percent neither/nor). On the other hand, just over half of the respondents agreed with the view that 'people shouldn't interfere with nature' (53 percent), a finding that could be related to low levels of interest in, and perception of benefits of, cloning.

Despite the fact that science is not perceived to be out of control, clear views about the need for control in science emerged. A finding later in the survey is linked with this. Sixty-nine percent of respondents agree that scientists should have to explain and justify their research to people. More than half of those interviewed (59 percent) agree that the government should keep tight controls on what scientists are allowed to do, while 22 percent disagree.

Respondents were offered a 'varies/depends' option for each statement, which is shown combined with 'don't know' responses on the following chart. The percentage giving this response ranged from less than 0.5 percent to 2 percent for the statement that people shouldn't interfere with nature.

Relationships Between Science and Technology and the Economy



Subgroup Differences

- The contribution of science and technology to enhancing New Zealand's international competitiveness is more widely appreciated by those over 35 than by younger people, by people with higher levels of education, and those with formal science training. Recognition is higher among Europeans than among Pacific peoples and Maori.
- Views about the need for the government to fund scientific research even if there is uncertainty about its economic benefits are more strongly held among a similar demographic: people over 35, people with higher educational levels, those with science training, and those in professional and managerial roles.
- Agreement that science is out of control does not outweigh disagreement among any subgroups. However, agreement matches disagreement among Maori (33 percent agree, 34 percent disagree) The sub-group of Maori respondents who expressed no opinion either way (33 percent) matches the sizes of the groups with opposing points of view.
- Reflecting their cultural views, Maori and Pacific peoples hold more strongly to the view that people shouldn't interfere with nature (65 percent and 67 percent agreement respectively) compared with Europeans (50 percent). The view is also more widely held among people over 35 years (56 percent) than younger people (49 percent).
- Maori and Pacific people have greater than average levels of agreement with the statement that the government should keep tight controls on what scientists are allowed to do (64 percent and 70 percent respectively) compared with Europeans (57 percent).

Reasons for Attitudes Towards the Statement: 'The Government Should Keep Tight Controls on What Scientists are Allowed to do'

In total, 59 percent of those surveyed consider the government should keep tight control on scientific activities, while 22 percent disagree, and 16 percent hold a neutral view. Those who agreed or disagreed were asked an open question about the reasons for their point of view.

Those who believe in control have several motivations:

- Some fear scientists may be acting unethically and controls are needed to ensure their work and intentions are ethical.
- Others agree that the government has a right to monitor, as a representative of the New Zealand community.
- A significant group favours controls because they are opposed to a specific area of scientific research or a specific application (such as cloning, GM/GE, crop spraying, etc). Cloning was the area mainly mentioned which may reflect the mention of cloning in questions one and two.
- A fourth group favours controls to ensure a cautious approach, in the face of science and technology fields that are moving faster than our ability to develop appropriate protocols.

Those who do not favour government control argue this for three reasons:

- The major one is a distrust of government, and its involvement. There is also a belief that politicians don't have the skills and scientific understanding to make appropriate controls.
- Freedom is considered a key element in making progress.

- Controls are perceived to potentially stifle innovation.

A full list of reasons given follows in the tables below. The first table is interpreted as follows. Twenty eight percent of those who agreed with the statement (that the government should keep tight controls on what scientists are allowed to do) mentioned the need to keep scientists under control. In total, 21 percent of all those who were asked about their response to the statement talked of the need to keep scientists under control. There was an average of about 1.5 reasons per respondent (158 reasons given per 100 respondents).

Reasons for Considering the Government Should Keep Tight Controls on what Scientists are Allowed to do

	Agree With Statement	Total Open Responses
Base	**469**	**651**
	%	**%**
Scientists must be kept under control; may not be ethical	28	21
Government represents community; has right to monitor	23	18
Financial concerns: money could be spent unwisely	6	6
Science can be used for bad purposes	6	4
Need some controls/opposed to cloning	21	16
Concern about results/what can happen if things get out of control	20	15
Make safer progress with controls/ science moving too fast	11	9
Need controls on GM/GE	8	6
Need controls on scientific applications	7	8
Don’t mess with nature/play God	6	4
Need controls on spraying, etc	4	3
Need some controls; absolute power corrupts	3	3
Distrust government; government ignorant, stay out	3	16
Need freedom to pursue knowledge	6	11
Controls inhibit innovation	-	5
Need an independent control body, not government	2	4
All other	2	2
Don’t know	5	6
Total mentions (%)	161%	158%

Verbatim Responses: Belief in Control of Science and Technology

The following verbatim responses are included to provide an understanding of people's thought processes.

"Anything could happen that could be out of our control, and it could affect the world, and we wouldn't have a say."

"It's a good idea to make sure that the dollars that go into research should be monitored."

"They could be changing nature and cloning. If they change the genetic nature of something, it could change it and that would be bad."

"The government is representing the people and putting their point across in what's best for them."

"The whole thing with genetic engineering is that we are entitled to have a safe food chain, and I don't like the idea of scientists playing God."

"I think there should be restraints, but I think people who know about science should be on the deciding committees rather than politicians. People on the committee shouldn't have vested interests in the outcome of the research."

"Scientists will eventually make their ideas too big and think too wide. They'll destroy the planet. New Zealand shouldn't put too much effort into science stuff."

"Scientists have got to keep their research going, but there has to be some control by the government as far as cloning especially is concerned, and some sprays used and genetic engineering."

"Some of these loonies running round in white coats doing God knows what… They could be trying to breed three-headed sheep or something."

Reasons for Considering the Government Should NOT Keep Tight Controls on what Scientists are Allowed to do

	Disagree With Statement	Total Open Responses
Base	**174**	**651**
	%	**%**
Distrust government; government ignorant, stay out	51	16
Need freedom to pursue knowledge	22	11
Controls inhibit innovation	22	5
Need an independent control body, not government	8	4
Government should support science, not seek to control it	2	1
Financial concerns: money could be spent unwisely	6	6
Government represents community; has right to monitor	4	18
Scientists must be kept under control; may not be ethical	2	21
Need controls on scientific applications	7	8
Make safer progress with controls/ science moving too fast	4	9
Need some controls/opposed to cloning	3	16
Concern about results/what can happen if things get out of control	2	15
Need controls on GM/GE	2	6
Don't mess with nature/play God	1	4
Need controls on spraying, etc	1	3
Need some controls; absolute power corrupts	1	3
All other	3	2
Don't know	6	6
Total mentions (%)	147%	158%

Verbatim Responses: Oppose Control of Science and Technology

"If you keep too tight a control on science you inhibit innovation. You stop scientists being able to think laterally and outside the square. Control is more appropriate at the application stage than the research stage."

"Science should be free to reach whatever conclusions they reach, or you'll finish up with science only doing what politicians want."

"We need to keep on exploring things, to make sure we're going in the right direction. If we didn't try them out, we might still think the world is flat."

"Failed accountants and failed school teachers shouldn't be telling scientists what to do."

"I don't like control. If you are hurting animals, people, or the environment then put some form of control on it. But I'm not into being controlled, or having anyone having control on someone else."

"Politicians are voted in by lots of different people, whereas researchers have years of experience. It's separate from politics."

"We live in a free society where knowledge should be pursued."

BELIEFS ABOUT SCIENCE AND KNOWLEDGE BUILDING

Introduction

Statement design in this section was informed by research that reports likely *implicit* beliefs about science. In an analysis of 31 case studies Ryder (2001a) sought common patterns in the manner in which individuals were able to draw upon scientific information in relation to socio-scientific issues. As a result of this analysis, Ryder asserted that individuals engaged in debating and deciding about scientific issues need broad understandings in two interrelated areas of the nature of science – epistemology and sociology:

> Epistemology addresses the ways in which knowledge claims in science are developed and justified, e.g. assessing the quality of data, the relationship between phenomena and theory, and how conflicts of ideas are resolved in science (Ryder 2001a).

The statements in question five probe broad areas of belief about the *epistemological* aspects of science knowledge construction including:

- relationships between theory and investigation, including origins of predictions and the manner in which theory informs data interpretation; and
- awareness of error as an aspect of measuring that must be managed.

Science and Knowledge Building

The statement 'developments in science rely on scientists thinking outside the square' was a warm-up question. There is widespread recognition of the lateral thinking required for scientific development, with 76 percent of people agreeing that this is the case.

Some of the statements measure people's understanding of the complexity of science, data collection and interpretation, since past research has suggested that some people believe the interpretation of scientific data is straightforward if scientists have collected their data correctly. However, responses suggest that people have based their views on intuitive common sense, rather than an understanding of how scientific theory and evidence can be interrelated in different ways. Their views about the design and the origins of research questions are not as consistent as their views about issues of interpretation.

There is widespread disagreement that scientific predictions are mostly based on lucky guesses (57 percent disagree), indicating that people may have some understanding of the scientific process. However, less than half of those interviewed appreciate that new questions for investigation mostly come from previous scientific research (44 percent agree, 17 percent disagree, while 22 percent hold a neutral view and a relatively high 18 percent said they did not know). There is widespread disagreement (69 percent) that there is generally only one right way to investigate important scientific questions, while 10 percent agree with this statement.

People have a reasonable awareness of the challenges of gathering scientific data: 23 percent agree that, if they measure something really carefully, scientists will get exactly the same result each time, but nearly half (48 percent) disagree. There is moderate agreement that if scientists disagree about something, doing more experiments will help them get the right answer (62 percent agreement). This could indicate an awareness of the role of replication in research. On the other hand disagreement with this statement could indicate an appreciation that scientists who interpret the same data differently are bringing different theoretical models to bear on their thinking. Disagreement is higher among those who are tertiary educated; that is, people who might be expected to have been exposed to a range of theoretical models in their chosen subjects. Disagreement is not, however, higher among the more limited sub-group who have had formal science training.

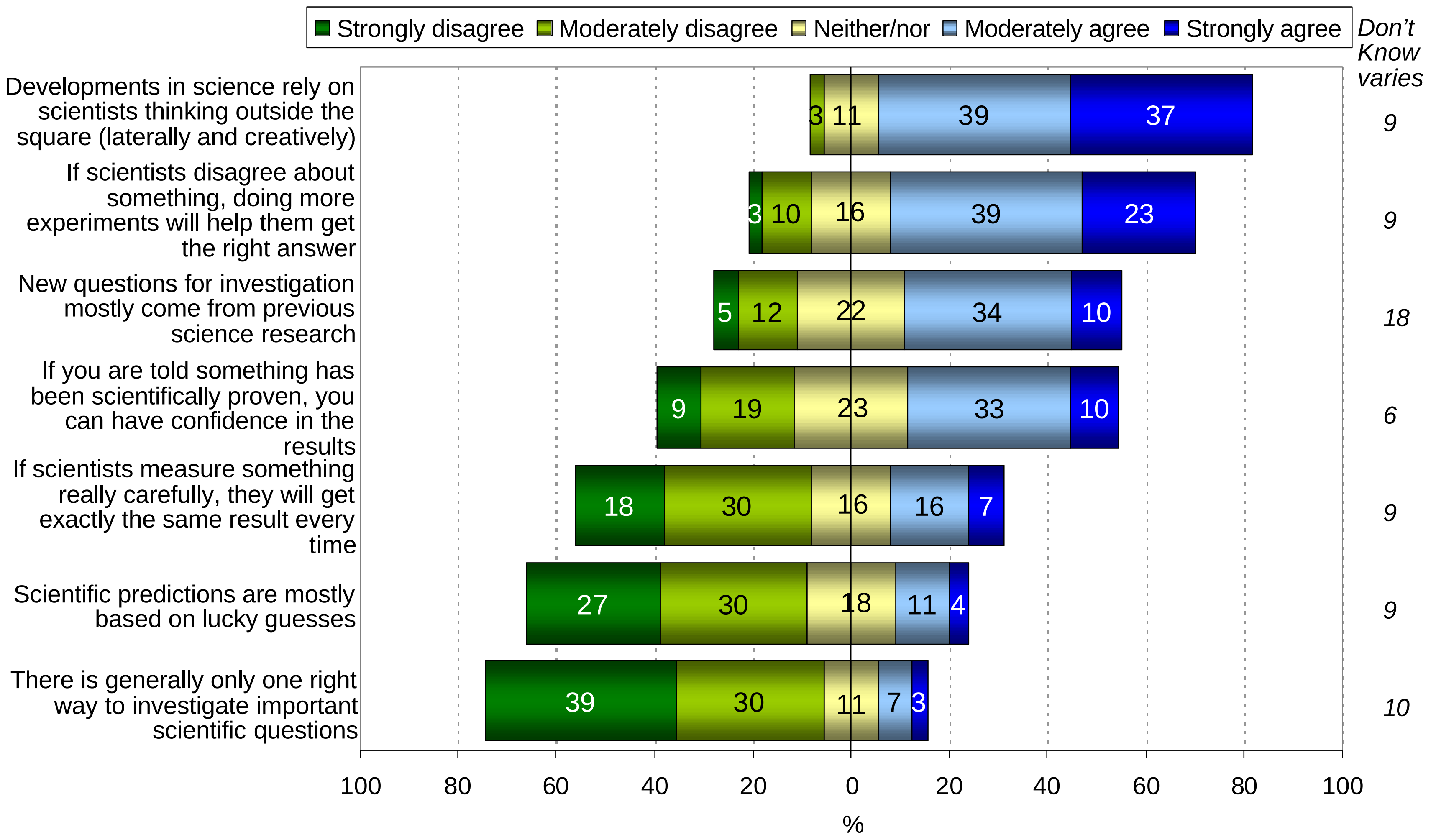
Together these responses do not suggest coherent patterns of thinking about the origins of questions for scientific research and their relationship to the body of available scientific knowledge. In view of the insights now available from the qualitative component of this research, it seems likely that these responses represent ‘common sense’ reactions to the statements provided. What seems to have been captured here are beliefs of the complexities and contingencies of everyday life rather than an understanding of the manner in which different scientific theories may lead to differing investigative approaches to the same question.

Media and advertising commonly make claims on the basis of their ‘scientific’ basis. One statement examined the extent to which people accept such scientific claims, without looking further to ask critical questions about the rigorousness of the scientific process and practices. Nearly half of those interviewed (43 percent) agree that they can have confidence in the results if they are told something has been scientifically proven, while only one in five (18 percent) disagree. Nearly a quarter (23 percent), however, hold a neutral view. Discussion of their reasons for levels of agreement or disagreement follows later in this section.

The following chart summarises levels of agreement for each of the science and knowledge building related statements.

Respondents were offered a ‘varies/depends’ option for each statement, which is shown combined with ‘don't know’ responses on the chart. The combined figures mainly comprise 'don't know' responses, as the percentage giving a ‘varies/depends’ response ranged from less than 0.5 percent to 2 percent for three statements. (These were: ‘if scientists disagree about something, doing more experiments will help them get the right answer’; ‘if scientists measure something really carefully, they will get exactly the same result every time’; and ‘if you are told something has been scientifically proven, you can have confidence in the results’).

Beliefs about Science and Knowledge Building



Subgroup Differences

Demographically based differences are less apparent in responses to this set of questions than to others, doubtless reflecting the problematic nature of some of the statements. However, there are indicators that people with a tertiary level education have a greater appreciation of the complexities of scientific data gathering and interpretations. For example, they are less likely than others to:

- consider scientific predictions are based on lucky guesses;
- believe that scientists who measure something really carefully will get exactly the same result every time;
- agree that there is generally one right way to investigate important scientific questions; and
- agree that they can have confidence in the results if told something has been scientifically proven.

Those who have specific formal science training tend to have a slightly greater appreciation of these complexities than those with no formal science training, but the differences are less marked than for the broader tertiary educated sub-group. This would suggest that the process of tertiary education of any type encourages complex understandings of the world.

Reasons for Attitudes Towards the Statement 'If you are told something is scientifically proven, you can have confidence in the results'

Just over two in five (43 percent) of respondents agreed that 'you can have confidence in the results if you are told something is scientifically proven', while one in five (18 percent) disagreed, and one in four (23 percent) hold a neutral view. All these people were asked the reasons for their views.

Those who feel they can have confidence tend to accept what they are told on *faith*: faith in the term 'scientifically proven', and a belief that appropriate scientific testing has taken place. To a lesser extent, they commented on having faith in scientists and their skills, and in science itself.

Five broad barriers emerged among those who do not feel they can have confidence in the results:

- a general distrust and cynicism, and need to see the scientific proof themselves;
- a belief that some aspects may have been overlooked in the process;
- the experience that scientific facts are subsequently proved to be wrong on occasion, as more sophisticated analyses are able to be carried out, or scientific theories change over time;
- science (and, by implication, scientists) can be used to mislead, to have a dishonest intent, particularly if scientists have vested interests; and
- on occasions, the application of the science has gone wrong.

Reasons for Confidence in ‘Scientifically Proven’ Results:

	Agree with Statement	Total Open Responses
Base	**340**	**587**
	%	**%**
Have faith in term. Assumption that testing has been done	47	28
Have faith in scientists. They know what they are doing	12	7
Depends on substantiation	7	8
Have faith in science. Take it on faith	6	3
General distrust. Have to see it myself	8	16
There may be overlooked aspects	6	9
Science can never be 100% proven	2	2
Science is often declared wrong later	5	10
Science can be used to mislead. Dishonesty	1	6
Recall times when application of science has gone wrong	1	5
Scientific views change	*	1
It’s advertising hype/ploy	2	4
Science/scientists may be biased/vested interests	1	4
Mistrust reporting	1	4
Disagree with specific scientific application	1	1
Respondent misunderstands scientific method	*	1
Other	4	4
Don’t know	6	5
Total mentions (%)	110%	120%

* means less than 0.5 percent

Verbatim Responses: Confidence in ‘Scientifically Proven’ Results

> *“One assumes things have been researched and tested and proven in good situations, to prove a theory.”*
>
> *“That’s the only way you prove anything – scientifically.”*
>
> *“We have to believe in our scientists in New Zealand. We have to have faith in them.”*
>
> *“Sometimes you have to take the evidence presented as being as close to truth as possible, while remaining sceptical.”*

"When you take medicine from the doctor, you don't question it."

"Depends who says it, and who employs the scientists who have done the research, whether it's independent research."

"The research would be done by people who are capable."

Reasons for NOT Having Confidence in 'Scientifically Proven' Results:

	Disagree with Statement	Total Open Responses
Base	**228**	**587**
	%	**%**
General distrust. Have to see it myself	28	16
There may be overlooked aspects	14	9
Scientists disagree among themselves	6	2
Science can never be 100% proven	3	2
Science is often declared wrong later	18	10
Science can be used to mislead. Dishonesty	13	6
Recall times when application of science has gone wrong	11	5
Scientific views change	1	1
It's advertising hype/ploy	7	4
Science/scientists may be biased/vested interests	7	4
Mistrust reporting	7	4
Depends on substantiation	7	8
Have faith in term. Assumption that testing has been done	*	28
Disagree with specific scientific application	1	1
Respondent misunderstands scientific method	1	1
Other	3	4
Don't know	4	5
Total mentions (%)	131%	120%

* means less than 0.5 percent

Verbatim Responses: Lack of Confidence in 'Scientifically Proven' Results

"It depends who's doing the research and what kind of stake they have in the results. If they can use it to support their product or theory, they may be biased."

"There's lots of variables in scientific research, and sometimes research can be forged."

"Just because it's scientifically proven, it may not have been proven in general. It may not have been proven all round."

"It's a common advertising claim, but it isn't always true. You need to look behind the claim."

"Science is far from infallible, and you don't believe everything you hear."

"You can't trust them. They keep telling us things are beneficial, and then in a few years we find they are not. In other words, scientists are liars."

"Science isn't really an exact thing, and scientists have been wrong in the past."

"In my lifetime, I've heard them make statements, and then they get totally contradicted."

SOCIOLOGICAL ASPECTS OF SCIENCE

Introduction

Question Six statements probe beliefs about scientists' motivations for research and attitudes towards risk and uncertainty in science, where *value judgments* are likely to frame responses to the issues raised:

> The sociology of science addresses the interactions between scientists, e.g. collaborations between globally networked science groups, and also how science professionals interact with those outside of science, e.g. scientists framing research questions in response to government priorities, or the impact of the communication of science findings on people's lifestyle decisions such as what to eat, or how to travel (Ryder 2001a).

Trust in Scientists and their Work

Three statements examined the issue of people's trust in scientists and their motivations for research.

People believe strongly that it is important for a community to have some scientists who are not linked to business interests (86 percent agreement) and/or to have some scientists who are not linked to government interests (83 percent), indicating a degree of recognition of the importance of independent thinking.

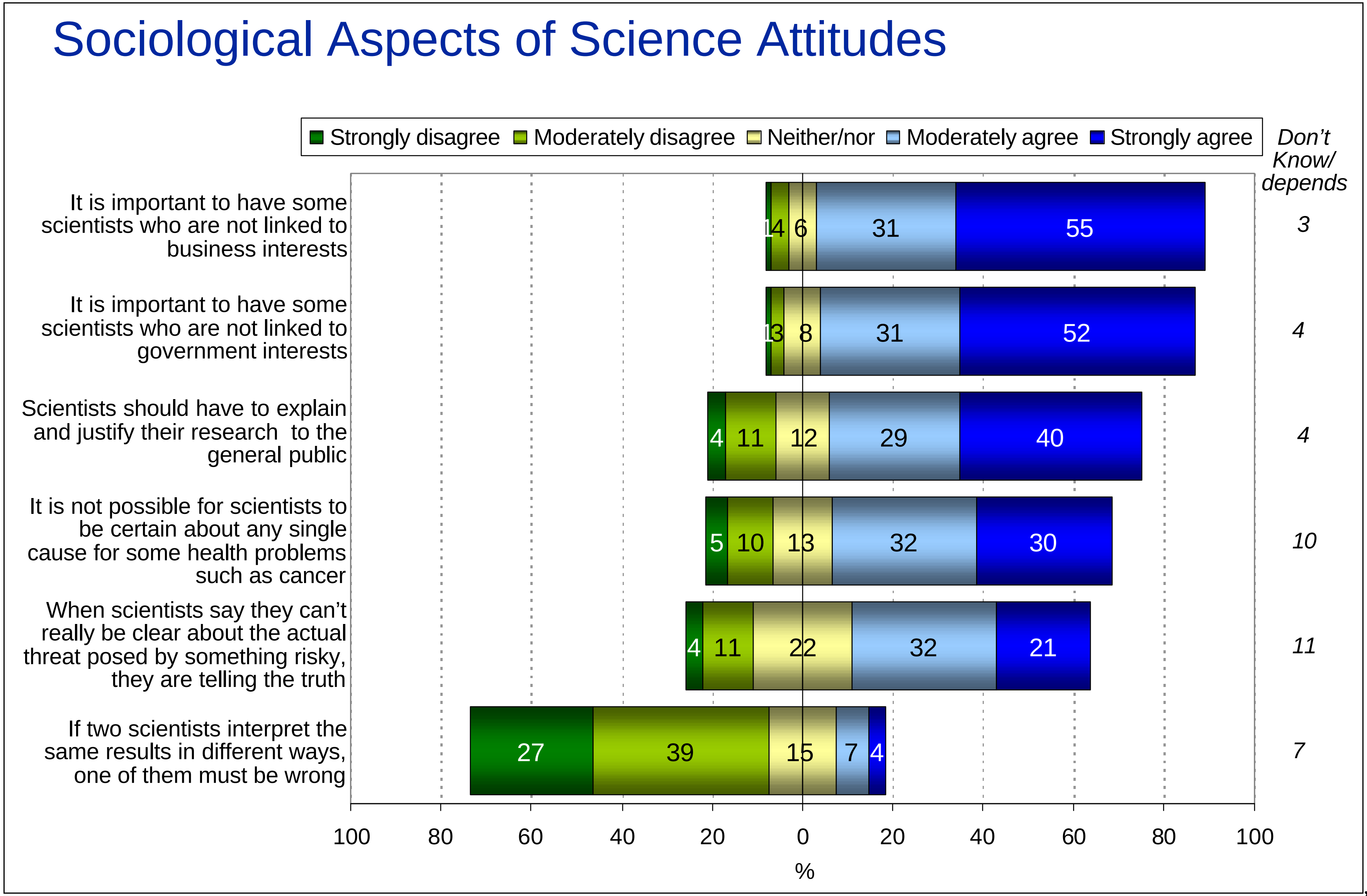
There is wide agreement (69 percent), that scientists should have to explain and justify their research to the general public; a key finding for scientists involved in research of public interest.

Agreement outweighs disagreement three to one that, when scientists say they can't really be clear about the actual threat posed by something risky, they are telling the truth (53 percent agree while 15 percent disagree). However, one in five (22 percent) hold a neutral view.

Responses to the other three statements in this section suggest that people may have some appreciation of the complex world of science: 66 percent disagree that, if two scientists interpret the same result in different ways, one of them must be wrong (11 percent agree); and 62 percent believe that it is not possible for scientists to be certain about a single cause for health problems such as cancer. As for the 'science and knowledge building' statements in question five, it is also possible that some of these responses actually represent common sense awareness of the contingencies and uncertainties of life in general.

The chart on the next page summarises views of the total sample.

Respondents were offered a 'varies/depends' option for each statement, which is shown combined with 'don't know' responses on the chart. The combined figure mainly comprises 'don't know' responses. The 'varies/depends' category accounted for between 0.5 percent and 2 percent of responses. For the statements: 'scientists should have to explain and justify their research to the general public'; and 'when scientists say they can't be really clear about the actual threat posed by something risky, they are telling the truth' 2 percent of the respondents said it would depend on the issue.


Sociological Aspects of Science Attitudes
Strongly disagree
Moderately disagree
Neither/nor
Moderately agree
Strongly agree
Don't Know/ depends
It is important to have some scientists who are not linked to business interests
1 4 6 31 55
3
It is important to have some scientists who are not linked to government interests
1 3 8 31 52
4
Scientists should have to explain and justify their research to the general public
4 11 12 29 40
4
It is not possible for scientists to be certain about any single cause for some health problems such as cancer
5 10 13 32 30
10
When scientists say they can't really be clear about the actual threat posed by something risky, they are telling the truth
4 11 22 32 21
11
If two scientists interpret the same results in different ways, one of them must be wrong
27 39 15 7 4
7
100 80 60 40 20 0 20 40 60 80 100
%

, with

Subgroup Differences

Older people generally gave higher levels of agreement for each of the statements in this section. Some of their responses are likely to be based on life experiences: for example, their wider agreement that it is not possible for scientists to be certain about any single cause for some health problems, such as cancer.

There are indications that younger people (under 35s) are more cynical of the motives of scientists than older people. For example, younger people are less inclined to agree that scientists are telling the truth when they say they can't be really clear about the actual threat posed by something risky.

Reasons for Attitudes to the Statement 'When scientists say they can't really be clear about the actual threat posed by something risky, they are telling the truth'

In total, 53 percent agreed with this statement, while 15 percent disagreed with it, and 22 percent held a neutral view. Those people with a view were asked their reasons for their views. Those who consider scientists are telling the truth in such situations commented that:

- they have faith in scientists;
- scientists may not know everything; and
- admitting uncertainty is evidence of honesty.

Those who disagree that scientists are telling the truth in such situations are inclined to believe that scientists are hedging their bets, or protecting their backs. A proportion believe that, in such cases, scientists may well be deliberately misrepresenting the truth and that hidden agendas may be involved.

While the 'unknowns' and complexities of science in areas where there may be risk are generally mentioned by those who are inclined to believe scientists are telling the truth, some who disagree also cite this reason. In this case, awareness of complexities appears to act to reinforce suspicions about honesty.

People on both sides perceive that the public good may be an issue. Those who consider scientists are telling the truth see a need for people to be told of potential problems even when these are not fully proven. Those holding the opposite view argued that scientists may downplay the dangers of a situation, for the public good.

Reasons for Agreeing that Scientists Tell the Truth About Risk

	Agree with Statement	Total Open Responses
Base	**423**	**556**
	%	**%**
I have faith in scientists/skilled people	28	22
Vagueness is possible/may not know much	22	19
Admitting uncertainty is evidence of honesty	12	9
There are many variables, complexities	9	8
No-one can be 100 percent sure	9	7
They are making people aware of potential problems	7	5
Faith in the regulatory system	2	2
Cynical response: they are hedging their bets, protecting their reputations	8	15
Deliberate misrepresentation. Hidden agendas	3	7
They may downplay dangers for public good	2	4
Seeing is believing. General distrust	2	3
Some scientists/scientific research is incompetent	1	1
Distrust linked to past events eg. Twin Towers	*	1
Depends on the source	*	2
Other	4	4
Don't know	9	10
Total mentions (%)	118%	119%

* means less than 0.5 percent

Verbatim Responses: Agreement that Scientists Tell the Truth About Risk

The following verbatim responses are included to provide an understanding of people's thought processes.

> *"When a scientist tells you everything's OK, you can't be sure, but when they say they're not sure, there is honesty in that."*
>
> *"If they are scientists, they should know what they are talking about."*
>
> *"I think they're being honest. I hope so… you think they're credible people."*
>
> *"They know more than I do. I can't argue with them."*
>
> *"I think scientists have exact methods and are generally an ethical bunch of people."*
>
> *"They will be telling the truth to the best of their knowledge. They may not know the true results, as they will be unable to test for it."*
>
> *"They wouldn't say it if they didn't believe it was true. They wouldn't jeopardise their experiments if they weren't sure of telling the truth."*

"It's the basis of science – how scientists and scientists work."

Reasons for Disagreeing that Scientists Tell the Truth About Risk

	Disagree with Statement	Total Open Responses
Base	**118**	**556**
	%	**%**
Vagueness is possible/may not know much	10	19
There are many variables, complexities	5	8
I have faith in scientists/skilled people	1	22
No-one can be 100 percent sure	1	7
They are making people aware of potential problems	1	5
Faith in the regulatory system	1	2
Cynical response: they are hedging their bets, protecting their reputations	42	15
Deliberate misrepresentation. Hidden agendas	19	7
They may downplay dangers for public good	9	4
Seeing is believing. General distrust	7	3
Some scientists/scientific research is incompetent	3	1
Distrust linked to past events eg. Twin Towers	3	1
Depends on the source	4	2
Other	5	4
Don't know	13	10
Total mentions (%)	123%	119%

Verbatim Responses: Disagreement that Scientists Tell the Truth About Risk

The following verbatim responses are included to provide an understanding of people's thought processes.

"They always hide something."

"Most people don't know for sure that what they really believe is true, anyway."

"I don't believe they are all telling the truth all the time. Some have a political or other agenda that they don't tell us about. I live in the real world. I don't believe everyone tells the truth."

"Sometimes it depends who's paying, who controls the outcome….you run into government classifications, that is the Secrets Act. Whoever pays the money sometimes, calls the tune. Scientists might want to release something which is not in the public interest, but the big business says no."

"They can't always predict the outcome of a particular science breakthrough."

"There are so many variables, and science is a learning experience in itself. They can't know for certain what is going to happen in the future."

"You never seem to get two scientists who agree."

"A lot of science is not conclusive. It's inherently uncertain."

"No one can predict anything. You can't predict earthquakes, or the weather. Sometimes you don't know how things are going to react. No one is infallible."

"If they say they don't know, they won't be able to continue with their work."

UNDERSTANDING OF SCIENCE IN THE REAL WORLD

Introduction

The first three statements in this section probe participants' ideas in relation to some aspects of formal science thinking. It is almost impossible to frame such questions without assuming a 'deficit' view of the science understandings of at least some participants (see section six). However, actual science understandings could be one important aspect of a cluster analysis and we felt it was important to include this component. It has been placed near the end of the survey because some participants in the trial stages reported that they felt their knowledge was inadequate to answer these questions satisfactorily and we did not want such feelings to influence the manner in which other questions were answered.

The first two statements in this question attempt to differentiate between those who hold strongly realist views of scientific entities and those who differentiate theoretical entities from actual objects. The third statement relates to a common misconception about a widely discussed science entity (*New Scientist*, 29/7/2001). The final question is again partly sociological and checks awareness of the *consensual* nature of validation of new scientific theory.

Science in the Real World

A key point to note is the high level of 'don't know' responses to these questions – particularly for the question about genes, and the ability to see atoms.

One in three people do not know whether all tomatoes contain genes, regardless of whether they are genetically modified or not. Among those able to express a view, the majority view is that all tomatoes do contain genes. This contrasts with recent research in Europe (*New Scientist*, 29/7/2001) that suggested there is a common misunderstanding that only genetically modified organisms contain genes. The New Zealand result indicates a reasonably sophisticated understanding that every cell of every living thing does in fact contain genes. Understanding is greater than average among those with formal science training (70 percent agreement) and the wider sub-group of those with a tertiary education (69 percent).

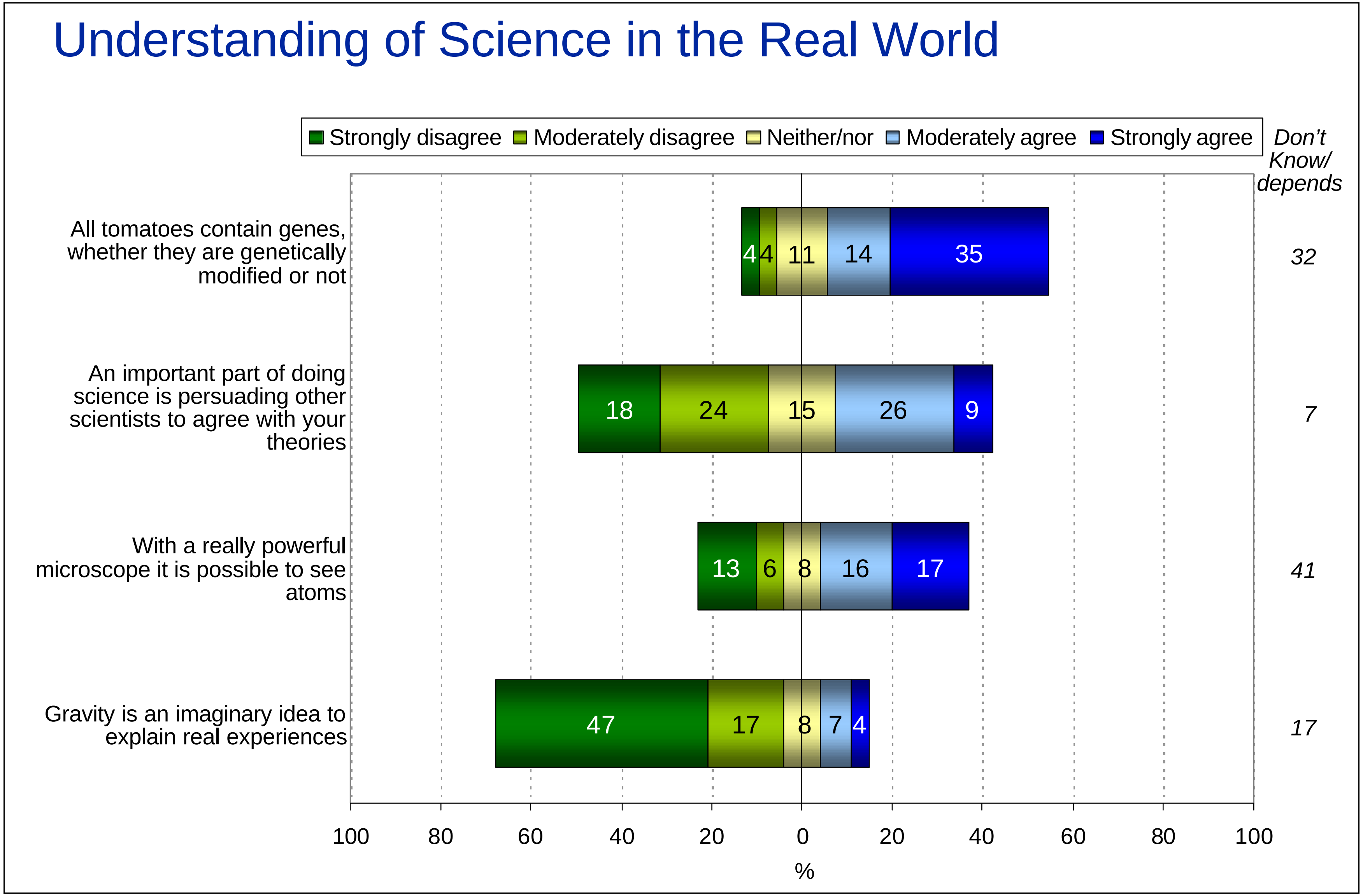
Views as to whether atoms can be seen with a really powerful microscope are mixed: 23 percent agree while 19 percent disagree, but 41 percent do not know. People without any formal science training and those with no tertiary education are more likely to believe that atoms can be seen. Only 11 percent of people agree that gravity is an imaginary idea to explain real experiences, while 64 percent disagree that this is the case. (These views are consistent across most demographics.)

Theoretical scientists recognise atoms and gravity as models that can be represented in different ways to theorise and reflect on different real experimental effects. Responses to the questions about the ability to see atoms with a really powerful microscope and whether or not gravity is an 'imaginary' idea suggest that a significant proportion of people do not hold this view but rather they believe that scientific entities are real 'things'. However, the use of the word 'imaginary' could have prompted interpretations other than those that were intended. Although this was done in an attempt to make the question less abstract, the meaning would have been clearer had the word 'theoretical' been used instead.

Past research has suggested that a mistrust of science may be linked with a view of the scientist as a lone maverick, working without regard to what anyone else thinks. Findings from this study tend to confirm such findings. While 35 percent agree that an important part of science is persuading other scientists to agree with their theories, 42 percent disagree that this is the case. It is interesting that answers are not affected by whether or not people have formal science training. Again, should these questions be used in future studies, we suggest the word “persuade” is changed for a word such as “convincing” that has overtones of rational argument rather than the more emotionally ‘loaded’ processes that can accompany ‘persuasion’.

The following chart identifies the proportion agreeing and disagreeing with each statement.

Respondents were offered a ‘varies/depends’ option for each statement, which is shown combined with ‘don't know’ responses on the chart. The combined figure mainly comprises ‘don't know’ responses, with the ‘varies/depends’ category accounting for between 0.5 percent and one percent of all responses.


Understanding of Science in the Real World
Strongly disagree
Moderately disagree
Neither/nor
Moderately agree
Strongly agree
Don't Know/ depends
All tomatoes contain genes, whether they are genetically modified or not
4
4
11
14
35
32
An important part of doing science is persuading other scientists to agree with your theories
18
24
15
26
9
7
With a really powerful microscope it is possible to see atoms
13
6
8
16
17
41
Gravity is an imaginary idea to explain real experiences
47
17
8
7
4
17
100 80 60 40 20 0 20 40 60 80 100
%

Information and Trust in Relation to a Specific Issue

Introduction

The questions in this section look at the types of things people want to know about a science-related issue that may potentially affect them, their willingness to engage with the issues, and the nature of the actions they would take if they were to do something about it. They also probe trust in various information sources, using the context of a 'health-related issue of personal concern'. Some of the information sources listed were reported on in the context of GM by Harsant & Kalafatelis (2001), enabling some comparisons to be made.

Types of Information People Want to Know

Respondents were asked what types of things they would want to know about an issue, if they were concerned it could possibly affect their health. Health was used to provide a context for the question as previous studies have shown that health is an area involving science, of concern to the vast majority of people.

Nine in ten people made at least one comment about what they would want to know. The average number of comments per respondent was two. The main information sought relates to the issue's immediate impact on them: how it could be treated or managed, and how to recognise it, etc. One in four people expressed interest in wider information, relating to the issue's cause, and one in seven (14 percent) said they would want to know about research that has been done, with further comment about the reliability and/or sources of information about the issue, enabling them to judge its relative merits. Interest in accessing such information was most common among the 35 to 54 age group, and those with formal science training.

The following table lists the types of information people wanted to know.

What Types of Things Would you Want to Know About a Health Issue?

Base	**801**
	%
How it could affect you/your health	40
How you can treat it/what you can do about it	34
Everything. As much as possible	23
How it spreads. How you can catch it	13
Symptoms. How to recognise it	13
Whether safe/how dangerous	7
How to prevent it	2
What causes it. Why it has happened	24
What research has been done/methods used	14
Sources of information	7
Facts, without bias	7
How reliable the information is about it	3
Who funded the research	*
Depends on the issue	6
Other	1
Nothing/don't know	11
Total mentions (%)	205%

Likely Action Over an Issue that Could Affect Health

When asked what they would do if they were concerned about an issue that could affect the health of many people in their community, three in ten people said they personally would wait and see, do nothing, or not know what to do. People under 35 years were generally less likely than older people to know what they might do about the issue.

Three levels of action were suggested by the remaining seven in ten:

- finding out more about it (35 percent);
- a second level of action was discussion and talking – to officials such as local parliamentarians, a local Health Board or the Ministry of Health, or other health professionals; and
- a smaller proportion (about one in four) would take a more active role – joining a lobby group, protesting, writing letters etc. Such actions were more commonly mentioned by people aged 35 years and over.

A full list of actions mentioned follows.

Likely Actions About a Health Issue that Could Affect Lots of People in the Community

Base	**801**
	%
Find out more about it	35
Speak up about it. Discuss it. Make it widely known	19
Talk to parliamentarian	11
Talk to local Health Board/Ministry of Health	10
Talk to other health professionals	8
Join a group/lobby/protest	12
Sign petition/write letters	7
Go to meetings	5
Do what I could to help	4
Other	8
Wait and see	4
Nothing	8
Don't know	17
Total mentions (%)	148%

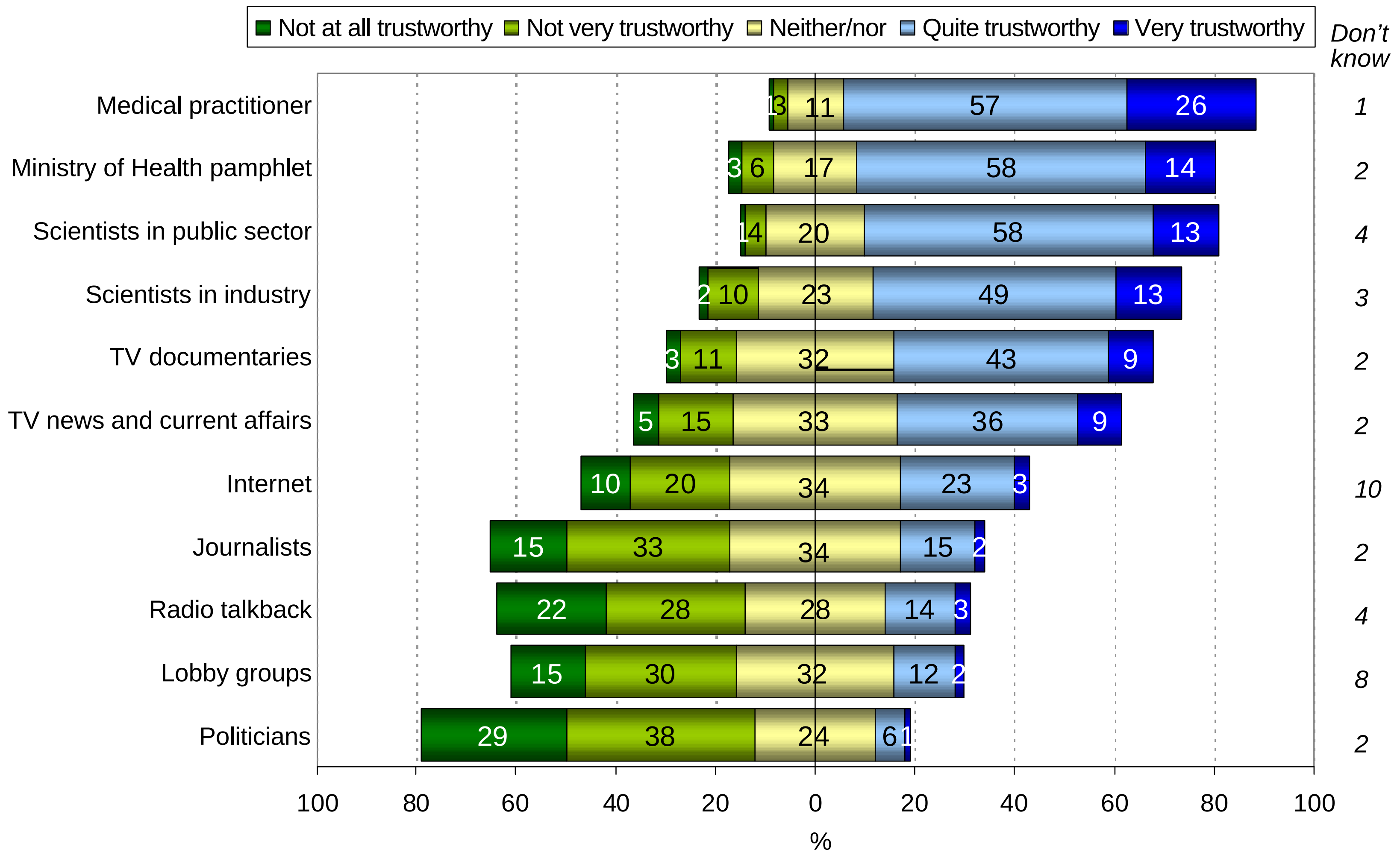
Trustworthiness of Various Information Sources

Respondents were asked how trustworthy they would find information about the issue, from eleven different sources. Given that the topic had a health context, it is not surprising that medical practitioners were rated as the most trustworthy sources (83 percent trustworthy), and Ministry of Health pamphlets rated as the second most trustworthy source (72 percent trustworthy).

Scientists (either in the public sector or in industry) were the only other sources considered trustworthy by more than six in ten people; public sector scientists more so than scientists in industry (71 percent and 62 percent respectively). Television ranked as the fifth most trustworthy source overall, with 52 percent considering television documentaries a trustworthy source, and 45 percent considering television news and current affairs programmes a trustworthy source.

A group of sources where people might be expected to express vested interests were all rated as less worthy of trust. These included journalists (48 percent distrust), radio talkback (50 percent distrust), lobby groups (45 percent distrust), politicians (67 percent distrust) and the Internet (30 percent distrust). With high levels of 'neither/nor' responses, all of this group except the Internet were rated as trustworthy by less than 20 percent of respondents, and less than 10 percent in the case of politicians. Perhaps reflecting the limited access of some demographic groups, 10 percent of respondents said they did not know if the Internet was trustworthy. This was a high 'don't know' response for the sources listed in this question, although lobby groups attracted an 8 percent 'don't know' response. The following chart compares trustworthiness ratings for the different sources.

Comparative Trustworthiness



Subgroup Differences

Generally, people aged under 45 tended to rate each source as more trustworthy than did people aged 45 and over. The 45 to 54-year age group was the less trusting age group, about any source.

Maori and Pacific peoples also tended to give higher trustworthy ratings than did Europeans.

SECTION THREE: SEGMENTING THE GENERAL PUBLIC ON THEIR ATTITUDES TO SCIENCE

To better understand the linkages between the public's attitudes to science, a factor analysis was undertaken, followed by a segmentation based on the key factors identified. Factor analysis attempts to identify underlying variables, or factors, that explain the patterns of correlations within an observed set of variables.

There are 29 attitude statements included in questions three to six. A set of seven factors that explained 47 percent of the variance in the original data were identified from these 29 attitudes statements. Each factor is uncorrelated with all of the other factors.

The factors extracted (in order of explanation of variance) were:

1. Interest in science, technology, and learning new skills
2. Need to keep controls on science
3. Benefits of science for New Zealand
4. Science is consistent, repeatable
5. Need for independent scientists
6. Scepticism about science findings and methods
7. Honesty of scientists

A score for each factor was calculated for every respondent in the survey. The set of scores was run through a 'k-means' cluster analysis routine. The objective was to identify groups whose members are as similar as possible to other members in that group, but as different as possible from members of other groups, based on the seven attitudes towards science-based factors identified. Two other criteria applied in the construction of the groups were that the number of groups was kept at a reasonably small number, and that the size of the groups was fairly constant. Both of those considerations are based on practical requirements. A very large number of groups tends to confuse rather than enlighten, and groups based on a small proportion of the population are of theoretical rather than practical interest. With these considerations in mind a total of six groups were identified.

The six segments derived and their sizes are as follows:

	Unweighted %
1 Confident Science Believers	25
2 Concerned Science Supporters	18
3 Educated Cynics	16
4 Confused and Suspicious	14
5 Uninformed Individualists	14
6 Left Behind.	13

A brief discussion of the profiles for each segment follows.

SEGMENT 1: CONFIDENT SCIENCE BELIEVERS

This segment is the largest segment, representing 25 percent of those surveyed. It is the most highly educated group, and has the highest level of science training. This segment has a high level of intrinsic interest in science, and appreciates the benefits it brings to society and its importance to economic and environmental well-being. Theoretical understanding of science in the real world is somewhat better than that of other segments, although members of this segment are inclined to realist views.

Because of their formal education, however, members of this segment can engage with science thinking, and they have more experience to bring to their personal judgments; hence their realist views are not a barrier to the same extent that they may be for other segments.

Demographics

This segment is balanced in terms of gender, and it has the largest population of 35 to 44-year-olds of any segment (28 percent). The group has a higher incidence of tertiary qualifications than any other segment (44 percent) and also of formal science qualifications (33 percent). Not surprisingly, the segment has an occupational bias toward professional occupations (including teaching, nursing etc). It has the highest personal income profile (28 percent are on personal incomes exceeding $50,000).

Access to the Internet is greatest among this segment (84 percent).

Interest in Science

Compared with other segments, Confident Science Believers are interested in most science and technology topics, and they have the greatest appreciation of the benefits associated with each of these. Most of them (87 percent) can see the benefits of research into earthquakes and making buildings safe. Half of them (51 percent) appreciate the benefits offered by space research, compared to an average of 39 percent. This suggests that the Confident Science Believers are likely to look beyond their own interests to wider questions about science and technology.

Interest in Science and Learning

Reflecting their educational and science backgrounds, Confident Science Believers strongly enjoy finding out about new ideas in science (93 percent). They make an effort to keep up with new technologies that could be useful in daily life (89 percent), and they are most likely to consider that it is important to know about science (85 percent). Generally, they place strong value on keeping on learning new skills (99 percent).

Science and the Economy and Control

Confident Science Believers demonstrate the strongest appreciation of the contribution of science to achieving international competitive advantage (88 percent) and preserving New Zealand’s environment (93 percent). They believe that the government should fund scientific research even if unsure of the economic benefits (75 percent). They are least likely to agree that science is out of control (8 percent), and to believe that the government should keep tight controls on science (49 percent). This attitude is motivated by a belief that scientists need freedom to pursue knowledge and make progress.

Science and Knowledge Building

Confident Science Believers have a reasonable appreciation of how scientists build their science knowledge, recognising the role of lateral thinking in science developments. They are most inclined to think that doing more experiments will produce the right answer (70 percent). Reflecting their scientific backgrounds, they have the greatest level of agreement with the statement that, if told something has been scientifically proven, they can have confidence in the results (59 percent). But their confidence is dependent on the level of substantiation provided.

Sociological Issues

Of all the segments, this group is most likely to believe that it is important that some scientists in the community are not linked to government or to business interests. They believe generally in the honesty of scientists, agreeing that scientists are telling the truth when they say they are not clear about the actual threats posed by something risky (70 percent). Of all the segments, they give scientists the highest trustworthiness ratings as a source of information (83 percent for public sector scientists and 69 percent for industry-based scientists). They also consider government institutions to be highly trustworthy.

Science in the Real World

Confident Science Believers show the greatest theoretical understanding of science in some areas, although there are gaps in their understanding. Two in three (65 percent) agree that all tomatoes contain genes. They are least likely to regard gravity as an imaginary idea to explain real experiences (8 percent) but this response may be related to the wording of the statement.

SEGMENT 2: CONCERNED SCIENCE SUPPORTERS

Concerned Science Supporters are the second largest segment, accounting for 18 percent of the sample. They are people whose view of science is somewhat naïve, although they are interested in and appreciate the benefits of science and technology. They consider it important that the government keep control on science, and they have a limited understanding of how scientific knowledge is built.

Demographic

This group has a slight female bias (54 percent), and they are weighted towards the 35 to 54 age group. Their education levels match the average, as does the incidence of formal science training. Reflecting their age, this group has a higher than average incidence of managerial occupations (17 percent). This segment has a relatively high proportion of Maori (16 percent).

Interest in Science and Technology

Concerned Science Supporters show a greater than average interest in new technologies: space research, transport, and computing and the Internet. Their perceptions of the benefits of science and technology match the average, with greater than average appreciation of the benefits of computing and the Internet.

Interest in Science and Learning

Concerned Science Supporters identify with the need to keep up with new technologies of use in their daily lives (76 percent), and they attach great importance to keeping on learning new skills (97 percent).

Science and the Economy and Control

Like those in other segments, this group has a strong belief in the importance of science and technology in maintaining international competitiveness and preserving the environment (82 percent and 87 percent respectively).

They share with Confident Science Believers a strong sense of the importance of government funding scientific research even if unsure of the economical benefits (64 percent). But, unlike Confident Science Believers, this segment believes strongly in the need for government to keep tight controls on science (77 percent). Just under a third (30 percent) consider science is out of control, and this segment is more inclined than most others to this view.

Science and Knowledge Building

Concerned Science Supporters, like others, recognise that developments in science come from lateral thinking (76 percent). However, some of their other views about knowledge building differ substantially from the average and show a naïve view. A third (32 percent) think that scientific predictions are based on lucky guesses, and only a third agree that new questions in science come from previous science. A third believe that, by measuring carefully, scientists will get the same result every time.

This segment is less confident than most others about the results if something is scientifically proven, because key points may be overlooked, or because the science can be proven wrong later.

Sociological Aspects

Concerned Science Supporters show some naivety in their views of the interpretation of science. One in four agree that, if scientists interpret the same data in different ways, one must be wrong. At the same time however, this segment generally agrees (68 percent) that it is not possible to be certain about the causes of health problems such as cancer.

Reflecting their belief that the government should keep tight controls on science, people in this segment generally agree (74 percent) that scientists should have to explain and justify their work to the public.

One of the key distinguishing characteristics of Concerned Science Supporters is their disagreement that scientists are telling the truth when they say they are not clear about the actual threat posed by something risky (only 7 percent agree, compared with 53 percent average agreement). This segment tends to believe scientists are hedging their bets, or protecting their reputations, and they are also concerned about hidden agendas.

Science in the Real World

This segment does not have a good theoretically based understanding of science, with 41 percent agreeing that it is possible to see atoms with a high powered microscope, for example.

Trustworthiness of Information Sources

Despite their feeling that scientists may not be telling the truth, Concerned Science Supporters' trustworthiness ratings for scientists are only slightly lower than average.

SEGMENT 3: EDUCATED CYNICS

The Educated Cynics account for 16 percent of the sample. This segment is similar demographically in many ways to the Confident Science Believers. What differentiates them from the first segment is less interest in science, less appreciation of its benefits, and less enjoyment in finding out about science. The Educated Cynics do not see a need for government control of science, nor do they see a strong need for scientists to have to justify and explain their research to the public.

Demographics

The Educated Cynics have a slight male bias (53 percent), and in age terms this group is slightly underrepresented in both the under-35 and over-55 age groups. Like Confident Science Believers, this group has a greater than average incidence of tertiary education (31 percent) and of formal science training (23 percent). Reflecting their education, people in this group are likely to be in business and managerial occupations, and to have higher than average incomes. They have a high level of Internet access (75 percent).

Interest in Science

The Educated Cynics have a slightly lower than average level of interest in all science and technology areas, with the lowest level of interest in environmental sciences (75 percent for saving endangered species and 46 percent for climate change). They tend not to rate the benefits of science and technology as highly as other segments, with the exception of new methods of transport (67 percent beneficial). Like Confident Science Believers however, they are more inclined than other segments to identify benefits from cloning (33 percent).

Interest in Science and Learning

Their attitudes towards learning and learning about and keeping up with new science areas are slightly lower than the average. Only 67 percent agree that they enjoy finding out about new areas in science, and only 61 percent consider it is important to know about science.

Science and the Economy and Control

The Educated Cynics recognise the importance of developing science to help New Zealand enhance its competitive advantage, but reflecting their comparatively low level of interest in environmental science, rate the importance of science and technology in preserving the New Zealand environment lower than all other groups (61 percent).

Fewer than half (42 percent) consider the government should fund scientific research even if unsure of the benefits, but neither do they consider the government should keep tight controls on science (only 30 percent agreement). This group fears that such controls can stifle innovation. They also have a distrust of government. Reflecting a more positive than average belief in cloning, segment three is least likely to agree that people should not interfere with nature (31 percent).

Science and Knowledge Building

Their views tend to match the average for all areas of science and knowledge building. The Educated Cynics tend to believe that doing more experiments will help to produce the right answer (64 percent), and they appreciate the lateral thinking required to achieve science developments. They do not have a strong confidence in the results if something is scientifically proven (only 39 percent agree), unless they see it for themselves.

Sociological Aspects

Compared with other segments, the Educated Cynics have a strong appreciation (70 percent agreement) that it is not possible to be certain about a single cause for health problems like cancer. Like the Confident Science Believers (segment one) and the Confused and Suspicious (segment four) they believe that scientists are telling the truth when they say they are not clear about the actual threat posed by something risky. They see that this reflects scientists' lack of knowledge rather than representing a cynical response on the part of the scientists.

Unlike other segments the Educated Cynics do not generally believe that scientists should be accountable, or have to explain and justify their research to the public.

Science in the Real World

The views of this group tend to match the average: their view of science is a realist one rather than based on a highly theoretical complex understanding of science.

Trustworthiness of Information Sources

The Educated Cynics tend to rate the trustworthiness of each information source at a lower level than other people. They are the least trusting of lobby groups of all the segments (6 percent), and less trusting of professional sources (general practitioners, scientists, television) than others.

SEGMENT 4: CONFUSED AND SUSPICIOUS

This segment represents 13 percent of the total sample. What differentiates the Confused and Suspicious is a belief that science is out of control, that there is a lot of conflicting evidence about science and what to believe, and that the government needs to keep control of science. They do not have a strong appreciation of science's role in achieving economic success. They put faith in common sense, which can be a barrier to understanding the complexities of the scientific world.

Demographics

The Confused and Suspicious have a higher representation of women (57 percent) but they are reasonably balanced age-wise, by educational level, and by occupation group, against the average. Personal incomes tend to be low, reflecting the proportion of women in the group.

Interest in Science

The Confused and Suspicious have a comparatively high level of interest in some areas of science, particularly environmental sciences and medical areas (both new techniques and genetic testing) and scientific issues of importance to the world (earthquakes and climate change). They identify benefits particularly in the area of new methods of transport, climate change research, and endangered species research. Of all the segments, they are least likely to identify any benefits with cloning (13 percent only), although their level of interest in cloning is moderate (30 percent).

Interest in Science and Learning

The Confused and Suspicious attach high importance to learning new skills (97 percent) and say they enjoy finding out about new ideas in science (72 percent). A key distinguishing feature for this segment is their high level of agreement that there is so much conflicting information about science, it is hard to know what to believe (86 percent compared with a 56 percent average).

They also agree more than average that science and technology are too specialised for them to understand (36 percent).

Science and the Economy and Control

The Confused and Suspicious are not strongly convinced that New Zealand needs to develop science to enhance its international competitiveness (only 55 percent agree), and they are also less likely than most other segments to believe that science and technology are important in the preservation of the New Zealand environment (70 percent).

They have strong concerns about science being out of control, and three-quarters (78 percent) want the government to keep tight controls on science. This is based on a view that scientists may not be acting ethically, and concerns about the dangers of science being out of control. Linked with these attitudes is a strong belief that people shouldn't interfere with nature (70 percent), and that scientists should have to explain and justify their research to the public (87 percent agreement).

Science and Knowledge Building

Like other segments, the majority of the Confused and Suspicious (79 percent) appreciate that developments in science rely on lateral thinking. Two attitudes distinguish them from other segments: they are least likely to agree (2 percent) that there is only one right way to investigate important scientific questions, and they are also least likely to agree that they can have confidence in the results of something that has been scientifically proven (14 percent agree). This is because there may be unknowns or overlooked variables, because science can be declared wrong in the light of subsequent developments, or because the application also goes wrong. They also consider that science can be used to mislead, and that scientists can be dishonest.

The Confused and Suspicious are less likely than other segments to consider that doing more experiments will lead to the right answer (50 percent agreement) and one in four believe that scientific predictions are made on the basis of lucky guesses.

Sociological Aspects

Given the above attitudes, it is not surprising that the vast majority (96 percent) of this segment agree that it is important to have some scientists who are not linked to government or to business interests.

They are most inclined to the view (84 percent agreement) that it is not possible to be certain about any single cause for health problems such as cancer, reflecting their beliefs that scientists often disagree, and that scientific theories change over time. They are also most inclined to agree (72 percent) that scientists are telling the truth when they say they can't be clear about the actual threat posed by risky things.

Science in the Real World

The Confused and Suspicious' view of science in the real world tends to match the average. Half think that all tomatoes contain genes, only a quarter believe that atoms can be seen with a really strong microscope, and 11 percent agree that gravity is an imaginary idea.

Trustworthiness of Information Sources

While the Confused and Suspicious consider that scientists in the public sector are trustworthy (72 percent), they are much less inclined to believe this of scientists employed within industry (52 percent).

SEGMENT 5: UNINFORMED INDIVIDUALISTS

This segment comprises 14 percent of the sample. It is characterised as male, and is a younger segment than others. Despite an interest in new technologies, their understanding of science is relatively unsophisticated. They don't see a need for control over scientists nor the need for scientists to be independent.

Demographics

This segment has the greatest male bias of any segment (55 percent). It is the youngest segment: 27 percent are under 25, and a total of 49 percent are under 35 years. Students and semiskilled technical occupations are prevalent. The incidence of formal science training is lower than the average (17 percent), and the segment has lower than average access to the Internet (65 percent). It has the highest incidence of Maori (18 percent).

Interest in Science

Generally, this segment's interest in science and technology topics is slightly below average. Their interest in cloning is low, at 17 percent. Uninformed Individualists are not strongly aware of benefits for the various science and technology topics, with ratings all below the average.

Interest in Science and Learning

Despite a claimed lack of interest in specific topics, the majority of Uninformed Individualists (79 percent) say they enjoy finding out about new ideas in science. Their interest in keeping up with new technologies exceeds the average (72 percent), and their attitude toward the importance of knowing about science also exceeds the average (70 percent).

Science and the Economy and Control

Segment views here generally match the average. The main differences are slightly greater agreement (60 percent) that people shouldn't interfere with nature, but lower than average agreement that science is out of control (16 percent). Only half (55 percent) agree that the government should keep tight controls on science.

Science and Knowledge Building

Again, the views of Uninformed Individualists are generally close to the average. However, they are less likely than others to appreciate that new questions come from previous research (34 percent agreement). Like those in segment six (the Left Behind), they have a reasonable level of confidence in results that are scientifically proven (52 percent). Like the Left Behind, this confidence is based on faith, rather than other factors.

Sociological Aspects

The Uninformed Individualists' attitudes towards control of scientists distinguish this segment from all others. Only 35 percent agree that it is important that some scientists are not linked to government (the average is 83 percent) and only 42 percent agree that some scientists should not be linked to business interests (the average is 86 percent). Their attitudes towards scientists' interpretation of data are relatively unsophisticated: only 39 percent agree that it is not possible to be certain about any single cause for health problems such as cancer.

Science in the Real World

Uninformed Individualists have higher levels of "don't know" responses to the gravity, atom, and genes questions, although they are not as high as those of the Left Behind. Only a third agree that all tomatoes contain genes, for example, while 36 percent say they don't know.

Trustworthiness of Information Sources

Their ratings of the trustworthiness of various information sources tend to match the average (see page 43).

SEGMENT 6: LEFT BEHIND

The Left Behind is the smallest group, accounting for 13 percent of the total sample. The segment is sharply differentiated by its demographic profile: female, older than the average, and less well educated. The Left Behind do not understand the complexities of new science and technology areas, nor are they interested in learning about them. They strongly disagree with anything that interferes with nature, such as cloning.

Demographics

This segment has a distinctive demographic profile, having the strongest female bias (64 percent) and a strong older age bias. In total, 43 percent are aged over 55 compared with 26 percent of the total sample. Given their gender and age profile, it is not surprising that 30 percent of this segment describe their occupation as home duties or retired. The segment has the lowest level of education – 74 percent have only secondary – and they are least likely to have a formal science qualification (10 percent). Two in five are on incomes below $20,000. Their Internet access reflects their age profile: only 54 percent have such access.

Interest in Science

The Left Behind claim a high level of interest in medical techniques, saving endangered species and improving the quality of our agricultural and horticultural products. They have a low level interest in non-familiar science areas (19 percent in space research and 36 percent in computing and the Internet). They have least interest in cloning (15 percent) and, like the Confused and Suspicious, they see little benefit in it (17 percent). This segment also shows lower than average appreciation of the benefits of new technology areas (space research, transport, and computing) and they are least likely to appreciate the benefits of climate change research (53 percent).

Interest in Science and Learning

The Left Behind show little interest in engaging with science, which is likely to reflect their age and perceptions of their abilities in relation to science. Only 30 percent agree that they enjoy finding out about new ideas in science, and only 23 percent make any effort to keep up with new technologies that might be useful in their lives. However, they do acknowledge the importance of learning new skills (65 percent agreement). Over half (55 percent) say they find science and technology too specialised to understand, and two-thirds of this segment agree that there is so much conflicting information about science, it is hard to know what to believe.

Science and the Economy and Control

Despite their lack of positive engagement with some technological issues, the Left Behind have a very strong belief about the importance of science and technology in preserving New Zealand's environment (85 percent agreement).

Reflecting their views on cloning, the members of this segment have the strongest level of agreement that people shouldn't interfere with nature (80 percent agreement). They generally agree that the government needs to keep tight controls on science (68 percent), although they don't believe that science is out of control.

Science and Knowledge Building

The Left Behind's views on knowledge building and science are the function of a lifetime of observation and experience. Two-thirds agree that doing more experiments will produce the right answer. They are unlikely to consider that science predictions come from lucky guesses. People in this segment are least likely to know whether there is one right way to investigate important science questions – one in five don't know, while 48 percent disagree. They have one of the strongest levels of confidence in results that are scientifically proven (51 percent), tending to take the science on faith and at face value.

Sociological Aspects

The Left Behind definitely agree that scientists should have to explain and justify their work with the public (81 percent agree). They share this view with the Confused and Suspicious, which has a similar view of the need for tight controls on science. Like most other segments, the Left Behind consider it is very important to have scientists who are not linked to the government or business interests (88 percent and 90 percent respectively).

Science in the Real World

Responses to questions about atoms, gravity, and genes are characterised by very high levels of "don't know" response: 30 percent for the gravity/imaginary idea question, 49 percent for the all tomatoes contain genes question, and 54 percent for the atoms can be seen with a microscope question.

Trustworthiness of Information Sources

This segment's rating of the trustworthiness of various information sources is close to the average. They tend, however, to regard their general practitioner as a particularly trustworthy source, and they rate the trustworthiness of television documentaries quite highly (60 percent trustworthy).

Actions over a Community Health Issue

Compared with other segments, the Left Behind are least likely to know what to do, or to adopt a wait and see approach, if their community faces a significant health issue.

GENDER DIFFERENCES IN THE SEGMENTS

Previous New Zealand research (CM Research, 2000) has suggested that there is 'some indication' that, when interacting with science and technology in relation to their own lives, 'women may be particularly vulnerable to feelings of inadequacy as a result of bad experiences of school science' (p. 52). The segmentation analysis reported here does indicate some trends in gender differences with respect to science, although we found no evidence that school science experiences per se are the cause of these. Rather a combination of factors appears to influence gender trends, for both males and females.

Patterns of female attitudes to science

The Confident Science Believers (segment one) are a gender-balanced group. Educated women in professional occupations are as interested in science and as aware of its benefits as are their male counterparts.

Three of the remaining segments – Concerned Science Supporters (segment two); the Confused and Suspicious (segment four); and the Left Behind (segment six) – all show a gender bias toward females, although the differences are small for segments two and four.

Those in segments two and four are differentiated from those in segment one by their lower levels of education and their higher levels of concern about science and technology. Their awareness of times when science has led to unintended consequences appears to be linked to their desire for tight government controls on the work of scientists. However it is important to note that members of both these segments are interested in science and technology. Women generally show a higher level of interest in health and environment related issues than men, so these areas could provide good 'hooks' (OST/Wellcome Trust 2001, p. 317) for communicating with them.

The Left Behind (segment six) is the most skewed towards women and may be the hardest group for science communicators to reach. Some in this group have not had a secondary education at all, and so may not have had opportunities to engage in an organised way with science at any stage of their lives. This may explain their tendency to adopt a more passive stance towards science related issues.

Patterns of male attitudes to science

The Educated Cynics (segment three) and the Uninformed Individualists (segment five) both show a small level of bias towards males. Both of these segments are characterised by lower levels of engagement with science and technology, although this appears to stem from quite different causes in each case.

While those in segment three are generally well educated, their interests tend to business rather than science and they do not rate the benefits of investment in science and technology as highly as those in some other segments. They are also less trusting of the government's role in regulating science and technology activity.

On the other hand, those in segment five appear to be somewhat disengaged from any consideration of issues to do with funding and control of science in general. Apathy, rather than active distrust would appear to distinguish the attitudes of this segment and they may be hard to reach whatever communication strategy is undertaken.

SECTION FOUR: COMPARATIVE TRENDS

INTRODUCTION

Some of the questions used in this research have been used in other studies overseas. This section compares the findings of the NZCER/ACNielson research with recent similar studies conducted in New Zealand, and in the UK. It is important to note that the comparisons need to be interpreted with caution. Answers to individual questions can be affected by the interviewing method, by the content of other questions in the survey, by minor wording differences, and by the position and ordering of questions within the survey. Our research experience suggests that cultural factors also impact on survey responses and particularly to ratings-based questions. Finally, survey timing in relation to current events can also have a significant impact on views. For example, this study was undertaken less than a year after the Royal Commission on Genetic Modification announced its findings in New Zealand. It was also undertaken during a summer in which there was significant discussion of the effects of climate change on weather patterns in the media, given unseasonable flooding in most parts of New Zealand during January 2002. The tables below show the results of the current research in comparison to research carried out in the UK (OST/Wellcome Trust 2000; 2001).

PATTERNS IN LEVELS OF PERSONAL INTEREST

Interest in Science and the Benefits of Science

	Interest		**Beneficial**	
	NZ 2002 %	**UK 2000 %**	**NZ 2002 %**	**UK 2000 %**
New medical techniques and treatment …………… (*UK: new medicines*)	82	84	93	94
Improving quality of agriculture and horticulture…. (*UK: new methods of food production and manufacture*)	66	48	80	64
Genetic testing (for human disorders)……………… (*UK: section in brackets not included*)	64	43	63	41
Computing and the Internet.………………………..	63	52	65	73
New (and faster) methods of transport……...…….. (*UK: section in brackets not included*)	56	55	64	66
Research into climate change…………………..……..	56	60	68	71
Space research and astronomy……………………..	37	47	39	57
Cloning……………………………………………..	31	23	26	18

Interest in Science and Learning

	NZ 2002 %	NZ 2000 %	UK 2000 %
It is important to know about science in my daily life …………………………….	66	73	59
There is so much conflicting information about science, it is hard to know what to believe….. (*UK: know what to do*)	56	NA	57

Relationships Between the Economy, and Science and Technology

	NZ 2002 %	UK 2000 %
NZ *(UK: Britain)* needs to develop science and technology to enhance its international competitiveness ………………………………………………	77	79
The Government should fund scientific research even if we can't be sure of the economic benefits…. ………… (UK: Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Government)	57	72

Comparative Similarities and Differences

Between the UK and NZ

In both places (NZ/UK) there is a strong correlation between personal interest and perceptions of benefits arising from an area of science and technology. This interest is highest for health-related aspects, and developments in this area are perceived to be beneficial by over 90 percent of both populations. In both places, level of interest and perceptions of benefits are lowest for cloning.

New Zealanders appear to be more interested than their UK counterparts in links between science and agriculture and horticulture, doubtless reflecting the importance of these areas to New Zealand economic activity. On the other hand UK respondents showed greater awareness of the benefits of research on computing and the use of the Internet, despite their expression of lower levels of interest in these areas. Given the relatively high levels of interest and Internet access for many New Zealanders (see appendix two) there are challenges here for NZ science communicators.

Changes in wording and question format can impact significantly on results. For example a recent UK survey reported that the public 'expects the impossible from science' (MORI 2002). This survey found that 71 percent of UK respondents expect scientists to give an agreed view, and 61 percent expect scientists 'to provide 100% guarantees about the safety of medicines'. By contrast the NZCER/ACNielsen survey found that 62 percent of New Zealanders recognise that it is not possible for scientists to be certain about any single cause for some health problems. Similarly 53 percent acknowledge that scientists are telling the truth when they say they can't be clear about risks (see page 32). When asked about absolutes, it seems that people may respond in kind. When the question is framed in terms that acknowledge risk and uncertainty, responses are more realistic.

The qualification of the statement made about genetic testing may have been responsible for the higher level of interest expressed and benefits seen by NZ respondents. Similarly, the rewording of the question about government funding of science and technology may have contributed to the large difference in rates of agreement between NZ and the UK. However previous New Zealand research suggests that there may be some issues of relationships between science and the business sector that are New Zealand specific. These are explored below.

Between this Project and the CM (2000) Survey

In 1998 and in 2000 the CM Research organisation reported on public attitudes to science in New Zealand. The overall pattern of the research undertaken was similar to that employed in this project, with a quantitative telephone survey and qualitative small group discussions. The research questions in these earlier projects were broad, with science and technology initially characterised as 'looking for new knowledge and understandings, using knowledge to provide ideas, for developing products or finding new ways of doing things' (CM Research 2000, p. 3). Our approach was based on respondents' need for contextual support to cue their thinking about attitudes that might not be a conscious part of their everyday thinking. This approach provided rich data but somewhat limited the direct comparisons that could be made with the CM research.

The current survey has found a lower agreement with the general idea that it is important to know about science in daily life (66 percent) than was reported by the CM research (2000) (73 percent). However, in the CM survey the question was framed somewhat differently. In that project personal interest was juxtaposed with the importance of science and technology to New Zealand's economy, environment, business and industry sectors, society as a whole, and the future generally. In the current survey the statement was part of a question that was directly concerned with personal learning dispositions.

In the current survey, 31 percent of New Zealanders agreed with the statement that science and technology are 'too specialised for me to understand', whereas in the CM research 26 percent agreed with the statement that science and technology 'is only for really intelligent people'. The proportion of those who might be expected to actively avoid engaging with the ideas of science appears to have remained relatively stable.

The seemingly lower level of interest in 'knowing about science in my daily life' in the current survey belies the high levels of interest shown in areas of science and technology that are most likely to be of personal relevance. New Zealanders, like those surveyed by OST/Wellcome Trust in the UK, show a very high level of interest in new medical techniques and treatments. In the CM research, only 23 percent of survey respondents mentioned medicine and health when asked a much more open question about the images that they associated with science and technology.

Sixty-six percent of New Zealanders in the present survey professed an interest in 'improving the quality of agricultural and horticultural products', and this jumped to 80 percent agreement that such research is beneficial. By contrast, only 6 percent of CM respondents related farming/agriculture to science and 7 percent to technology, when making unprompted responses to the types of activities they associated with science and technology.

In our research there was a higher than average representation of people in business and managerial roles in segment three – the Educated Cynics. This segment were also characterised by a lower than average level of interest in science and technology, although twenty three percent had formal science training. The qualitative component of the CM Research (2000) identified three types of business owners, differentiated by the degree of commitment they showed to investment in science and technology as they developed their business interests. One of these groups saw their contribution to New Zealand's economy in employment terms. Members of this group also showed less interest than those in the other two groups in taking a role in contributing to developments in science and technology. Thus one challenge for science communicators would appear to involve helping some business owners, and some managers within the business community, to see the links between investment in science and technology and business and employment growth.

Between this Project and Genetic Modification (2001) Benchmark Survey

In 2001 a telephone survey of people's awareness of and knowledge about genetic modification was carried out for the Ministry for the Environment (Harsant and Kalafatelis, 2001). Just over six hundred members of the pubic were surveyed to inform the development of a public information campaign on genetic modification. The intent of this research was thus broadly similar to the purposes for our research project, although one specific area of science was the focus. While the questions were framed very differently, some broad similarities can be drawn between our findings and those of the Harsant and Kalafatelis:

- They report that 4 percent of the 603 respondents to their telephone survey mentioned GM/GE without prompting when questioned about issues of importance to New Zealand's future. In response to our open question about government controls of science, 6 percent of people spontaneously mentioned GE as a specific concern (page 15).

- In the GM survey, Maori were reported as 'significantly more likely than non-Maori to claim that genetic modification meant "playing with nature/playing with God" (16 percent c.f. 9 percent respectively)'. We also found that Maori and Pacific peoples hold stronger views that 'people shouldn't interfere with nature' than do Europeans (page 14).

- 'Preferred' sources of information in the GM survey were ranked in the same *order* as 'trusted' sources of information in our survey, with Government Departments ranked above scientists, and scientists ranked above the media.

SEGMENTATION COMPARISONS

With the CM (2000) Survey

Because quite different types of questions were asked, it is not possible to directly compare the six segments found in this survey with the four segments found in the CM research (2000). In part this reflects the different aims of the two research projects. The CM research was intended to inform 'science and technology *promotion*'. This research is intended to inform *communication* between scientists and the public. We believe that there are subtle but important differences of emphasis in these aims. The qualitative components of our research support this belief. We found considerable suspicion about the motives of those who use obvious 'public relations' type approaches to communication about science, especially in areas of public concern.

The CM survey asked about perceptions of issues of importance to New Zealanders in general (i.e. not necessarily science-related) and about attitudes to science and technology as an open question. Our survey provided a range of *contexts* to focus thinking about interest in, and perceived benefits of, science and technology. CM researchers asked about attitudes to employment in science and technology related 'jobs and careers'. We felt it was more important to establish how people conceptualise science in general as only a proportion of the population will be directly employed in such jobs/careers. Our questions focused more directly on attitudes towards science (which were then able to be broadly correlated with conceptualisations of what science is) and on people's personal feelings about keeping up with new ideas in science and technology. These newly introduced aspects segmented the population in quite different ways to those reported in the CM research.

With the UK (2000) Survey

The UK study by the OST/Wellcome Trust (2000, 2001) also undertook a segmentation analysis, based on design premises more closely aligned with those used in this survey. We drew on the question bank used in that research, adding our own questions about conceptualisations of science itself. The UK study included questions that were designed to evaluate 'interest in science' within the wider context of people's leisure interests and personal values frameworks.

We did not refer to the UK clusters until after our own analysis had been completed. However, in view of the differences between the two surveys, the similarities between the clusters are perhaps surprising. They do appear to represent broadly similar demographic groups in both places, albeit with some cultural differences. Since each cluster shows distinct patterns of attitudes and beliefs about science, this information should be of considerable value for science communicators.

Both studies identified six segments, although the segment sizes are different, as shown on the next page. Brief summaries of each pair follow, highlighting the similarities and differences between the segments.

SEGMENT COMPARISONS BETWEEN NEW ZEALAND AND THE UNITED KINGDOM

New Zealand 2001	%	UK 2000	%
Confident Science Believers	25	Confident Believers	17
Concerned Science Supporters	18	Supporters	17
Educated Cynics	16	Technophiles	20
Confused and Suspicious	14	The Concerned	13
Uninformed Individualists	14	Not Sure	17
Left Behind	13	Not For Me	15

In this section, descriptions of each of six New Zealand population segments are juxtaposed with those found in the UK research for ease of comparison.

Confident Science Believers (NZ – 25%)
Confident Believers (UK – 17%)

The Confident Science Believers are the most highly educated NZ group, with the highest level of science training. Confident Science Believers have a high level of intrinsic interest in science, and appreciate the benefits it brings to society and its importance to economic and environmental well-being. Their theoretical understanding of science in the real world is somewhat better than that of other segments, although they are still inclined to realist views.

The UK Confident Believers are also supportive of science because they appreciate its benefits. Like their New Zealand counterparts, they are well educated and tend to live in households with above-average household incomes. They express confidence in society and the political system to control scientific developments, whereas their NZ counterparts are inclined to believe that scientists need freedom to pursue knowledge and make progress.

Concerned Science Supporters (NZ – 18%)
Supporters (UK – 17%)

Reflecting their average levels of education, Concerned Science Supporters are people whose view of science is somewhat naïve, although they are interested in and appreciate the benefits of science and technology. They consider it important that the government keep control on science, as they do not have a strong personal understanding of how scientific knowledge is built.

UK Supporters are more likely to have qualifications in science and engineering than their NZ counterparts, although not to such a high level as the Technophiles (see next page). Like their NZ counterparts they express less confidence in scientists, but expect the government to keep science under control. They tend to be younger than the Confident Believers and the Technophiles.

Educated Cynics (NZ – 16%)
Technophiles (UK – 20%)

The Educated Cynics are similar demographically in many ways to the Confident Science Believers, with high levels of income and education. What differentiates them is less interest in science, less enjoyment in finding out about it, and a lower level of expressed appreciation of the benefits of science and technology. The Educated Cynics do not see a need for government control of science, nor do they see a strong need for scientists to have to justify and explain their research to the public. While they trust scientists, they are somewhat less trusting of information sources than other groups.

The UK Technophiles also tend to be well educated and to live in households with above-average incomes. They are generally more interested in science than the NZ Educated Cynics. They differ from the UK Confident Believers in being much less trusting of government and the regulatory system, although they have more confidence in scientists. As a whole, this is the group with the highest level of qualifications in science and engineering, whereas the New Zealand sample tends to include those in business and managerial occupations.

It seems quite possible that the larger segment of Confident Science Believers in NZ includes some of the Technophiles segment of the UK population. This UK segment shows a cynicism toward the UK government that could be a consequence of the BSE crisis, which did not directly affect New Zealand meat consumers.

Confused and Suspicious (NZ – 14%)
Concerned (UK – 13%)

What differentiates the Confused and Suspicious is a belief that science is out of control, and that there is a lot of conflicting evidence about science and what to believe. Like the Concerned Science Supporters, the Confused and Suspicious think that the government needs to keep control of science. They do not have a strong appreciation of science's role in achieving economic success. They put faith in common sense, which can be a barrier to understanding the complexities of the scientific world.

Both the NZ Confused and Suspicious and the UK Concerned tend to have a demographic profile similar to the average, and both groups have a strong female bias. The UK Concerned also tend to be anxious about their ability to cope with the changes they perceive as being brought by science and technology, and about society's ability to cope with these developments. Their scepticism of authority is greater than any other UK group, including the Technophiles.

Uninformed Individualists (NZ – 14%)
Not Sure (UK – 17%)

The Uninformed Individualists tend to be male, and to be a younger segment. Students and those in semiskilled occupations predominate. Despite an interest in new technologies, their understanding of science is relatively unsophisticated. They don't see a need for control over scientists, nor the need for scientists to be independent.

The UK Not Sure tend to be poorly educated, under 35, living in households with below-average incomes and are more likely to be living with children than any other group. They stand out because they tend to neither agree nor disagree, or say that they do not know, in response to the attitudinal statements. They tend not to identify any benefits brought by science and technology.

Left Behind (NZ – 13%)
Not For Me (UK – 15%)

The Left Behind segment is sharply differentiated by its demographic profile: female, older than the average, and less well educated. The Left Behind do not understand the complexities of new science and technology areas, nor are they interested in learning about them. They strongly disagree with anything that interferes with nature, such as cloning.

The Not For Me UK segment also tend to be largely uninterested in science and technology, although they think that it is important. Like their NZ counterparts they also tend to be poorly educated and to have lower levels of personal incomes, and they too are much more likely to be aged over 65.

Summary of Broad Trends

These clusters suggest that *education* is a key factor in shaping attitudes to and interest in science. Correlated with that, but secondary to it, are levels of income and gender. *Age and experience* and *attitudes to authority* also impact significantly on attitudes to science. As people get older they appear to take more account of life's contingencies, and accordingly to be more tolerant of uncertainty and more aware of complexity in cause/effect relationships. There is no clear ethnic differentiation within these segments – New Zealanders do appear to share broadly similar values with respect to science.

DIFFERENTIATING COMMUNICATION STRATEGIES

The segment descriptions identify six groups with different combinations of interests in, and concerns about, science and technology. The OST/Wellcome Trust researchers suggested that a different 'tone of voice' (p. 330) would be needed to communicate with each of these different types of groups. However, they also saw it as important that the 'message' should remain essentially the same (OST/Wellcome Trust 2001).

The focus groups described in the next section of this report were chosen to represent different sectors of society who are likely to have different types of interests. While no one group was homogeneous in views and beliefs, the broad patterns of attitudes that did emerge add some insights into likely 'tone of voice' approaches that could be effective for communicating with the different groups.

Details of each focus group are set out on page 73. The teachers in focus group four, one or two of the young professionals in focus group three, and perhaps one member of the low income participants in focus group one appeared to be 'confident science believers'. This broad sweep is compatible with the size of this segment – at 25% of the New Zealand population, they comprised the biggest group of the telephone survey. These people are interested in science and willingly engage with ideas related to science research. A 'two way dialogue of specialists and non-specialists' (OST/Wellcome Trust, 2001, p. 315) should work well for communicating with all these people.

The kindergarten mothers in focus group two and several members of the low income group (focus group one) appeared to be most closely aligned with the Concerned Science Supporters and the Suspicious and Confused segments, as identified in the quantitative research. The responses of the participants in these two groups, described in the following section, provide illustrations of the types of factors that appear to result in the distrust of science and concern about its consequences expressed by both the Concerned Science Supporters and the Confused and Suspicious. For example, it will be of interest to science communicators that participants in these focus groups were the most likely to conflate science and business interests, and they were keenly aware of any possibility of a 'public relations' spin' (as they saw it). Thus there are different 'tone' issues to consider when communicating with these groups.

Several members of the young professionals (focus group three) appeared to align with the Educated Cynics in segment three. Their confidence that they are well capable of attending to science matters - if and when they so choose - sets them apart from all the other groups. Again details are elaborated in the following section.

No members of any focus group appeared to belong to either the 'left behind' or the 'uninformed individualists'. This might have been partly a factor of age – no participants were of retirement age, nor were any in their teens or early twenties. We suspect however that it would be difficult to gain the support of people in either of these segments to participate in consecutive meetings of the model we used here. (We suspect, but cannot confirm, that two members of the low income focus group did not return to the second meeting because they did not feel sufficiently interested or comfortable with the material presented to do so.)

However we found that members of all the focus groups, regardless of their interest in science brought strong everyday understandings to bear on the judgements that they made about the worth of science research. This tendency poses considerable challenges for science communicators, as discussed in sections five and six.

SECTION FIVE: THE FOCUS GROUP RESEARCH

A RATIONALE FOR THE RESEARCH APPROACH

A reconvened focus group methodology was used for the qualitative aspects of the NZCER research, following the approach taken by The Wellcome Trust (1998) when researching public perceptions of cloning. For reasons outlined below, the context selected here was cell phone safety.

As a result of their focus group research, the Wellcome Trust group reported that members of the UK public, when presented with opportunities to explore a controversial science issue in depth, are well able to grasp the key *science* concepts. However, these researchers found that a distrust of scientists' motivations and regulatory frameworks remained unchanged (OST/Wellcome Trust, 2000). In Britain this lack of trust may extend to politicians as well as scientists. The telephone survey component of the NZCER research also found evidence of such distrust of scientists and/or of politicians, although these views do not necessarily go together. For the 29 percent who disagreed that the government should keep tight controls on scientists, the most commonly expressed reason was that the government cannot be trusted in this role. On the other hand, for the 59 percent who agreed that the government should keep tight controls on what scientists are allowed to do, distrust of scientists was the most commonly expressed reason (16 percent of respondents had no opinion on this statement. Details are on pages 20–23 of this report.)

Building on the OST/Wellcome Trust research, the NZCER researchers proposed as a tentative hypothesis that such distrust might be a function of a lack of broad understanding of how science ideas are investigated, debated, and resolved within the science community itself. That is, aspects of the *nature of science* are as important to the discussion as are the relevant science concepts. This tentative hypothesis was used to frame some of the questions in the telephone survey and also informed the shaping of the material for discussion in the focus group research. Thus, materials selected for review and discussion in the focus group sessions introduced ideas about:

- different ways of investigating a basic research question and criteria by which the validity and reliability of reported research might be judged by other scientists, and by the wider public (session one); and
- accountability procedures (e.g. protocols for reporting the management of experimental error) and peer-review processes that are built into the working practices of professional science (session two).

We believed that an abstract discussion around sweeping questions about the nature of science was unlikely to be informative, since many people would not know how to describe their views and/or attitudes in generalised terms. Socio-cultural theories of learning and knowledge hold that peoples' attitudes and beliefs are context-dependent and somewhat variable, perhaps even inconsistent, across a knowledge domain (Rogoff 1990; Case 1996). Thus the question of context selection became an important methodological decision for both practical and philosophical reasons.

CHOICE OF CELL PHONE SAFETY AS A CONTEXT

Because the use of a discussion context is a means to an end, not an end in itself, it is important that it should not come to dominate the discussion at the expense of opportunities to explore and clarify general patterns of attitudes and beliefs. The purpose of the research is to report on patterns of attitudes and beliefs in general, not just those that may be specific to one issue. For this reason, we felt it was important to choose a context that would engage interest because it would be familiar and topical, yet that would not necessarily precipitate strong feelings or elicit participants' predetermined stances on a highly contentious issue. (It was realised that the location of cell phone towers might well fall into this latter category for some people. While it was anticipated that this could be raised within individual groups, the organised stimulus material used in the focus group sessions related to the use of hand-held cell phones).

Characteristics of the cell phone context that were seen as helpful for the wider research purposes included:

- many New Zealanders own and use a personal cell phone;
- the safety of the radio-frequency radiation exposure is largely NOT in contention amongst scientists – although there is a clear level of distrust of their assurances amongst certain sectors of society (as evidenced by the proliferation of web sites that canvass this issue) and some question about the advisability of allowing children to use cell phones for prolonged conversations;
- interesting issues of *relative risk* arise when cell phone use is implicated in car accidents;
- the complex and strict specifications for Specific Absorption Rate (SAR) testing of levels of microwave emissions from different phone models, as published by the American Federal Communications Commission (Means & Chan 2001), illustrate several aspects of *empirical rigour* in gathering scientific data. The relevant protocols can be broadly characterised without recourse to highly technical data/description; and
- a wide range of research projects have addressed the question of cell phone safety, including some that illustrate *correlation* approaches (e.g. epidemiological studies) and some that illustrate *causation* approaches (e.g. thermal effects in vivo).

The Prevalence of Biological Issues in Contemporary Debate

By definition, any issue that is seen as a *health* issue is inescapably biological. While the issue of cell phone safety is most commonly represented as an issue of physics, we saw an opportunity to probe how people conceptualise the actual health risks associated with some contentious aspects of contemporary biology. It was anticipated that the research would shed some light on secondary questions such as:

- Is 'health risk' seen by many people as an all-purpose 'bogey' – a vague unsubstantiated fear?
- Is a health risk typically interpreted as meaning a cancer risk and how is cancer understood?
- How else are health risks conceptualised in these contexts?
- Can people discriminate between different sources of health risks and if so on what grounds do they judge the likely health consequences of different risks?
- What types of 'evidence' are likely to be seen as most convincing?

It was felt that any insight into such questions could be very useful for providing explicit advice to scientists working in areas with biological implications who wish to communicate with the public about their perceptions of risk and uncertainty in their research.

Debate About Ethical Issues

The researchers acknowledge that ethical issues that arise from some science research (especially at the cutting edge of biology) are critically important, and that the context of cell phone safety does not readily lend itself to a discussion of such issues. However, for this project, we wished to maintain a clear distinction between *ethical* views and attitudes and beliefs about *science* itself. While these are initially separate questions, any correlation in general patterns will obviously be of significance, and will be discussed at the end of this report as a possible focus for future research.

THE FOCUS GROUP RESEARCH DESIGN

Four focus groups each met for two sessions of approximately two hours' duration, with an interval of two weeks between these two sessions. The sessions were conducted between 12 February and 5 March.

Sample

Each focus group was intended to represent a different sector of wider societal groupings:

- Focus group one was composed of low income or unemployed people, recruited with the help of a social service agency.

- Focus group two was composed of mothers with young children, recruited with the help of the staff at one kindergarten.

- Focus group three was composed of young urban professionals, recruited as a group of friends by one of the participants.

- Focus group four was composed of teachers with an interest in science, recruited with the help of the Wellington Science Teachers Association.

There were five participants in the first session for each group, with three participants returning for the second session in two of the groups, and in one group a sixth person came to the second session. (Six participants had been expected in each case). Although a more gender-balanced sample had been sought, 15 females and 6 males participated in total.

Data Collection

All focus group sessions were audio-taped and the tapes were subsequently transcribed. One of the two researchers present took notes to record the main substance and general tenor of the interactions, to serve as a reference point when questions about the tone and/or overall intent of specific comments were raised during the analysis phase (Waterton & Wynne 1999). Participants were asked to keep a diary record of conversations about the discussion topic during the interval between sessions and these comments were collated to identify recurrent themes. Written responses collected during each session were also collated to identify possible patterns and themes emerging.

FORMAT OF THE FOCUS GROUP DISCUSSIONS

The First Focus Group Session

At the first workshop, participants explored their initial ideas about the topic of cell phone safety, and their perceptions about, and awareness of, research related to this topic. Following the Wellcome Trust model, participants then received information about research on the possible effects of cell phone emissions on human health. Because the overall intention of the current research is to inform communications strategies, the written information about actual research projects was provided at a typical 'sound bite' level of detail, such as might be expected from a radio news item, or a 'news brief' in a daily paper. The six pieces of research used were modified from materials originally intended to help senior secondary school students in the UK learn about aspects of the nature of science. The UK examples represent different approaches to research (including both correlation and causation studies) and raise differing issues of validity and reliability (Hind, Leach, Ryder & Prideaux 2001). The selected examples were rewritten to lower the reading demand somewhat, and to provide brief explanations of technical terms where necessary. The research summaries, as presented to the participants, are included as appendix four. Participants were given the opportunity to discuss the six research projects before individually noting their own reactions to each one on a recording sheet provided (see appendix six).

The Second Focus Group Session

At the beginning of the second session, participants discussed any thoughts or conversations they had had in the fortnight since their first session. Any new questions that had arisen were addressed where possible. While the facilitators in the UK study did not always feel that they were able to address new questions adequately (Wellcome Trust 1998), this did not prove to be an issue in the context chosen for this project. Participants had typically thought about and discussed the first session with other people in the interval, but very few new questions were actually raised. This may have reflected the deliberate choice of a context that did not directly raise contentious ethical issues, or ask people to reflect on their fundamental values.

Materials chosen for this session were shaped to illustrate aspects of accountability in scientific inquiry. Thus, information about SAR testing protocols was summarised to illustrate:

- control of all possible variables;
- explicit identification of sources of measurement error;
- standardisation of techniques for comparative purposes; and
- modelling as a means of reducing 'real world' complexity and/or ethical issues that could arise if using humans for testing.

Following discussion of these protocols, the response of each participant to the entire focus group discussion was captured via the use of excerpts from six selected commentaries about cell phone safety. These were sourced from easily accessed Internet sites and were chosen from a plethora of possible materials to represent a range of points of view with respect to the cell phone safety debate. The URLs for the internet sites from which the materials had been accessed were included in the materials presented to the participants. These six examples are included in this report as appendix five. After discussion of the six examples, participants were asked to individually record a brief written response to each one, indicating whether they found the material believable or not, with reasons.

The PowerPoint presentation used to present the two planned sessions is included as appendix three.

PRESENTATION AND ANALYSIS OF THE FOCUS GROUP DATA

Presentation of Data

To maintain their anonymity, participants were assigned a number that identified their group, and then each of them as individuals with the group – M101, M102 etc. Comments from the audio-taped data are presented below. In the interests of brevity and clarity, some longer interchanges have been paraphrased rather than reported verbatim. The group and the session in which each comment, or interchange of comments, was made are noted in brackets at the end of that excerpt from the conversation. Comments made or questions asked by the researchers are differentiated by the use of italics.

Diary entries and written comments are identified at the end of each selected excerpt. The coding system is to be read as in the following examples:

- M101-D indicates person 1 in focus group 1, and a diary entry.
- M203-1W indicates person three in focus group two, and a written comment from the first session.

Square brackets have been used where explanatory detail has been added to comments made by participants.

Analysis of Data

During the initial stages of analysis of the focus group data, a typology of responses produced from earlier research was used (Korpan, Bisanz & Bisanz 1997).

Korpan *et al.* provided a group of 60 American college students from an introductory psychology course with constructed 'news briefs' purporting to report results of several quite different scientific studies. These were fictitious and involved hypothetical but scientific-sounding materials such as a 'pesticide' called Permaldrin. The researchers asked the participants to rate the plausibility of the conclusion reached in each case and to 'generate requests for information they would need to determine whether the conclusion was true' (p. 520). From the questions that were generated, Korpan *et al.* identified nine distinct categories of responses. These categories and examples of questions from their research that illustrate each category are tabled below.

Table One: Response Categories (Korpan *et al.*, 1997) Used as a Basis for Initial Data Analysis

Category of response	**Examples of questions of this type**
• Social context	Are the researchers qualified to do this research? Who paid for this research?
Agent/theory	What other pesticides have this effect?
Methods	Was a control group used? How did they measure decline in mating behaviours?
• Data/statistics	What kind of proof do they have? What kind of statistical tests did they do?
• Related research	Do other researchers get the same result?
• Relevance	Are other birds affected by Permaldrin in the same way?
• Other	Is the theory behind this research falsifiable?
• Ambiguous but relevant	How did they come to this conclusion?
• Off task/irrelevant	Does Permaldrin really exist?

Collation of Responses of Focus Group Participants

Many of the responses from all the participants in the focus group discussions of cell phone safety could be classified into four of the above categories: relevance, method, data/statistics and social context. Of these four groups, social context and relevance tended to predominate in the discussion data, while the written data mainly alluded to relevance, method, and data/statistics. The provision for several different types of data collection (including both verbal and written) appeared to allow a somewhat wider range of categories of response to be represented.

We also found that a significant proportion of the focus group participants' discussions fell into the categories which Korpan *et al.* classified as 'ambiguous but relevant' (topics that fell into two or more categories) or 'other' (contained relevant information that was not covered in the other categories). Korpan *et al.* assigned few responses to these categories in their research. It is important here to note some of the theoretical and methodological differences between our research and Korpan *et al.*'s. In the latter study, minimal focus was given to the university students' reponses in the 'other' and 'ambiguous but relevant' categories. This is likely to partly reflect the hierarchical nature of response category typology they had constructed for their analysis. Underlying their approach was an inherent assumption that 'a hallmark of scientific literacy is the ability to make effective requests for information or to ask good questions about scientific research' (Korpan *et al.,* 1997, p. 518) and responses that reflected lesser degrees of science literacy sophistication were not strongly scrutinised. Furthermore, their study was conducted with university students in a first-year psychology course. In this context, one might expect to find that at least some of the participants would construct 'good questions' about scientific research.

In contrast, the goal of our research was not to assess participants' 'scientific literacy' *per se*, but to investigate, in a more open-ended way, the thoughts, feelings, and attitudes which contribute to participants' views of science within a particular discussion context. In this respect, many of the 'ambiguous but relevant' or 'other' comments and ideas made during the discussions were the most interesting and revealing. Therefore, we allowed for emergent categories which would encompass any significant themes or ideas not adequately reflected in the categories in table one, to evolve from our data analysis. One significant category to emerge we called 'overall plausibility'.

Individual (written) responses made in relation to each piece of research or Internet commentary (appendices four and five) were of particular interest, coming as they did at the end of group discussion of issues raised by the materials presented. In only a few instances did all the participants in any one group respond in the same way to each exemplar. This is illustrated by the collation of written responses to the 'believability' of the six different pieces of research presented during the first session's discussion.

In the table that follows, responses that suggested a research approach/findings were convincing are coded Y (yes). Responses that rejected the research as not convincing are coded N (no). Where the totals add to less than five, one individual has not made a judgment on that piece of research.

Table Two: Individual Convincing/Not Convincing Responses to the Six Selected 'Research News Briefs' in Focus Group Session One

	Group 1 Low income	**Group 2 Kindergarten mothers**	**Group 3 Young professionals**	**Group 4 Teachers**
Research example 1 nematode worms	Y = 2 N = 3	N = 5	Y = 2 N = 2	Y = 1 N = 4
Research example 2 rat behaviour	Y = 3 N = 2	Y = 1 N = 4	N = 5	Y = 1 N = 3
Research example 3 rat lymphomas	Y = 2 N = 3	Y = 4 N = 1	Y = 1 N = 3	Y = 2 N = 3
Research example 4 rat breast cancer	Y = 1 N = 4	Y = 2 N = 3	N = 4	Y = 2 N = 3
Research example 5 epidemiology	Y = 1 N = 4	Y = 1 N = 4	Y = 2 N = 2	N = 5
Research example 6 epidemiology	Y = 4 N = 1	Y = 4 N = 1	Y = 2 N = 1	Y = 1 N = 3

While the numbers involved are very small, they demonstrate that participants made varying decisions on the basis of the same available information and debate. Instances such as the consensus rejection of the first research example by focus group two appeared to originate in strong arguments advanced by one or more participants in the group. A paraphrased summary of the interchange in this particular instance is reported on page 83 of the report. Despite the variability in individual responses, most groups did incline to a majority view that in most instances rejected research reports as unconvincing. In only five instances (shaded light grey on table two) was a research report found to be convincing by the majority in any one group, and three of these related to research report six – one of two epidemiological studies.

As these varied responses suggest, individual participants within each group could hold quite different viewpoints on some issues. However, there were also some broad areas of similarity within the different groups, and each did tend to have a different profile of attitudes, comments made, and positions taken. The teachers and young professionals tended to be more critical of all the reports, whereas the low-income group held very diverse opinions generally. These similarities and differences are further illustrated in the comments reported in the sections that follow.

The following sections present participants' responses categorised in terms of each of the five identified categories: social contexts; relevance; methods; data/statistics; and overall plausibility.

DISCUSSION RELATED TO SOCIAL CONTEXTS

Broad Trends

Comments related to the social contexts in which scientific research is carried out were made most frequently during group discussion. When seeking to make personal connections between the science context (cell phone safety) and their own personal knowledge, participants tended to draw frequently on three 'common sense' areas of judgment. These three areas were:

- perceptions of how public relations processes work;
- the sense that 'money talks'; and
- awareness of the necessity to gain funding to pursue lines of inquiry, keep a job, or utilise new technologies.

Some differences between individuals and between groups also emerged, as outlined next.

Non-differentiation of Science and Business Interests

Participants in the 'low income' and 'kindergarten mothers' groups (focus groups one and two respectively) did not appear to differentiate between science and business, even when prompted to think about the connections they were making. When asked to write down their initial thoughts at the outset of the first focus group about whether or not they thought they had been 'told the truth' about cell phone safety, eight out of ten answered that the truth has not been told. These two groups tended to link their responses directly to telecommunications companies. Their verbal comments when these responses were discussed give some indication of the nature of the connections that they made in reaching this judgment:

M103 I think we all suspect that we don't get told the truth, even if there is the truth to be told, we don't get told it.

M102 Well I pretty much agree with everybody else. I don't believe we are told the truth and I would imagine, but I don't know for sure, but I would imagine cell phone companies actually know that they cause harmful effects on people but they hire PR companies to downplay that sort of thing (group one, session one).

I. *Let's just talk a little bit about the second question now, about whether the truth has been told, about cell phone safety…*

M201 Well I don't think so actually [that the truth has been told]. I think there's too much money involved, too many businesses, big businesses. I mean no-one's really going to give everyone bad…they want to get out there and sell the phones, they don't want bad publicity. I think they're probably keeping a lot of the safety issues behind closed doors.

I. *So when you say 'they' you're thinking about the actual cell phone company?*

M201 Telecom…whoever's got money to lose. I mean that's just my personal thought….

I. *…Can I ask how you see that connection operating between the commercial firms and scientists who might do some of this research, do you actually think there's a strong connection there?*

M201 Maybe money talks. Maybe I'm paranoid. Maybe these research companies and what not, it's like, oh yes they get them to do them, but to their liking of what they want. The way I see it, it's what they want to let out, information, but I don't know, maybe money changes hands, perhaps, who knows? (group two, session one).

In a short interchange two of the mothers of young children linked honesty and trust to funding issues via a familiar dilemma:

I. *You mentioned mammograms before. You thought something is being held back.… What sort of something?*
M205 There's this other way that is not invasive [an alternative to mammograms]. There's this other treatment that you can have and it's not a radiation treatment. It's called a thermograph. And that gives a far more defined…. I read about it, somebody was handing out articles on them…. It was just really interesting.
I. *So you were actually thinking about alternative ways?*
M205 It's like a heat detection.
M202 Is it more expensive?
M205 Must be. [Laughs as this comment is made.] (group two, session one).

Participants in the 'young professional' and 'teacher' focus groups (focus groups three and four respectively) appeared to be more aware of complexities in the interconnections between science and sources of funding. From the conversations it appeared that these groups were more likely to have direct interaction with people who are scientists. However, they too brought their everyday experiences and reservations to bear when considering issues of trust and possible bias:

M405 I worry a bit in New Zealand with the change of funding that occurred. And whether that's put a lot of pressure on scientists. Is it 'success or you lose your funding'? Or you go overseas and there's an amazing amount of publicity. Every so often you hear about the global warming and the effect on New Zealand. So it can come around about the same time each year, when the funding is coming up again. And you start to get a bit sceptical. That happened for a couple of years in a row and I thought – very, very sceptical. And I think global warming's still on it [the funding agenda]. I still haven't come down on which side global warming comes down for that reason. But that's where I began to get really concerned about the scientists and what they were doing. Whether it's the pressure to get funding, especially in New Zealand.
M401 It seems to be only the projects that that have immediate commercial dollars sort of things.
M404 And that's worrying too. So a scientist will come with an idea because they know that they could sell it for this company and make money from it. And is that where science should go? Should we just be driven by the commercial? (group four, session one).

This issue of global warming was raised by the young professionals during their second focus group discussion and appeared to be interpreted in the same way as it was by the teachers' group during the first session:

M304 The whole climate change issue is keeping a lot of people in jobs right now.

M303 So you've got to be telling how bad it is going to get or how… because otherwise there is no point [in] you having a job. If you can't find something that's a danger to the life on earth then why worry about it. [You'd have to] get a new job.

M305 And also you might want to publish a new book, and get more money for that (group three, session two).

The Impact of the Debate on Health Issues Related to Smoking

In every focus group, previous dishonesties in the area of research findings related to the health effects of smoking were raised as a basis for mistrust. On occasion, as in the next interchange, the issue was explicitly linked to scientists, not just to tobacco companies. This part of the conversation began with one participant asserting that scientists wouldn't allow their name to be put against any dubious research findings because their reputation would be at stake:

M402 I would actually disagree with you [one of the other participants]. That it's not likely to happen [dishonesty in research] because it's got people's names against it. Because if you think what happened with so-called research into whether smoking harms you, then they had people whom they employed who basically said it didn't harm them and they had all the data to back it up etc. So people certainly put their names against it…. Researchers…if they are given enough money to do so.

M405 Because it is interesting because they have actually said now that they have… that was the big case in the States wasn't it, that they actually did have the data. They knew.

M402 But they had another person who actually had his name against it. And I know that one particularly because my husband worked for a cigarette company at the time, and kept spouting this information (group four, first session).

The young professionals, with their links to the PR industry, were more inclined to make links to the highly selective nature of some reporting of the smoking issue:

M301 I think the analogy with smoking is a good one in that, in this case, I think that it's not necessarily that we haven't been told the truth, but I think there's been a deafening silence from industry to rebut a lot of claims that have been made about the safety of cell phones. They are just like with tobacco (group three, first session).

For some in this group, a distrust of the selective reporting of scientific research findings was tempered by an awareness of accountability systems and of the risks of litigation where public safety has been demonstrably neglected for the sake of commercial gain:

M306 My first thought is that…perhaps we haven't been told the truth because the [mobile telephone companies] would be reluctant to disclose, because they stand to gain financially. However if they are aware of any danger, they have a duty to warn, otherwise they would be liable in a huge way further down the track, when the public at large does know of the results. So I would say, in summary, that I think we've been told the truth as far as they know and as far as government know, because if they knew otherwise they are exposing themselves (group three, first session).

One participant reported that the issue of truthfulness or honesty in the reporting of science had arisen in the context of conversations held with other people in the interval between the two focus group sessions:

> M404 Two or three [people whom M404 had spoken with had responded that it would depend who scientists were working for]. Whereas I would actually separate this word "truth" from science…. I think truth is a bit dependent on trust as well…. Especially the smoking, which I think really showed up that things can be manipulated by organisations that can mediate between the public and the science or the scientist (group four, session two).

Perceptions of the Status of Research Institutions

The young professionals (group three) and the teachers (group four) made some judgments about the various research exemplars at least partially on the basis of perceptions of whether or not scientists would be in a position to report independently of external funding influences:

> M303 Well they've [Britain] got Oxford and Cambridge and you can imagine them doing it and they've got no…there's no sort of financial reward.
> M306 It's very sensible.
> M303 Whereas my idea is that American studies, universities get funded by corporates.
> M301 I trust NZ research more than I do American (group three, first session).
>
> M405 I would trust…. I don't believe that scientists actually produce data that's not trustworthy - not usually.
> M401 It's an interesting statement about the American [statutory regulations]. You think everything good comes out of America, but out of Mongolia…would you trust the scientists' findings in a country that was a third world country? (group four, second session).

Appeals to Human Nature

The young professionals also talked about the motivation provided by the drive to find something new. The teachers were the only group to differentiate between basic and applied research, which led to the suggestion that the motivation for each kind of research might be different:

> M303 Isn't it a bit boring [for scientists] to come up with the same information that somebody else has come up with anyway? Isn't it just a little bit more interesting to come up with something new?
> M305 Well it's quite good to try and prove somebody wrong as well (group three, second session).
>
> M404 Basic research, where you know, a group of people, or an individual might have an idea and then just seek to go with it. I think there should be resources, place for that. I think there are constraints on that…. I think the [current societal] paradigm influences the development of ideas. What's fashionable, what's possible for us. I'm talking about basic research. I'm not worried about applied

research because I think that goes on as paid for. But personally I really feel that the scientists should be supported in their development of basic, basic research….

M401 Well part of me is still [thinking], what's the reason behind a lot of the research? And there are two basic things: profit and money; and the good of human kind. So you've got the genetic diseases, which is good of human kind, and you've herbicide resistance in crops, which is just a money thing. So who controls that? (group four, second session).

DISCUSSION RELATED TO RELEVANCE

Broad Trends

When responding individually in writing to each of the six pieces of research presented in the first focus group session, the most frequently made type of comment was related to personal perceptions of the relevance of the research carried out. As the following written and verbal comments show, participants sometimes could not see the relationship between what had been done in a given piece of research and the overall question of cell phone safety for humans. Such comments were made by participants from all four focus groups:

Examples of Written Responses to the Research Summaries (Session One)

> *It may be reliable but not really relevant to humans (M102).*
>
> *Worms aren't of the same makeup as humans – so shouldn't be compared (M 201).*
>
> *Seems an odd comparison [human and rat behaviour] so what can humans gain from that – doesn't tell me enough (M205).*
>
> *Seems irrelevant to the issues re cell phones and radiation (M403).*

Selected examples of discussions concerning the relevance of the use of nematode worms and/or rats and mice to research human health questions are given below.

The Relevance of Nematode Worms

Example one from the first focus group session described the use of nematode worms to research a human health question. The report mentions that nematodes were 'chosen because the ways their cells work are well understood and their biology is simpler than that of bigger, more complex creatures' (appendix four). However, this brief explanation did not appear to convince any participant in any of the four groups. All questioned the relevance of making links between research on nematode worms and human health issues.

I.	*Which brings us to that question I asked before, of whether it's credible to apply things that have been done to animals, to humans. I would be interested in your opinions about that.*
M401	I think it depends how closely related they are. The nematode worm to the human genetically is completely dissimilar. It's like looking at chimpanzees and monkeys and stuff like that. [We are] much more closely related to genetically modified pigs, which have got human blood and stuff in them (group four, first session).

One member of group two produced a complex chain of reasoning, grounded in her everyday experiences of the natural world, that confused individual cells with whole organ systems. She noted that some birds eat karaka berries, which are poisonous to humans, and argued that this means that their cells are of a very different make-up from human cells. The others in the group were impressed by this argument, and all of them subsequently rejected this piece of research as unconvincing.

The Relevance of Rats and Mice

In a similar vein, some participants were unsure of the relevance of using mice to research the safety of cell phones for human use. For some participants, the mention of breast cancer (in research project four) seemed to add an additional layer to these doubts about relevance:

> M205 I thought No. 4 was convincing and [also] No. 3. Although the thing you have to look at I suppose is the breast thing with mice. That bothers me, because I can't see them having the same make-up. They don't have the same as what we have as human beings. So I don't… it may not be significant for them to prove it against rats, mice or whatever you want to call these things, but I mean they're not made up the same as us. So I'm sure if we were put in that situation [of prolonged exposure to microwave radiation] I don't know if we would come out the same (group two, first session).

For some participants, the use of GE as a research tool (to heighten the susceptibility of the mice to potential carcinogens in their environment) was seen as somehow biasing the results in favour of a non-effect, rather than increasing the sensitivity of the test. Again, this was a layer of complexity added to other doubts about the relevance of using mice to research a human health question:

> M102 And the way that they are using mice and genetically doing this….
> M103 That part I find interesting too. The fact that they are GE mice and…
> *I. And you think that that somehow affects the validity?*
> M102 Well yes I do, because I also have to…once again because it's science that's intervened in the first place, you have to just take their word once again, that they've used the right genes to produce the right mice supposedly. Why not use normal mice? I don't know… (group one, first session).

Similarly, many participants failed to see the relevance of aberrant rat behaviour (research project two) to possible harm to humans from cell phone radiation:

> M402 It seemed [that the research report made] some big leaps. We couldn't work out what alcohol had to do with rats in the first place, because they don't normally go around finding alcohol to drink. And also if they drink alcohol, then obviously it would take them a while to find the platform under the water. It just seemed to me to make some huge leaps. So I wasn't convinced with that one either.
> M404 So you've got [these rats and] irradiated worms that grow faster. So this is all very gothic.
> M403 Rats which binge on alcohol and can't find the submerged platform in water.
> M402 How do you know a rat's bingeing on alcohol? How do you do that as a quantitative study? He's bingeing there. Yes [laughs].
> M403 Perhaps they don't run their little wheel around often enough?
> M402 There's also something about the stress levels of laboratory-bred rats but doesn't say how they measured that at all. So there's really not enough information there to tell. There's big holes in it. You need an awful lot more, indicators, to understand what it's all about so you can take it seriously (group four, first session).

M204 It’s too obscure really. Cloudy water – what’s that all about? We’re not going to be sitting under cloudy water I hope for too long. And then bingeing on alcohol…. I don’t sort of…doesn’t sort of give us anything. It’s not comparing enough (group two, first session).

In spite of reservations about the relevance to humans of research on nematode worms and mice/rats, a number of participants felt that this kind of research was at least more ethically acceptable than research on humans or closely related species:

M104 They are carbon-based I presume. In terms of…we're all life forms, but the distinction made is…these things are far removed from humans so that when you’re getting up to rats you're getting up to small mammals. And then you get into the ethical issues of ‘can you experiment on rabbits or primates or do you just use human volunteers?’ (group one, second session).

Recognising the Relevance of Evidence

Participants in all four focus groups demonstrated an awareness of the complexity of health issues and of sources of uncertainty in research. They brought their everyday experiences to bear on the issues at hand and their conversations at different times took account of:

- the time delays for some health effects to become apparent; and
- complex interactions between many variables in human body functioning as contributing to uncertainty in reaching definitive answers in research relating to human health:

M303 How can you get a true control group when you’re doing studies with humans because everybody’s different?
M305 Yes we’ve all got different DNA and all the rest of it (group three, session two).

M105 What I was trying to point out is that they are so harping on about cell phone users, high risk of cancer. The cell phone users have a very fast pace of lifestyle. They eat a lot of fast food, their stress levels are way high. I used to work in the IT industry. I worked using a cell phone seven days a week, sitting on my bed with a headset on, on call, using a laptop 24 hours a day. That was my tool. It’s a very stressful lifestyle (group one, first session).

M305 I don't know…obviously if you were a high phone user you probably would get headaches, loss of concentration, burning and twitching, but not necessarily because the phone is damaging, just because you're working so bloody hard! (group three, second session).

DISCUSSION RELATED TO METHOD

Broad Trends

Comments related to the method used in each of the research projects discussed during the first session again appeared to be weighed against participants' everyday understandings of what might be a valid way to seek an answer to a particular type of question. Sometimes, comments were made about what a participant would expect to happen when a particular method was employed, and research reports were rejected on the grounds that what was reported to have happened did not match this expectation. Examples five and six – the two studies that employed epidemiological approaches – seemed to be most problematic for all of the groups.

Examples of Written Responses About Methods

In Response to the Research Summaries (Session One)

> *Being exposed to radiation each day for that length of time has to have an effect* [where the research said there was no effect] *(M201).*
>
> *Expectations that mice exposed to that much radiation would get cancer – perceptions! (M304).*
>
> *…questions whether 'wriggled' is scientific and can be measured (M303).*
>
> *Only exposed overnight (M304).*

Puzzling About Epidemiology

Research examples five and six – the epidemiological studies – attracted considerable comment about their methods. The methods used did not appear to make sense to at least some participants in focus groups one and two. The following comment captures confused thinking about research project five:

> M105 A study was made of 209 people with brain tumours and a control group of 425 people without brain tumours [reads out rest of research report five verbatim]. I find they are very…not at all convincing and it just doesn't even…the number of people in each group…and also why take two groups of people who are the same? [in numbers] They've already got tumours. I don't understand how they can reach a conclusion on that – they're more likely to develop tumours when they've already got it.
>
> *I.* *So there's something about the sequence in which that worked that you don't find convincing?*
>
> M105 I would be more convinced if they had similar number of people in the control group, and if they were people without brain tumours at all (group one, first session).

One participant in group two stated at one point that project five hadn't 'even compared apples with apples in respect of the amount of people that you're dealing with' and that 'I like project six better because it compares the same amount of people' (M206, first session). Both research projects five and six retrospectively sorted people with and without brain tumours into two groups – mobile phone users and non-users. However, the fact that the initial groups in research project five were more unequal in number appeared to represent a feature that was not seen as acceptable in a scientific investigation. While not directly stated, comments about these two research reports also suggested that the retrospective nature of the sampling methods used in these studies was seen as problematic by some members of the first two focus groups. One participant was sufficiently challenged to return to the second session with a solution to the question of methods that could be used with humans:

> M104 We were talking about the effects of cell phones and studying them, the long term effects and the problems…. We looked at the studies that have been done, but we all seemed a little bit inconclusive in that the size of the sample group and the number of…what is it…the people with brain tumours but only a small percentage had cell phones. That the linkage was difficult to try and get a control group that was not influenced by the cell phones to compare another group who were.

M104 went on to describe how he had considered the possibility of comparing cell phone-users to people in a third-world country, but thought this raised difficulties because many other health and social differences would affect two such different populations:

> M104 So I eventually came up with Amish because they're a community in America who reject modern technology…so that would be interesting to do a comparison with that community from there and a community that uses cell phones (group one, first session).

The Necessity to Design Research

One participant who was very interested in ‘alternative’ health and environmental positions was concerned about the suggestion that the word ‘design’ could be applied to the planning and preparation of scientific research. This participant took the view that the act of designing could deliberately slant the nature of the results that could be achieved, as for example when ‘…talking to kids… it's like, in asking children questions it is so easy to get information from them by the way you word it’ (M101, first session).

This could have been related to her view of what counts as scientific research, expressed during the same session:

> M101 What science is to me, really basically, on a basic thought is that science proves not, like science doesn't go out to prove that something is…it will prove something by proving what's not. So it depends which light is on and which lenses are in as to what science does. So for me…. I mean science is great [but] it's…. I wouldn't depend on it, like whole-heartedly (group one, second session).

DISCUSSION RELATED TO DATA/STATISTICS

Broad Trends

Some of the comments about methods of investigations also referred to the data that emerged. Similarly, some comments that were primarily about findings (data/statistics) also referred to methods.

Some participants from every focus group appeared to be bothered by situations where researchers attempted to repeat earlier research but got different results. Those who reacted this way interpreted this situation as casting the credibility of the research into doubt. However, several people saw the same inconclusiveness as evidence that the research had been reported honestly. Such comments were made most often in relation to the report of questions and hypotheses about cell phone safety taken from the *Scientific American* website (see appendix five) and were made in writing as well as verbally. On the other hand, the phrase ‘statistically significant’ appeared to be accepted on trust.

Examples of Written Responses About Data/Statistics

In Response to the Research Summaries (Session One)

> *Interesting that a statistically significant difference was shown (M104)*
>
> *They stated themselves that it may not be statistically significant (M202)*
>
> *Comment about not statistically significant (M305)*

In response to Internet reports (session two)

> *Findings not able to be replicated by other researchers – not conclusive (M105).*
>
> *Results too broad – one produced a result, one failed* [Scientific American report] *(M204).*
>
> *No other researchers could replicate results? Studies for evidence not conclusive’* [Scientific American report] *(M305).*
>
> *Speculative language and implication of hypothesis – no definite conclusions* [Scientific American report] *(M403).*
>
> *Convincingly inconclusive (M101)*
>
> *I have respect for* Scientific American *– gives evidence and doesn’t conclude much – allows us to form our own opinion (M401).*

The Significance of the Word 'Significant'

Participants knew that phrases such as 'significant result' or 'significant difference' were important to scientists and that such significance could be statistically proven. Interestingly, in view of their scepticism in other areas, some were prepared to take such claims on trust:

M206 They found some statistics, in quite significance. It's interesting that they did find something quite significant in one, instead of nothing really in the other (group two, first session).

M301 In project five they talked about the mobile phone users being 2.5 times more likely to develop tumours close to their phone ear than non-users, but there's a phrase there 'statistically significant' which has actually swayed me on both of them. Like the first one says 'the result may not be statistically significant'. So I've sort of gone and thrown that out, because then the next one says 'this difference is statistically significant'. And so I suddenly think that looks quite good, and in that project 6 that involved 40 percent of the group of 30 with a particular tumour, where mobile phone users were 18 percent in the control group without this special form of neurocytomas were mobile phone users. I get swayed easily by little comments like that.

M305 See for us who aren't scientists…we just see these words and accept them (group three, first session).

Responses to the Issue of Repetition

During their second session, the mothers in group two related the perceived dilemma – that similar methods could lead to different results – to an earlier part of the conversation about the challenge of reading cervical smears, something that was familiar to them as a result of the recent Gisborne inquiry. With some prompting, they did agree that variation in findings might be accounted for when techniques were difficult to replicate without the necessary level of expertise.

From a different perspective, one teacher said she had recently heard a Kim Hill radio interview with Lord May, the President of the British Royal Society. May had apparently discussed the advisability of telling people more about areas of uncertainty in scientific research. This group was inclined to support the position that people would be more trusting of this type of communication than they would be of bland reassurances:

M404 Not follow a politician's route, and saying 'right this is safe you can eat it. Have faith in our industry.' But saying, 'well OK we've got these problems, but there's no evidence at the moment that this effect might happen.'

I. And you were saying that Kim Hill was sceptical?

M404 I just felt there was an initial drawback, but I think he [Lord May] was very forceful, very articulate.

M405 So he advocates being well informed?

M404 Yes.

M405 Well I mean if you look over the last 100 years and where we're going to. We are demanding more information aren't we? Hopefully, scientists do not accept things at face value. These are good points (group four, second session).

However, participants in the young professionals group three foresaw challenges for the accurate communication of information about the findings of scientific research when journalists were being employed to interpret results for the media. In this group the problem of communicating scientific research to the general public was a prevalent theme in both focus group sessions. This issue, which lies at the heart of the reason for commissioning this report, is explored in a later section.

DISCUSSION RELATED TO OVERALL PLAUSIBILITY OF RESEARCH OR REPORTING

Broad Trends

In our analysis of the data gathered in the focus group sessions, we found that a high proportion of the comments made during the focus group sessions could not be coded discretely into the categories of social context, method, relevance, or data/statistics. Given the nature of the data – that is, verbal comments taken in the context of a group discussion – it is not surprising that participants' comments did not always fit neatly into these categories.

These categories were derived from a typology of questions that people *might* ask about research and which would give an indication about their level of 'scientific literacy' (Korpan *et al.*, 1997). The referent for these categories is scientific research itself (because social context, method, relevance, and data/statistics are all features of scientific research). Many of the participants' comments could be described as relating to the 'overall plausibility' of a research report or a research claim. The referent for the 'overall plausibility' category is not scientific research, but the person who is making the judgment (because decisions about whether or not a claim is plausible may be based on factors that are unrelated to these features of scientific research). For example, during the second session, when participants were asked to comment on how 'convincing' they found the information in a series of Internet excerpts, their spontaneous responses indicated that their judgments were based on combinations of ideas including:

- whether a claim concurred with their own knowledge or observations;
- their opinions about the credibility or reputation of the person reporting the information;
- the perceived adequacy of the evidence provided to support an assertion made in the excerpt; and
- the reader-friendliness of the excerpt.

A sample of participants' responses to the overall plausibility of research claims is given below.

Responses to Internet Commentaries (Session Two)

> *Children's skulls are thinner and she is an MP (M305)* [responding to Internet excerpt, appendix five, example two].
>
> *This* [the list of claims made] *doesn't concur with my own observations – where did the evidence come from? (M402)* [responding to Internet excerpt, appendix five, example three].
>
> M206 I think too …… that example 2 [of the Internet excerpts] ….. that also had an impact on me too. Because she spoke it in plain, well, common English. And said about thinner skulls and I thought that was a lot, it was immediate impact again (group two, second session).

M303 But that might be a fact – that there is new evidence of health effects from cell phones coming out all the time. But this from [names person] is typical. What new evidence? Is she the only person that knows about this new evidence? (group three, second session).

However there were no such doubts about example four. Every participant in every group rejected the argument that was presented as unconvincing:

M403 I was interested in the example four [names person] his findings or indications are pretty scattered aren't they? He talks about balance and things like different moods and suicides. He says [there is] strong evidence that extremely low frequency microwaves are associated with acceleration [of the listed effects]. He doesn't actually say what the evidence is. It's just a statement isn't it? To me it's quite a strong, a little sensational…there's no actual…

M402 It's quite a lot sensational. He doesn't actually say what the strong evidence is…. And also I know that because people use cell phones…. I've never seen any of them carrying on like that. So it's seems highly unlikely for me.

M404 I picked on that one as well. I just focused on some of the words that are used and I found 'strong evidence' placed right next to the word 'association'. Sort of contradictory to me. I don't think they sit well. And I was fascinated by the mood, depression, suicide, anger. I think gin does the same! (group four, second session).

M304 Examples three and four are both really interesting because you've got on the one hand the personal stories of effects, and then example four is much more, well, it seems almost extreme given the list of things supposedly linked to the microwaves. But there is a kind of scientific explanation at the end. The alteration of the cellular calcium ions and the seratonin balance is quite interesting but neither of those things really convince me of anything, and that [example 4] one where he's talking about moods, depression, suicide, anger, rage and violence, well really there are so many causes for those sorts of things.

M303 (sarcastically) One of the biggest common elements is actually breathing. Everybody breathes and these things happen to you. So you can link anything to anything (group three, second session).

Variability of Individual Responses

For our focus group participants, plausibility was strongly related to personal perceptions. Each individual brought their own patterns of beliefs about science and common-sense observations of life to the judgments that they made about the plausibility of the research projects and the Internet reports. This could account for the mixed responses to the research projects reported in table two (see page 77).

Public Communication of Science

Broad Trends

The young professionals and the teachers appeared to be most aware of tensions in the reporting of scientific research. While a higher level of detail allows for more careful personal judgments to be made, it also increases the length and complexity of research articles. By their own admission, some members of every group acknowledged that they would not typically read such articles. However, all were supportive of providing detailed information where it could be accessed by those with a particular interest in an issue. Their ideas about how to do this are outlined below.

In every group, strong pleas were made for communications about science to be written in plain language. Because the first Internet example used in focus group two was visual rather than verbal, some comments about the respective power of these different modes of communication emerged as a significant component of this aspect of the discussions in all groups.

The Tension Between Detail and Brevity

During the discussion about the 'sound bite' research reports introduced during session one, members of the young professionals focus group became acutely aware of the shortfall in information that typically occurs when science issues are reported in the mass media. However, with their insider knowledge of the PR industry, they also saw dilemmas in making any change in this situation. On the one hand, they acknowledged that they personally needed more detail than was provided by the research reports in session one for the purposes of debating the overall question of cell phone safety. On the other hand, they also believed that such detail would be most unlikely to be published in the mass media.

In an extended exchange during their first session they discussed the necessity to manage research results from several sources where these differ in detail, if not in the thrust of the overall finding. One participant recounted an anecdote from his own job, in which he had been working with a group of researchers to communicate the findings of New Zealand studies on second-hand smoke inhalation. Several different studies had produced data to suggest that between 100 and 667 New Zealanders had died of second-hand smoke in one year. According to this participant, the researchers involved had been unhappy with the suggestion that this array of figures might be 'averaged' for the purpose of media reporting. Finally, the researchers decided to agree on the publication of the result from the one investigation which they thought had used the best methodology. When this situation had been described, one of the other participants in the group responded with horror. Those in the group with PR experience did not appear to convince this participant that it was an honest attempt to manage an impossible tension:

> M303 They picked it from…that's appalling.
> M304 They voted on it.
> M301 They decided it was the most credible. The actual answer is, is that research conducted in that year showed that somewhere between 100 and 667 people may have died from second-hand smoke inhalation in that year .
> M303 That actually shows you how appalling the research is.

M301 But the issue though is more, for me, about how the truth is one thing. The truth is that there are a number of studies done in a year. And the methodology for each of them was this and each of them came to this conclusion. But I'm a communications person, I want one thing and so…. I'm forcing them to squeeze into this little box, because I know that the media are more likely to jump on to something that says 'yep, about 400 people died in NZ of second hand smoke each year'. Then they do a headline which is ‘400 people died of second hand smoke in NZ’, but they are not going to do a headline out of ‘somewhere between 100 and 667 people die in NZ from second hand smoke inhalation’ (group three, first session).

Participants in this focus group returned to the same dilemma in the second session:

M304 I really like [example] five though because it's…it's a little bit longer, but it's quite reasonable. It's not taking an extreme position, and it's really talking about some of the limitations that exist around the science and to me it makes sense. It's a kind of comment on this particular issue that I would respect because of that.
M303 But it's not likely to get reported is it?
M304 No it's not (group three, second session).

Making Information Accessible

Members of several groups articulated the desire to be given clear, impartial information about health-related issues, but then to be left with the freedom to make their own consumer decisions, as and when they felt the need to do so:

M306 We're going back to your point about information available. There is quite a lot of information available to us now, that we're just not aware of because we're not really interested. When I was pregnant I really looked into the safety issue, like going through airport things etc., because it can affect the foetus. And so I looked into a lot more and found out a lot more and at airports I refused to go through the thing and I had to be body searched each time. Because for me that was important, and it's something I've never come across before, but because it was really important to me, I looked into it…. If the person is personally interested in it, then of course they are going to want all the information. It's not a matter of ‘oh I can't cope with it’. If they're interested and passionate about it, of course they want all the information, and then it's the consumer's choice as to what they read or don't use. It's their right to have all the information put there (group three, first session).

M402 I suspect also people want the right to be able to make up their own mind sometimes. I was just thinking of the issue of vaccinating children. So if people do feel really strongly about it...[they will] go and find out…. If they don’t care, well then they will just get on with it. But if there’s something else happening then…you would want the right to be able to say ‘no I don’t want to have my child vaccinated’ or whatever (group four, session two).

With some prompting, the mothers in group two discussed their preference for avenues of access to health related information in the context of nit treatment for their young children – an issue about which they all appeared to have strong feelings:

I.	*Say we took the nit question rather than the cell phone question. If you knew that somewhere you could get a sheet that said 'this is what's in this product, this is what we've done to test it, and this is what the [safety] issues are', would that be helpful?*
M202	Very helpful.
I.	*And where would you want to see that information come from? What sort of form would you want it to be in?*
M206	On the product. On the box.
M203	On the box. You know those little sheets they put in boxes and they tell you all about it (group two, second session).

One member of the young professionals group had gone looking at websites related to the issue of cell phone safety in the interval between sessions. He had printed out some of the results of his searches and brought these to the second session:

M303	And this is quite close to the issue. If you go to the Ministry of Research, Science and Technology web page [pulls out printout of MoRST website], then you go 'I want to look at research and innovation in New Zealand'. So you click on that, and you go to that page…and 'I want to look at Current Research in Innovation news' [pulls out printout displaying the following words] '404 object not found'. So yes. That to me pretty much says it all. I'm assuming that they're [MoRST] the closest organisation to actual people on the doing the work and so I'm thinking this is clearly going to be the most direct form of communication to get information (group three, second session).

Keeping websites up-to-date is a challenge and they can be off-line for a number of reasons. However, at least for this group MoRST has a clear mandate to act as an intermediary between scientists and the public.

Communicating in Plain Language

In all groups, the use of plain everyday language was seen as a key to credibility as well as to effective communication. When an attempt was made to communicate different viewpoints and uncertainty in plain language, this was seen by some as further evidence of the honesty and credibility of the source. On the other hand, emotive language and hyperbole were seen as unconvincing.

Written Comments About Plain Language (session two)

> *Sensible, essential information on children, radiation and aerials* [Internet excerpt – see appendix five, example two] *(M101).*
>
> *Said in plain English. Makes sense. It's a cautionary statement which is better than being too dogmatic one way or the other.* [Internet excerpt – see appendix five, example two] *(M206).*
>
> *Narrative style – moderate positioning. Reasonable. No scare-mongering* [Internet excerpt – see appendix five, example five] *(M304).*

Agendas present. Language tends to be emotive [Internet excerpt – see appendix five, example three] *(M403).*

Verbal Comments About Plain Language

M206 Yes I would be happy with it [an information sheet with nit treatment] but if they would put it in plain English, it would be a lot easier. For people…like you were saying having labels on food and on medicines. It's written in a way that the man on the street can really understand (group two, second session).

M303 I like the digestibility of example five in that it's kind of like you'd actually go to maybe a talk and a public speaker, all that sort of thing, and it's almost like somebody's speech, which I like.
M305 Yeah, [I feel the] same. It's accessible.
M303 It is. And it does prove that you can actually, you know, show data or research in a form which is accessible to people that don't necessarily understand them. It picks up the important bits without being extremist (group three, second session).

In at least one instance the use of technical terms was also seen to get in the way of meaningful communication:

M305 Whereas [example four] it's sort of like you'd have to explain to me what the alteration of cellular calcium ions is and how cellular calcium ions relate to your body, because I don't know what it is. To me it might mean that you're lacking in milk or something like that (group three, session two).

The Power of Visual Information

As one participant noted, people respond immediately to visual information:

M305 But other people I spoke to as well, when people had seen the picture of the outline of the person and the waves sort of going into the brain [on the notes from the first session]…. Most people said that they reckon if they saw that instantly they would think that cell phones are dangerous. That's a really bad thing…. Like the picture tells them a thousand words (group three, second session).

In session two, the first example taken from the Internet purported to show an 'actual photo' but was in reality a computer-generated image of three heads. Although these were supposed to represent an adult, a ten-year-old and a five-year-old, all three 'heads' were identical in both size and shape (see appendix six). Notwithstanding this obvious visual clue, participants in every group were initially taken in by the power of the images presented, although not every member of the teachers' group was personally convinced:

M404 I found the top one the most dangerous….
I. *Because?*
M404 Well for a start you've got a relationship of a Senator here..[names American politician]. He's got diagrams and he hits you with the last sentence and the first word 'proving'. I think it's really powerful. I think that could have an affect, that could sway opinion.
M401 It doesn't say anywhere what those pictures are.

I.	*What about these pictures?*
M401	They're pretty graphic. They look horrendous but it doesn't actually say whether it's radiation, it doesn't say it's heat.
I.	*Yes, it says, actual photos of radiation entering an adult brain.*
M401	Are these the ones you showed us last week?
I.	*It's a similar type of image.*
M401	It doesn't say the radiation comes from cell phones anywhere does it?
M402	There seem to be a few little jumps don't there?
M404	The setting up of children. It's a very powerful image.
M405	(looks at the image) The child's head doesn't seem to change from there to there. Size.
M402	And I agree with you. I think having a photo like that, or whatever it is, picture, diagrams or whatever, that they look scientific so people…[are convinced by them] (group four, second session).

Only when their attention was steered to the features mentioned did participants in the other three groups look more critically at the mismatch between words and images (or indeed at the obviously 'fake' features of the image itself). As all the comments about this Internet example illustrate, social contexts and expectations of relevance also played a part in determining the nature and strength of reactions to these images:

M206	I think just the visual impact as well as the fact that the last one is a child. That gives you a fright. Well it does to me anyway. A small child having received that much radiation. The word 'radiation' too is very emotive, you know you think nuclear power and 'frying your brain' and all that kind of stuff. So, yeah. So that makes a definite impact [before the discussion of fakery] (group two, second session).
M305	Well, example one, I have to find, I say is quite believable because it's very visual. But then coming from a Senator, and it doesn't really say where he got the information from, so it could be that he's trying to get elected so he's just scaring everybody, but the picture certainly worked for me (group three, second session).

However, even though the image was undoubtedly powerful, with a little more debate, most people put it into perspective, one way or another:

M303	But the first one [the visual image] is that bad? I mean if it's not bad, then it doesn't really matter how long or short or anything.
M305	Yeah, like when you put headphones on to listen to your radio is the picture going to look the same?
M303	When you have a bath is your entire body going to be heated up or anything like that? Who knows? It sort of states a fact for me, but the fact is it seems irrelevant (group three, second session).
M206	They've been teaching them [the participant's primary school-aged children] how to discern in terms of advertisements. What kind of information are they trying to get across? How are they hooking you in? So children are learning that sort of thing, so this is very relevant to children's education that they should be trying to interpret scientific information, the sources that…from issues like this (group two, second session).

The mothers in this group also expressed a desire for information about science issues to be provided in a format which would allow them to interact with the material in the company of their children, learning about the issues together.

Discriminating Between Internet Sites

Those participants who were familiar with the Internet used the URLs associated with each of the Internet excerpts given in the second session as one basis for making judgments about the quality of information, albeit with initial prompting from us in some cases:

> M303 …and it's from ‘www.crystallinks.com’. That just freaks me out. How do you find these websites? (group three, session two).
>
> M105 Well if the website is ‘Geomancer’, that brings up a cultist thought to me, and I think that the Americans are run on money, so I mean that kind of closes [prevents me] believing him, but that's a personal thing
>
> M104 Can I say I agree with this…in terms of the sources – ‘the Geomancer’, ‘the Green Party’, ‘Crystal Links’ and ‘Earth Files’ all cause me to question the reliability. I mean I work with people who are members of [names political party] but some of them are incredibly naive and accept all kinds of myths, which are completely without foundation, and even get their own myths confused. So …. I mean I would still be sceptical. She makes some interesting comments about children's skulls, but then she says 'there is new evidence' you see. So she has made a valid comment that we have to be sensible about it and protect in terms of children. That's interesting, that's valid. But then she's leaping to evidence of the health effects, where is the evidence? (group one, session two).

Findings in Perspective

The excerpts reported in this section show that participants were generally both able and willing to engage meaningfully with the material shared with them. In her journal, one of the kindergarten mothers commented that the experiences of the first session had been reassuring for her:

> *After reading all the data provided and through our discussions – I feel cell phones and their sites may not be as harmful as I first believed (M201-Journal entry).*

Like the researchers in the Wellcome Trust project (1998), we found that the participants enjoyed the opportunity to engage with science ideas in a low-key setting. However, our research focused more on understandings *about* science, with the context of cell phone safety used as a means to an end rather than as an end in itself. This somewhat different focus allowed some tentative insights into factors that appear to help shape public attitudes to science in New Zealand, as described in the next section.

SECTION SIX: ATTITUDES TO SCIENCE

INTRODUCTION

The research outlined in section five reported on the sense that the focus group participants made of the information we shared with them about the issue of cell phone safety. The participants themselves introduced a diverse range of other science-related issues into the discussion at various points. As they talked to each other and to us, some insights into their more general ideas about science emerged. This section seeks to combine the insights that arose within the context of the issue of cell phone safety with the broader pattern of attitudes to science revealed during the telephone survey research. The section begins with a short discussion about ‘science literacy’ to provide a framework for the discussion that follows.

THE IDEA AND SIGNIFICANCE OF SCIENTIFIC LITERACY

Understandings *in* Science

The term ‘scientific literacy’ is sometimes used to encompass understandings *in* science – as in holding a wide-ranging understanding of the ‘big theoretical ideas’ of the field. The long list of topics described by Hazen & Trefil (1990) in their book *Science Matters: Achieving Scientific Literacy* illustrates this content-based interpretation of science literacy.

Where the theoretical ideas of science have been emphasised, surveys have commonly found many members of the general public to be wanting in the necessary levels of understanding and/or detail. However, criticism based on such perceived shortfalls in conceptual understanding has come to be regarded as a *deficit* view of scientific literacy (Layton 1993). The assumption that well-developed theoretical understandings are a necessary precursor to engaging with science has been subjected to increasing levels of critique. Aspects of this critique are introduced later in this section.

Understandings *about* Science

The wide range of meanings assigned to ‘science literacy’ (Laugksch 2000) can also encompass understandings about the nature of science, and attitudes and values held towards science. In this research, we have interpreted the meaning of science literacy in this broader sense. The focus group discussions sought to reveal the participants’ broad understandings of the epistemology of science (as in theory/data relationships, for example) and of the sociology of science, as outlined in section two of the report.

Interactions Between Science and Everyday Understandings

Jenkins (1997) points out that all so-called ‘science literacies’ are issue-dependent, and also relate to the context of use (defined by him as areas such as employment, family, leisure, policy making). However, according to Jenkins, previous research in this area has revealed that:

> 'Citizen thinking', i.e. everyday thinking, turns out to be much more complex and less well understood than scientific thinking and, as might be expected, well-adapted to decision making in an everyday world… (p. 40).

We wanted to know how the mix of ideas in and about science, held by our research participants, interacted with their everyday thinking to shape their attitudes and beliefs in areas where science knowledge is still unsettled – that is when the science is still 'in the making' (Bingle & Gaskell 1994).

This sense of bringing everyday judgments to a science issue has already been noted in findings reported in section six. As participants interacted with science ideas concerning cell phone safety, they brought to bear their everyday understandings related to both the content and the methods of science. This section seeks to add insights into how everyday understandings might have been shaped, and may then continue to influence people's thinking about and attitudes towards science. This synthesis is then used to shape recommendations for more effective communication between scientists and members of the public, and to signal ongoing questions in need of more discussion or research.

A Focus on the 'Content' of Science

What do People Need to Know About Science Theories?

This is just one of the questions that are critically important to the decision making of science communicators. While attempting to avoid adopting a research design that would lead almost inevitably to the construction of a 'deficit' view of the science knowledge of some of the research participants, it was nevertheless very evident that people brought differing levels of theoretical understanding to the focus group discussions. Similarly, the telephone survey found widespread uncertainty about those few theoretical questions that were posed (especially in relation to the status of genes and atoms as theoretical entities). The only general conclusion that could be drawn from this section of the research was that most people are inclined to strongly realist views – that is, they see the theoretical entities of science as 'real things', even if they appear to know very little more about them.

But what 'more' about the theoretical ideas of science might people need to know in a specific sets of circumstances, and how easily can they come to know that which is identified as important from the scientists' point(s) of view? We have found a range of arguments about these inter-related questions in the research literature.

- Layton (1993) suggests that many people can engage with the theoretical ideas of science in a specific area, if and when they are motivated by personal need or interest to do so, a position that has been endorsed in much subsequent public understanding of science literature. The Wellcome Trust (1998) researchers reported that people had little difficulty in engaging with the broad theoretical ideas needed to discuss social and ethical issues related to cloning (although they did add the caution that such ideas need not be introduced in detail). The telephone survey component of the current research project reported 48 percent disagreement with the statement that 'science and technology are too difficult for me to understand' and 73 percent agreement with the statement that 'I enjoy finding out new ideas about science'. Together these findings suggest that it is worth making the effort to help people understand key ideas in science, if and when they perceive a need to so engage.

- From a different perspective however, Roth & Lee (2002) have suggested that individuals do not need to know a lot of science themselves, if they have access to opportunities to discuss concerns framed from their own perspectives with those with scientific expertise. In this socio-cultural view:

  > ...individual-centered approaches to scientific literacy do not account for the fundamental role of division of labor in the make-up of society, allowing us, for example to drive cars without knowing anything about engineering or mechanics, the design of external mirrors to reduce wind noise, or the chemistry of rubber that allows a maximum of tire sliding friction (Roth & Lee, 2002, p. 35).

  The case studies described by Roth & Lee (2002) and by Tytler, Duggan, & Gott (2001) document the *trust* that developed between the scientists involved and others who were active in each group. Because of this trust, the detailed knowledge of the scientists was accepted by others in the group, who saw their own contributions as being made in other ways (e.g. by contributing detailed local knowledge). Given the level of lack of trust of scientists reported from the telephone survey, such collaborations would arguably need to be built carefully and patiently.

  Tytler *et al*. also ponder whether one of the participants in their case study might have been 'more confidently involved' if he had had 'a surer grasp of substantive, or procedural [science] ideas' (p. 359). As they point out, the environmental group eventually prevailed in this dispute because they used science well to reveal flaws in the science arguments advanced by their opponents.

- Solomon & Thomas (1999) review research that suggests that, for many people, the act of *participation* is what is important. In this view, the sense of being included, through invitations to group discussions that support joint decision making and action, is the key to successful adult interaction with science, in areas of public concern.

For the moment we put these differing points of view to one side to review what actually happened when our focus group participants engaged with the ideas of science in the chosen context of cell phone safety. We return to this debate about the level of knowledge needed to engage with science issues at the end of the section.

Engaging with the Theoretical Ideas of Science

Whichever point of view is adopted, science communicators do need to be aware of the challenges they may face when members of the public bring their own everyday understandings to the theories of science, as they attempt to relate these to an issue of concern. The following analysis suggests that, when addressing this question, attention to 'big' ideas rather than fine detail could be a helpful beginning point for decision making.

Thinking About Cell Theory

Example one from the first focus group session described the use of nematode worms to research a human health question. The report briefly explains that nematodes were 'chosen because the ways their cells work are well understood and their biology is simpler than that of bigger, more complex creatures' (appendix four).

In this case, the underpinning theoretical premise is that most cells, whatever organism they are a part of, carry out the same set of basic operations, using the same basic cell organelles. Examples might include respiration, cell division, and protein synthesis – although the actual proteins made will obviously vary between organisms and indeed between cell types within one organism. If this premise is accepted, and if the cells of nematodes are seen to be affected by low-level microwave exposure, then it is possible that cells of higher organisms will be similarly affected. This link did not appear to be recognised by any of the four groups. As a consequence, all rejected research on nematode worms as being irrelevant, or of limited relevance, to humans.

Other research from the science education field suggests that this finding could have been predicted. One recent research project that probed the cell biology understandings of nearly five hundred British 14–16-year-olds found that they had very confused ideas about cell processes (Lewis & Wood-Robinson 2000). Both this study and a similar Spanish study (Banet & Ayuso 2000) found that many students of a similar age group also had very confused ideas about the most fundamental relationships between genetic material and cells. As shown in section five, the teachers (focus group four) used their understanding of genetic diversity in different species to argue that changes to the cellular activity of nematode worms were of limited relevance to human cells.

While the focus of the question was somewhat different, it is interesting to note that 32 percent of participants in the telephone survey said that they did not know whether genetically modified tomatoes contain genes. Only 35 percent of those surveyed were sufficiently confident to 'strongly agree' that such tomatoes do contain genes.

The lack of an understanding of the similarity of cells at the very basic level may be an artefact of the predominance of genetics over other areas of cell biology in recent public communications about science. Or it may be that this very basic theoretical idea seems so obvious to science communicators that they do not see the need to develop the point. Yet the understanding of the similarity of basic operations in all cells underpins research in other important health-related areas.

Radiation – Another 'Big Idea'

Comments made during the focus group sessions suggested that many participants did not differentiate between *types* of radiation. Thus, when asked for their initial ideas about safety issues related to the use of cell phones, one participant in group one said 'I wrote "radiation causing brain tumours/cancer"'. The diagram used to differentiate between ionising and non-ionising radiation (see appendix three) attracted considerable interest.

There was some evidence that the meaning that we had in mind when discussing the distinction between different types of radiation was not necessarily the meaning that was constructed by the participants. One member of focus group two, as she was preparing to leave the first session, made a comment that suggested that she now thought ‘the shorter the wavelength, the more dangerous the radiation’ and she used this association to reassure herself that microwaves are ‘not as dangerous as I thought’. This represented a considerable over-simplification of the distinction that we were attempting to draw between ionising and non-ionising radiation. In part this might have happened because some participants did not appear to appreciate that they are exposed to other sources of radiation daily. This insight emerged from a comment made at the start of the second session:

> M201 [Last time’s discussion and the information provided] probably made me more aware of things so far with what we have learnt. It just was reassuring pretty much that they are doing a lot of studies about it [cell phone safety] and they are doing it world wide, and yeah there's a lot of information there. I just found it quite good, reassuring. And they're not as bad as what I really thought that they were. It's just a little bit of knowledge, which goes a long way. It's mainly that and just another thing with…. I mean there's a lot of things around the house that we don't know about like smoke alarms, computers and all the radiation and stuff that comes off of them, and no one knows because it is not broadcast. It's only [said about] all the cell phones, it's like 'oh you'll get brain cancer and blah blah', and everyone sort of goes into a big tizz about it, but there's lots of other things out there [that emit radiation] too (group two, second session).

Can ‘Science Content’ Communication Challenges be Anticipated?

The radiation example illustrates the nature of some challenges science communicators face when drawing on the theoretical ideas of science to discuss issues of concern. However, where there is access to relevant research in the science education field, science communicators could access this to *anticipate* the kinds of theoretical ideas that could assist them in making links to everyday ideas that may be held by members of the public. An extensive bibliography of such research exists (Pfundt & Duit 2000) and is updated regularly.

Where such research is not available, then focus group research of the type carried out in this research project has the potential to uncover everyday ideas that may be hampering effective communication between scientists and the public. However, the design and ‘tone’ of such shared conversations involves some delicate balancing of priorities. In the case described in section five (page 84), where one participant explained the differences as she saw them between bird cells and human cells, it was our sense that any attempt to debate that understanding, at that immediate time, could easily have curtailed the flow of the conversation. As it was, despite our response that the idea was ‘interesting’ this participant made the self-deprecating remark that she was probably ‘naïve’. Irwin (2001) notes that research projects that plan to provide science information as part of the design *assume* that a deficit will exist in public understandings. He poses a series of challenging questions in relation to this dilemma:

> Does dialogue imply that public knowledges are given the same status as scientific understandings – or instead that familiar deficit notions of an uniformed public are recycled? Who, for example, gets to decide what counts

as a legitimate problem for discussion? How are the *informative* (or information giving) and *consultative* (or information gathering) dimensions of participation to be balanced? (Irwin, 2001, p. 3, italics in the original).

A FOCUS ON THE NATURE OF SCIENCE

In his extensive survey of selected case studies of what adults needed to know about science in order to effectively engage with contentious science-related issues in their communities, Ryder (2001a and 2001b) differentiated between ‘subject matter knowledge’ and areas that encompass ideas *about* science including:

- understandings related to the knowledge-building processes that differentiate science from other disciplines (epistemology); and
- understandings related to the social processes of validation and control of that knowledge (sociology).

Ryder’s categories were useful for our research as he specifically sought to create a generalised framework of ideas about science that are important in public interactions with socio-scientific issues. Key factors that Ryder identified within these two areas were kept in mind as both the telephone survey and the focus group materials were designed. In this section we also use the two areas as a framework for the synthesis of the research findings.

Knowledge-Building Processes (Epistemology)

Factors found to be important in the studies that Ryder (2001b) analysed are summarised below. They included:

- assessing the quality of data (e.g. understanding inherent variability of measurement);
- study design (e.g. appreciating that there is a range of possible methodologies, each with different purposes and outcomes, recognising relationships between sample size, sample bias and validity, understanding the selection and control of variables);
- assessing the validity of interpretations made of the data collected (including differentiating between correlation and causation studies and understanding how this difference impacts on both study design and interpretation);
- recognising that interpretation may draw on knowledge sources in addition to the data actually collected in the study;
- recognising that disagreement about data interpretation can be a legitimate feature of science;
- identifying relationships between theoretical models and the design and interpretation of empirical studies;
- being aware of assumptions made in relation to models, instances where estimation has been necessary, and of the role of modelling in the estimation and management of experimental error; and
- appreciating how all of the above contribute to uncertainty in science.

While it would be difficult for any one research project to meaningfully investigate all of the above areas, a number of relevant insights did emerge from the analysis of the focus group discussions. These are outlined next.

The Ghosts of School Science Past?

Hogan (2000) has highlighted the challenges that face any researcher wishing to explore views about the nature of science. When discussing the significance of research related to school students' understandings about science, she draws a distinction between two kinds of knowledge. One kind encompasses what students say they think about science as it is practised by scientists. This kind of knowledge was elicited in the telephone survey. The other kind of knowledge is the personal understandings, beliefs, and commitments that are brought to science learning and mediate experiences of that learning. These beliefs, Hogan suggests, are brought to bear on the knowledge that the students themselves – not professional scientists – produce and encounter.

While Hogan's focus was on the manner in which school students interact with ideas about science, it seems prudent to bear her distinction in mind when interpreting evidence of adults' understandings of the nature of science. They too bring their own knowledge to bear on the issues they discuss. People can only answer direct questions about the nature of science by saying what they know explicitly. However, ideas about science that are held implicitly shape thinking in ways that are difficult to unravel. It seems likely that at least some of these ideas will have originated in meanings that were constructed from school science learning – especially for those adults who have had little to do with professional science in the years that have elapsed since they left school.

Negative attitudes held by some adults with respect to their past experiences of school science have been reported in previous research (CM Research 2000). We did not encounter comments of this nature, but the focus of our discussion topic lay elsewhere. However, we did encounter patterns of responses that suggested some lingering echoes of school science could be informing the *plausibility* judgements that were described in section five of the report.

Comments About the Methods of Science

When discussing the research projects introduced in session one, participants drew on ideas that seemed to them to represent plausibility and common sense. As they brought their everyday experiences to bear during the discussion, some insights into their possible implicit beliefs about the nature of science emerged. Some of the comments made about methods appeared puzzling at first. However, it could be that the preoccupation with certain aspects of methods can be traced back to a lingering influence from school science education.

The manner in which practical work in school science is typically carried out has been criticised for misrepresenting the diversity of methods of scientific inquiry as one unproblematic 'scientific method' (Jenkins 1996). Typically, this method is characterised as 'fair testing' at lower levels of the school curriculum (Watson, Goldsworthy & Wood-Robinson 1999) and/or as 'recipe' practical work at the secondary level. Where students follow instructions to 'discover' a science idea, this type of practical work has been criticised for enforcing empiricist views of the nature of science (Jenkins, 1996). The 'experiment'-focused framework excludes those types of inquiry that are typically practised in the systems sciences such as geology, meteorology, and ecology (Mayer & Kumano 1999). In all these fields, as in epidemiology, historical methods of data collection are important and valid.

The framework typically followed is as follows:

- a question or aim is posed (sometimes without any reference to relevant theory – as in ‘consumer testing’ questions – e.g. ‘Which is the strongest paper bag?’);
- a ‘method’ is established or given (for fair testing this will typically involve the identification of variables and the construction of suitable control);
- the ‘experiment’ begins and data are collected as planned;
- the ‘results’ are written up, often in some predetermined format; and
- a ‘conclusion’ is drawn, typically based on the experimental data alone, again with little or no explicit reference to any relevant theoretical models that might have influenced that interpretation.

Fair testing and other such traditionally ritualised approaches to school science practical work present a tightly bounded sequence in which various contingencies are able to be anticipated and managed in advance of an ‘experiment’ beginning. Samples are collected, or measurements are taken *after* this initial planning has been completed. Some of the comments made by participants in response to research projects five and six suggested a lack of understanding of the validity of *retrospective* sampling (see pages 86 – 87). Thus it seems at least possible that the reasoning pattern captured here represents a lingering trace of images about the nature of science that are implicitly promoted during school science education.

Falsification

Another point of view on the nature of science, albeit expressed by just one participant, may again possibly represent a lingering remnant of ‘practical work’ in school science. School students may be taught that scientific proof can only be obtained by the creation and subsequent disproof of a ‘null hypothesis’. This approach, first suggested by Karl Popper in response to philosophical challenges posed by other philosophers of science, appeared to be used by one participant to suggest that science deliberately restricts the types of approaches that will be used for seeking answers (see M101’s views on page 87). The undertone of this suggestion appeared to be that this can be used to bias research in ways that are convenient to the types of findings desired. Again, as in the ‘fair testing’ view, the effect may be to limit personal understandings of what can count as a valid method for seeking evidence to answer research questions in complex debates about contemporary issues.

Possible Ways to Deal with this Dilemma

When the reasoning behind the method and design of the research remains obscure, the research as a whole is likely to be rejected as implausible. Since comments of this type dominated the focus group discussions and were common in the written responses to the research summaries presented in the first session, this is clearly an area that could provide a fruitful focus for science communicators. When reporting science, checking for assumptions concerning the ‘obviousness’ of the theoretical reasoning behind method will be time well spent.

Understanding Significance

Comments about findings that were said to be significant (see page 89) reflect the mindset of those in the telephone survey who were prepared to take the phrase ‘scientifically proven’ on trust. This is another area in which science communicators could provide information to help people decide how significant the ‘significant result’ reported actually is, in the light of all the factors that impact on the research. They could provide a commentary that could be used to keep the findings in perspective relative to other research in the field, for example by explicitly discussing the manner in which sample size has influenced the overall significance of the research findings.

Relating Evidence to Theory

One criticism of common methods of school-based practical inquiry is that they neglect the development of theory/method links. In fact, research suggests that theory/evidence links are not successfully developed during most students' experiences of school science generally (Driver, Leach, Millar & Scott 1996; Solomon, Scott & Duveen 1996). In this case, it seems likely that the invisibility of these crucial links will be characteristic of the implicit beliefs about science held by a significant proportion of the population. Furthermore, Ratcliffe (1999) cites literature that suggests that scientists themselves may *implicitly* learn to co-ordinate theory with evidence as they come to master the methodological aspects of their work in close alignment with their theoretical thinking. If the development of these links is indeed implicit, then scientists themselves may not recognise the need to carefully shape their communication about this important aspect of their professional practice when reporting to the wider public.

Tytler *et al.* (2001) describe this dilemma as it unfolded in an actual environmental dispute. One leader of the environmental group was a psychologist who understood research methods because of his work. However, he downplayed the challenges of developing the necessary understanding of the emission-sampling regime at the local cement factory as being 'a statistical problem'. The researchers in this case observed that:

> It is intriguing that Jim classifies this as a statistical problem, yet it is clearly a methodological or procedural issue because it concerns accuracy and variability of measurement, analysis principles, and the adequacy of the monitoring regime in dealing with confounding variables. This "disappearance" of science has been referred to elsewhere and echoes the treatment of methodological knowledge as "common sense" by industrial science workers (Tytler *et al.,* 2001, p. 356).

Unless the issue of the seeming invisibility of theory/method/evidence links is proactively addressed, then problems for science communicators would appear to be compounded in the following manner:

1. Scientists may take the theory/evidence links of their work for granted, especially the very broad 'big picture' links that seem to them to be so obvious (for example the basic operational similarity of cells).
2. When reporting to the public, such links are assumed and may not be mentioned in the description of the research that is given (especially when brevity is an issue).
3. The methodology may then be judged against everyday criteria that are plausible to individuals who lack the relevant theoretical overview.

Rather than being weighed against validated scientific theory, evidence appears in these cases to be weighed against common-sense beliefs, with results such as those outlined in section five. When 'common sense' is brought to bear on questions of science methodology, the judgments made can thus continue to provoke suspicion about the plausibility and relevance of scientific research.

The Challenges of Contextualising Survey Questions

As noted in section two, at the time that the telephone survey questions were developed, we decided to check for awareness of theory/evidence links as part of the profile we were attempting to build in relation to public understandings about science. Our attempts to find ways to succinctly contextualise the probes resulted in the statements about Science and Knowledge Building (question five - see appendix one). When responses to the survey began to be collated we were initially surprised at what seemed to be a more highly developed awareness of theory/evidence links than we had expected. However, once the focus group data became available to inform the overall findings we came to suspect that the statements used elicited common-sense responses, and as such did not actually probe theory/evidence links at all. This issue is discussed more fully on pages 24 - 25.

The telephone survey did find that a majority of people (62 percent) believed that doing more experiments would help scientists to reach agreement. This could be interpreted as indicating that some of these respondents did not appreciate that disagreements of interpretation are often linked to the employment of different theoretical frameworks.

Seeing is Believing

Research suggests that those who hold essentially empiricist views of science perceive a 'hierarchy of credibility' (Desautels & Larochelle 1998, p. 118) in which tentative ideas (hypotheses) become theories which are then affirmed by appropriate empirical methods to become laws or, arguably, 'facts'. The process is seen to proceed from data gathering to theory building to law/fact establishment. Desautels and Larochelle suggest that such beliefs are strongly associated with realist views of science – found to be prevalent in the thinking of those surveyed for this research (page 37).

Another possibility is that people interpret the words 'experiment' and 'theory' in an everyday sense rather than in the narrower sense intended by scientific research. In this type of meaning an 'experiment' has an element of 'suck it and see' – an action is conceived and attempted, with largely unpredictable consequences. Similarly, a 'theory' in this everyday sense is 'no more than a simple everyday prediction [and] is conveyed in offhand comments like: 'I've got a theory that it's chips again for tea!' (Duveen, Scott & Solomon 1993, p. 20).

In the absence of a sense that theory influences both *how* we see and *what* we see, it seems almost inevitable that people who believe strongly that 'seeing is believing' will continue to be suspicious of some of the findings of scientists. In that case an important challenge for science communicators is to find ways of making these links more transparent, without in the process alienating people by introducing more theory than is necessary to make sense of the method and/or findings under consideration.

Bringing Everyday Knowledge to Bear on Science Issues

Participants drew on their everyday knowledge of social contexts and motivations to make judgments about whether or not to trust scientists' findings and reassurances. Personal decision making in this area appears to be contingent on the context of the debate, the source of the information, and on the type of detail provided in the information available.

Bingle & Gaskell (1994) advocated that, when asked to make judgments about areas of current scientific research – which they called 'science in the making' – school students could be taught to look at sociological issues such as possible bias related to employment interests. They used the open question of whether microbes from earth can contaminate other planets if they leave earth on the exterior surfaces of probes, and demonstrated that making judgments about the methodological aspects of this very real argument requires an in-depth specialist knowledge of the field. However, an analysis of sources of funding for the scientists who have adopted different sides in the debate, and of the established bias/interests of the journals where their research has been published, would allow people without such specialist science knowledge to at least engage with the debate. Unfortunately, as Solomon & Thomas (1999) point out, there do not appear to be any generalisable, reliable, and easily taught skills for deciding whether an expert, or a piece of evidence, is trustworthy.

Perhaps more manageably, Solomon & Thomas (1999) suggest that adults need to bring an understanding of a nation's social structure, as well as appropriate scientific knowledge, to debates about science-related issues. This includes aspects such as an understanding of:

- structures of government regulation and control;
- structures for societal decision making; and
- institutions that validate scientific research.

In the case of some science-related issues, such as global warming, they point out that global politics, as well as local politics, need to be understood. It is in this social area, they suggest, that a meeting point between 'science' and 'the public' can best be constructed. Again, analysis of our research data suggests some challenges that science communicators will need to address.

Perceptions of Scientists' Degree of Self-interest

The focus group sessions provided clear evidence that the participants did indeed make social context types of judgments when considering the plausibility of scientific research (see pages 78-82). Participants in all four focus groups linked the type of science that is done to funding sources and/or business interests. The telephone survey similarly showed that those who suspect scientists of not always telling the truth (15 percent of the sample) link scientists' motivations to 'hidden agendas' and self-interest.

Some of the websites searched during the compilation of the focus group materials referred to an increasing tendency to make links between cell phone safety research and the deliberate deception practised by some tobacco companies when discussing research related to the health effects of smoking. For example *'Tobacco-izing telephones: Stewart Fist's latest folly'* (Milloy 1999) is a stinging attack by one Australian journalist on another journalist who has used this link to raise doubts about the integrity of research carried out into cell phone safety. It became evident during the focus group sessions that this is a very real issue for science communicators to contend with.

Knowing About Validation Processes

Where social context criteria are used for making judgments about scientific research, they may not be balanced with a well-developed awareness of communal processes of validation for research findings, for example peer-review. Forty-two percent of respondents to the telephone survey disagreed that scientists need to persuade other scientists of the validity of their work. However, use of the word ‘persuade’ left the statement open to interpretations that we did not intend. Comments made during one focus group session suggested the idea of the scientist as ‘lone maverick’:

> M101 ...it depends on who is funding the science projects, because they’re loads of scientists that have been working things out in their garage and have got vehicles that can work on water, but it’s not in the interests of the commercial field….the information is passed to a certain point where a company then goes ‘that doesn’t suit us so we’ll do something about it’. And they’re kind of bigger than the little home scientist in his garage figuring things for the benefit of human kind… so that’s when a money mogul will come in and say ‘no we don’t want you to…we’ll shut you up’ (group one, first session).

Kelly, Carlsen, & Cunningham (1993) also warn that, in the absence of an understanding of the self-regulating processes of theory-building in science, people could develop the misleading impression that ‘anything goes’. This is very different from the more discriminatory awareness of the role of wider values in scientific research intended by theorists such as Bingle & Gaskell (1994).

Challenges for Science Communicators

Clearly, issues of trust, when linked to everyday understandings of the world of business and commerce, must be taken into account by science communicators. These issues are likely to strongly shape public perceptions in areas where there are obvious commercial gains to be made from the products of the research being carried out and/or where the research is about the safety of existing applications. It would appear advisable to provide transparent information about funding issues wherever possible.

However, it is also clear that addressing the social issues will not suffice as a complete response to the challenges canvassed in this report. While people do link issues of trust to socio-political issues such as sources such as funding, they also make personal judgments about the plausibility and validity of scientific research as it is reported to them. Such issues cannot be addressed without involving matters of theory and methodology, with careful attention paid to the links between these two areas. For this reason, we cannot agree with those who recommend a focus on the social issues alone.

The science ideas that underpin a research area do matter. However, we believe that it is decidedly unhelpful to respond to this challenge by attempting to remedy ‘shortfalls’ in people’s science understandings by giving them a lot of detailed information that they are unlikely to find personally useful. Science communicators need to establish a two-way dialogue with groups who are interested in their work. People will bring their own beliefs and understandings to bear in judging the worth of areas of science research. Unless these beliefs and understandings are made explicit, meaningful communication is unlikely to take place.

This project has sought to establish views about *science*. To that end, we deliberately avoided selecting any issue that could raise *ethical* concerns. However, personal values are also highly likely to impact on personal decision making. As for implicit ideas about science, it seems likely that people may not be able to explicitly identify all of the values that they bring to bear on their thinking about science-related issues. These values, and their influence(s) on personal decision making, are matters for further research.

RECOMMENDATIONS FOR EFFECTIVE COMMUNICATION

To establish avenues of communication that are trusted by more people, science communicators could:

- make the relevant *social processes* related to the research as transparent as possible (including sources of funding, compliance with existing regulatory controls, indications of the number and variety of research projects being carried out in the area, brief descriptions of peer validation processes, and other checks on the scientific validity);

- check for their own *assumptions* about relevant aspects of the science that seem ‘obvious’ (including basic theory, aspects of method, and the interactions between method and theory – where possible check against the science education literature for indicators of likely problem areas);

- shape information with these possible areas of misunderstanding in mind. Use simple direct language with a minimum of technical jargon and avoid excessive detail. Concentrate on centrally important concepts and principles;

- check new written materials with members of the public where possible before widespread release to ascertain meanings that are constructed when members of the public interact with the ideas as expressed;

- consider making use of visual materials where possible and provide a guide to ‘reading’ these in the manner intended (in particular, briefly explain any imaging techniques that are relevant to the area and give simple information about how to recognise and read the meaning of visual images of different types);

- make information available where it can be easily accessed as a matter of choice. If possible use a range of different formats/media to suit the preferences of different groups of people (for example, consider provision of more information with consumer products at the point of sale where appropriate);

- make better use of the Internet and provide a navigation guide to related sites, including those with a different but valid point of view; and

- avoid glib reassurances and any approach that puts a public relations ‘spin’ on potentially unpalatable or uncertain findings. People prefer honesty and can cope with uncertainty.

APPENDIX ONE: TELEPHONE SURVEY

Q1 First I would like to find out about your interest in some scientific and technological issues. As I read out each one, could you please tell me how interested you are in that topic, using the scale 1 = not at all interested, 2 = not very interested, 3 = neither/nor, 4 = quite interested, 5 = very interested.

READ OUT
ROTATE ORDER

	Not at all Interested	**Not very interested**	**Neither/ nor**	**Quite interested**	**Very interested**	**Don't know**
Genetic testing for human disorders	1	2	3	4	5	9
Space research and astronomy	1	2	3	4	5	9
New methods of transport	1	2	3	4	5	9
Computing and the Internet	1	2	3	4	5	9
Cloning	1	2	3	4	5	9
Understanding earthquakes and making buildings safe	1	2	3	4	5	9
Saving endangered species	1	2	3	4	5	9
Improving quality of agriculture and horticultural products	1	2	3	4	5	9
New medical techniques and treatments	1	2	3	4	5	9
Research into climate change	1	2	3	4	5	9

Q2 For each of those same issues could you now please tell me how beneficial you feel that each of these developments has been or is likely to be to humanity, on a scale where 1 = not at all beneficial, 2 = not very beneficial, 3 = neither/nor, 4 = quite beneficial, 5 = very beneficial.

READ OUT
ROTATE ORDER

	Not at all beneficial	**Not very beneficial**	**Neither/ nor**	**Quite beneficial**	**Very beneficial**	**Don't know**
Genetic testing for human disorders	1	2	3	4	5	9
Space research and astronomy	1	2	3	4	5	9
New methods of transport	1	2	3	4	5	9
Computing and the Internet	1	2	3	4	5	9
Cloning	1	2	3	4	5	9
Understanding earthquakes and making buildings safe	1	2	3	4	5	9
Saving endangered species	1	2	3	4	5	9
Improving the quality of agriculture and horticultural products	1	2	3	4	5	9
New medical techniques and treatments	1	2	3	4	5	9
Research into climate change	**1**	**2**	**3**	**4**	**5**	**9**

Q3 Please read slowly and carefully

I have some statements some people have made about science. As I read out each one, please tell me how much you agree or disagree with it, using the scale, where 1 = Strongly disagree, 2 = moderately disagree, 3 = neither nor, 4 = moderately agree and 5 = strongly agree

For many of these statements there is no right or wrong answer. We are interested to hear your opinions. It is OK to say you don't know rather than to guess.

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Varies	Don't Know
a)	I enjoy finding out about new ideas in science.	1	2	3	4	5	6	9
b)	I try to keep up with new technologies that could be useful in my daily life.	1	2	3	4	5	6	9
c)	Science and technology are too specialised for me to understand.	1	2	3	4	5	6	9
d)	It is important for me to keep on learning new skills.	1	2	3	4	5	6	9
e)	There is so much conflicting information about science, it is hard to know what to believe.	1	2	3	4	5	6	9
f)	It is important to know about science in my daily life.	1	2	3	4	5	6	9

Q4 And now I have some more statements about science. Again, please tell me how much you agree or disagree with each one. **(repeat scale if necessary)**

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Varies	Don't Know
a)	New Zealand needs to develop science and technology in order to enhance our international competitiveness.	1	2	3	4	5	6	9
b)	Science and technology are important for the preservation of New Zealand's environment.	1	2	3	4	5	6	9
c)	Science is out of control these days.	1	2	3	4	5	6	9
d)	The government should fund scientific research even if we can't be sure of the economic benefits.	1	2	3	4	5	6	9
e)	People shouldn't interfere with nature.	1	2	3	4	5	6	9

Note: when respondent has answered (e), please check that they have understood the negatives and answered appropriately. That is – do they believe it is ok to interfere with nature (should be a 2 or a 1). If they think it is not ok, they should answer 5 or 4.

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Varies	Don't Know
f)	The government should keep tight controls on what scientists are allowed to do.	1	2	3	4	5	6	9

Q4g (If code 6, 5 4 2 1 to Q4f ask) Why do you say that? **(probe fully)**

Q5 And now I have some more statements about science. Again, please tell me how much you agree or disagree with each one. Remember it is ok to say don't know rather than to guess an answer.

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Varies Depends	Don't Know
a)	Developments in science rely on scientists thinking outside the square **(if necessary)** (i.e. thinking laterally and creatively)........................	1	2	3	4	5	6	9
b)	If scientists disagree about something, doing more experiments will help them get the right answer......	1	2	3	4	5	6	9
c)	Scientific predictions are mostly based on lucky guesses..................................	1	2	3	4	5	6	9
d)	If scientists measure something really carefully, they will get exactly the same result every time..........................	1	2	3	4	5	6	9
e)	There is generally only one right way to investigate important scientific questions.	1	2	3	4	5	6	9
f)	New questions for investigation mostly come from previous science research.	1	2	3	4	5	6	9
g)	If you are told something has been scientifically proven, you can have confidence in the results.	1	2	3	4	5	6	9

Q5h (If code 6, 5 4 2 1 to Q6g ask) Why do you say that? **(probe fully)**

Q6 And now I have some more statements about science. Again, please tell me how much you agree or disagree with each one.

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Depends	Don't Know
a)	It is not possible for scientists to be certain about any single cause for some health problems such as cancer............	1	2	3	4	5	6	9

Note: when respondent has answered (a), please check that they have understood the negatives and answered appropriately. That is – do they believe scientists can agree on a single cause with nature (should be a 2 or a 1). If they think scientists cannot agree, they should answer 5 or 4.

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Depends	Don't Know
b)	If two scientists interpret the same results in different ways, one of them must be wrong......................................	1	2	3	4	5	6	9

c)	It is important to have some scientists who are not linked to government interests	1	2	3	4	5	6	9
d)	It is important to have some scientists who are not linked to business interests.	1	2	3	4	5	6	9
e)	Scientists should have to explain and justify their research to the general public	1	2	3	4	5	6	9
f)	When scientists say they can't be really clear about the actual threat posed by something risky, they are telling the truth	1	2	3	4	5	6	9

Q6f **(If code 5, 4, 2 1 to Q6f ask)** Why do you say that? **(probe fully)**

Q7 And now I have some more statements about science. Again, please tell me how much you agree or disagree with each one.

		Strongly Disagree	Moderately Disagree	Neither/ Nor	Moderately Agree	Strongly Agree	Depends	Don't Know
a)	With a really powerful microscope it is possible to see atoms.....................	1	2	3	4	5	6	9
b)	Gravity is an imaginary idea to explain real experiences.......................	1	2	3	4	5	6	9
c)	All tomatoes contain genes, whether they are genetically modified or not	1	2	3	4	5	6	9
d)	An important part of doing science is persuading other scientists to agree with your theories................................	1	2	3	4	5	6	9

Q8 If you were concerned about an issue that could possibly affect your health, what types of things would you want to know about the issue?
(do not read out)

How it could affect you/your health...................................... 01
How you can treat/cure it. What you can do about it 02
Symptoms. How to recognise it 03
What causes it/why it has happened...................................... 04
How it spreads/how you could catch it.................................. 05
Sources of information 06
How reliable the information is about it 07
Depends on the issue.. 96
Nothing 97
Other (specify) _______________________________________ **98**
Don't know... 99

Q9 If you were concerned about an issue that could possibly affect your health, how trustworthy would you find information about the issue, from each of the following sources. Firstly ________________ would you regard information as **(read out scale)**

State randomly	**Not at all trust worthy**	**Not very trust worthy**	**Neither /nor**	**Quite trust worthy**	**Very trust worthy**	**Don't know**
TV documentaries	*1*	*2*	*3*	*4*	*5*	*9*
TV news and current affairs programmes	*1*	*2*	*3*	*4*	*5*	*9*
Politicians	1	2	3	4	5	9
Medical practitioner	1	2	3	4	5	9
Journalists	1	2	3	4	5	9
Scientists who work in industry	1	2	3	4	5	9
Scientists who work in the public sector	1	2	3	4	5	9
Lobby groups	1	2	3	4	5	9
Internet	1	2	3	4	5	9
Radio talkback	*1*	*2*	*3*	*4*	*5*	*9*
Ministry of Health pamphlet	1	2	3	4	5	9

Q10 If people were concerned about an issue that could affect the health of many people in your community, what would you personally do about that issue?
(do not read out)

Nothing 01
Find out more about it 02
Talk to parliamentarian.. 03
Other **(specify)** ____________________________________ 98
Don't know.. 99

Q12 Do you have access to the Internet?

Yes.. 1
No 2

(If yes)
Q13 Where do you have access to the Internet?
At home... 1
At work... 2
At school/university/other 3
At a library... 4
Other **(specify)** ____________________________________ 8

APPENDIX TWO: ATTITUDINAL SEGMENTS

	Average	Confident Science Believer	Concerned Science supporters	Educated Cynics	Confused and Suspicious	Uninformed Individualists	Left Behind
Interest in science areas	%	%	%	%	%	%	%
Genetic testing……………………………..	64	74	62	63	70	56	56
Space research……………………………..	37	45	45	36	38	33	19
New transport methods……………………..	56	64	62	50	52	54	51
Computing……………………………….	63	72	73	61	59	62	36
Cloning…………………………………..	31	45	36	35	30	17	15
Earthquakes………………………………	60	66	56	50	66	66	57
Saving endangered species…………………	81	87	77	75	82	75	85
Improving Ag/Hort product quality………..	66	68	64	59	71	64	72
Medical techniques…………………………	82	88	77	77	84	79	82
Climate change…………………………….	56	69	56	46	63	52	56
Benefits of science areas							
Genetic testing………………………………	73	81	77	66	72	66	69
Space research………………………………	39	51	44	32	35	38	21
New transport methods……………………	56	77	66	67	71	60	51
Computing……………………………….	65	76	69	59	59	61	52
Cloning…………………………………..	26	37	27	33	13	22	17
Earthquakes……………………………… …	80	87	80	74	82	79	75
Saving endangered species…………………	79	83	83	70	85	71	80
Improving Ag/Hort product quality……….	80	85	80	73	82	76	82
Medical techniques…………………………	93	98	94	89	93	90	94
Climate change…………………………….	68	77	71	58	74	61	53
Interest in Science and Learning							
I enjoy finding out new ideas in science……	73	93	77	67	72	79	30
I try to keep up with new technologies that could be useful in daily life…..	67	89	76	59	69	72	23
Science and technology too specialised for me to understand………………..	31	17	31	21	36	35	55
It is important to keep on learning new skills	90	99	97	84	97	87	65
There is so much conflicting information about science, it is hard to know what to believe………………………………...	56	38	60	47	86	61	64
Important to know about science in my daily life…………………………..	66	85	71	61	63	70	26

	Average	Confident Science Believer	Concerned Science supporters	Educated Cynics	Confused and Suspicious	Uninformed Individualists	Left Behind
Science and Technology and Economy	%	%	%	%	%	%	%
NZ needs to develop science and technology to enhance international competition………………………………	77	88	82	70	55	75	88
Science and technology are important for the preservation of NZ environment…….	82	93	87	61	70	87	85
Science is out of control these days………..	24	8	30	21	47	16	22
The government should fund scientific research, even if unsure of economic benefits…………………………………..	57	75	64	42	39	57	56
People shouldn't interfere with nature……..	55	38	56	31	70	60	80
The government keep tight controls on what scientists are allowed to do….……..	59	49	77	30	78	55	68
Science and Knowledge Building							
Developments in science rely on scientists thinking outside the square………………	76	90	76	71	79	62	66
If scientists disagree about something, doing more experiments will help them get the right answer……………..…….	52	70	54	64	50	64	68
Scientific predictions mostly are based on lucky guesses…………………………	15	3	33	17	24	9	11
If scientists measure something really carefully, they will get exactly the same result every time……………….	23	23	31	29	9	26	22
There is generally only one right way to investigate important scientific questions.	10	8	13	10	2	17	16
New questions for investigation mostly come from previous research……………	44	49	32	48	48	34	49
If you are told something is scientifically proven, you can have confidence in the results……………………….…….	43	59	32	39	14	52	51

	Average	Confident Science Believer	Concerned Science supporters	Educated Cynics	Confused and Suspicious	Uninformed Individualists	Left Behind
Sociological Aspects	%	%	%	%	%	%	%
Not possible to be certain about health…….	52	54	68	70	84	39	58
If interpreted in different ways, one must be wrong………	11	4	24	20	2	5	14
It is important that some scientists are not linked to government……	83	96	84	88	96	35	88
It is important that some scientists are not linked to business interests……..	86	97	91	89	96	42	90
Scientists should have to explain and justify their work to the public…….	69	66	74	46	87	64	81
If scientists say they are not clear about risks, they are telling the truth……..	53	70	7	69	72	46	52
Science in the Real World							
With a really powerful microscope, it is possible to see atoms……………….	33	34	41	28	27	33	29
Gravity is an imaginary idea to explain real experiences…………………………	11	8	13	15	11	16	6
All tomatoes contain genes, whether they are genetically modified or not…………	49	65	48	49	47	37	32
An important part of doing science is persuading other scientists to agree with your theories……………………….	35	39	36	33	35	31	33
Trustworthy							
TV documentary……………………………	52	59	52	40	49	50	60
TV news……………………………………	45	50	50	40	34	47	48
Politicians…………………………………..	7	9	5	7	4	8	5
General practitioners……………………….	83	83	82	73	76	89	88
Journalists…………………………………..	17	21	14	15	15	17	18
Science in industry…………………………	62	69	59	59	52	63	65
Lobby groups………………………………	14	15	14	6	18	10	20
Internet……………………………………..	26	31	24	32	23	25	28
Radio talkback……………………………..	17	11	23	15	18	17	24
Ministry of Health pamphlet……………….	72	81	75	69	65	67	69
Science in public sector……………………	71	83	65	65	72	70	71

		Average	Confident Science Believer	Concerned Science supporters	Educated Cynics	Confused and Suspicious	Uninformed Individualists	Left Behind
Internet Access……………………………..		72	84	72	75	70	65	54
Gender:	Male………………………..	48	50	46	53	43	55	36
	Female……………………..	52	50	54	47	57	45	64
Age:	Under 25……………………	18	16	20	20	13	27	13
	25 – 34……………………..	16	15	14	19	17	22	8
	35 – 44……………………..	23	28	25	16	24	13	22
	45 – 54……………………..	17	20	24	14	16	11	16
	55 – 64……………………..	13	11	9	14	17	11	21
	65 plus……………………..	13	7	8	17	12	16	22
Occupation:	Home duties……………….	6	3	6	6	8	4	11
	Retired…………………….	15	8	8	19	17	15	29
	Beneficiary………………...	3	2	3	2	4	3	3
	Student…………………….	12	11	13	13	6	23	8
	Clerical/Sales…………….	11	9	14	10	13	5	13
	Semi-skilled/technician…..	17	19	17	11	19	25	14
	Business Manager/……….	14	14	17	18	12	12	8
	Professional………………..	16	29	14	15	9	10	11
	Labour/manual……………	6	3	7	6	11	5	4
Personal Income								
Under $20,000……………………………..		36	25	31		43	44	41
$20,000 - $30,000…………………………		12	11	11		16	9	19
$30,000 - $40,000………………………….		14	16	12		13	12	13
$40,000 - $50,000…………………………		10	10	12		9	12	7
$50,000 - $70,000………………………….		10	15	9		4	9	3
$70,000 plus……………………………….		8	13	13		5	5	2

	Average	Confident Science Believer	Concerned Science supporters	Educated Cynics	Confused and Suspicious	Uninformed Individualists	Left Behind
Education							
Secondary……………………………….	51	37	53	48	46	58	74
Technical………………………………..	20	18	20	21	30	16	17
University……………………………….	28	44	26	31	22	24	10
Have Formal Science Training ……………	21	33	19	23	18	17	10
Ethnicity							
European……………………………………	87	89	82	88	88	83	92
Maori……………………………………….	11	10	16	8	10	18	7
P.I…………………………………………..	4	3	6	3	2	6	3
Asian/other………………………………..	4	3	5	2	2	7	3
Refused……………………………………..	1	*	1	3	4	-	-

APPENDIX THREE: THE POWERPOINT PRESENTATION

Focus group Session One

Talking about cell phones and current scientific debates

Question One

What is it about cell phones that could make them dangerous to your health?

- Note down your first thoughts individually
- Share and clarify in group discussion

Question Two

Do you think we have been told the truth about cell phone safety? Why / why not?

- Note down your first thoughts individually
- Share and clarify in group discussion

Question Three

Do you think it is possible for scientists to give a definitive answer on how safe cell phones are? Why / why not?

- Note down your first thoughts individually
- Share and clarify in group discussion

Question Four

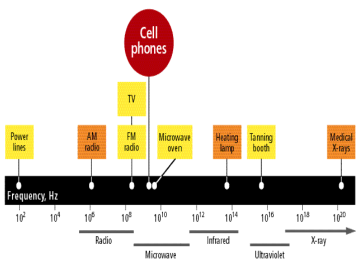
Your cell phone usage (individual responses to questions)

- Did any of these questions cause you any problems when answering?
- If yes, why was that?

Information to work with in the group discussion

How have we selected what information to present and how to present it?

- scientific information that seems to be agreed upon (between scientists, or between science and other interest groups) is displayed in blue text (like this)
- *our comments and questions are given in green text (like this)*



All of these can be called 'radiation' (including visible light)
Cell phones use radio waves which are relatively low frequency (longer wavelengths, less cycles per second)
Source: www.spectrum.ieee.org

Three biological **effects** of radiation

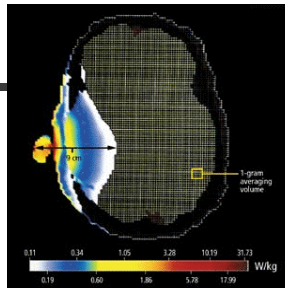
1. **Thermal** effects
2. **Ionising** effects
3. **Micro-electrical** effects

1. Thermal effects

- Thermal effects happen when the energy in microwaves heats up water-based living tissues. This effect happens straight away.

✓Radio waves are microwaves and they produce heating effects.

Scientists usually describe these as 'minor' and point out that our bodies have mechanisms to cope with heat changes.



[2] This computer model of a human head in cross section shows the distribution of the energy absorbed from a cellular telephone handset radiating 600 mW at 835 MHz. Most of the energy is absorbed within the first 1-2 cm beneath the surface of the skull. The 9 cm scale bar at left is shown for reference.
Source:www.spectrum.ieee.org

2. Ionising effects

- Ionising effects happen when the radiation changes atoms in ways that could cause damage to living tissues, including the genes/DNA inside cells. This in turn can lead to cancer, but there is typically a time delay before the effect is noted.

☒Radio-waves are NOT ionising radiation. Cell phones do not emit ionising radiation

3. Micro-electrical effects

- Micro-electrical effects: tiny changes to electrical charges can alter functions of cells at their boundaries with other cells (especially but not only muscle and nerve/brain cells).

Will my health be harmed?

- An **effect** is not automatically a **hazard**

? *Do all media reports make this distinction clear? Scientists argue that the body has many complex responses to cope with environmental effects. For example:*

- The body has built in adjustment mechanisms (DNA repair/ body temperature stabilisation etc.)
- People differ in their responses to different factors in their environment.

Open questions

The many different types of micro-electrical effects are currently areas of active scientific research.

? *Some cell phone safety research is studying these effects but the **significance** of the findings is in dispute - scientists, while arguing for caution, are typically not as alarmed as some health lobby groups*

More open questions

- Children have thinner skull bones than adults. Their heads are somewhat smaller and their brain tissue is still very actively growing.

? *Does this necessarily mean that they are more vulnerable to hazards from cell phone effects than adults?*

? *What about teenagers who are often active cell phone users? Again, scientists and lobby groups tend to disagree about issues of* **significance**.

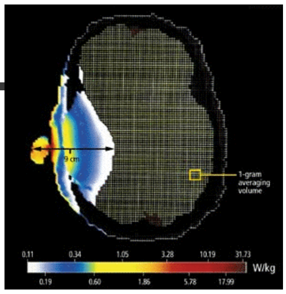
Measuring exposure to microwaves

Units for comparing different phones are called SARs

Specific **A**bsorption **R**ate

The New Zealand safety standard is based on the International Standard SAR of 1.6 W/kg

Some lobby groups think the SAR level is set too high. Some do not trust testing and reporting of SAR levels.



[2] This computer model of a human head in cross section shows the distribution of the energy absorbed from a cellular telephone handset radiating 600 mW at 835 MHz. Most of the energy is absorbed within the first 1-2 cm beneath the surface of the skull. The 9 cm scale bar at left is shown for reference.
Source:www.spectrum.ieee.org

Should I take precautions?

Shields that cover phones:

- cause the phone to boost its power levels;
- don't usually cover the aerial which emits most of the radio waves.

Although some commercial firms actively market these, scientists who have researched them mostly think they are a waste of money, or worse, increase the microwave exposure.

Should I take precautions?

Ear pieces for hands free kits:

- Enable the phone to be used at a distance from the head

An open question! Some investigations have found them to be safer but others have produced contradictory results

The biggest safety issue ?

- There is a definite link between car accidents and distraction through talking on a cell phone while driving
- Hands free kits only partially solve the distraction problem

Hands-free kits may or may not cut down on microwave exposure (depends on placement of car aerial/ phone unit distance from body etc.)

So what is the evidence so far?

- Many studies have been conducted world wide. Some results are inconclusive or conflicting.
- The six studies selected for today's focus group illustrate different issues in designing scientific investigations.
- The studies are deliberately reported at 'sound bite' levels of detail.

Question Five

A. Which (if any) of the reported findings are convincing to you?

B. What made you think/ feel/ decide that way?

C. Which of the possible types of health effects concerns you most? Why is that?

Useful questions to ask

- **What type of study is this?**
- **Is this investigation valid?**
- **Is this investigation reliable?**

What type of study is this?

- **Correlation** studies seek statistical links:

*i.e. Is there a **statistically significant** link between cell phone use and the incidence of ....?*

- **Causal** studies seek to explain how an effect could work e.g.:

*i.e. What **actually** happens to ....when exposed to microwaves?*

Is this investigation **valid**?

Have other explanations for statistical links been accounted for?

- How have samples been selected? (E.g: Is the sample large enough to eliminate chance or coincidence? Does the sample accurately represent the population being discussed?)
- Are the conclusions appropriately applied? (for example: should results from other animals be applied to humans?)

Is this investigation **reliable**?

- How many times and by how many people has this question been researched in this way?
- Do other scientists get the same or similar results?

Question Six

During this discussion today, has anything changed about

- Your understanding of cell phone issues?
- Your attitudes to cell phone issues?
- Your ideas about science in general?
- Your attitudes to science in general?

(please explain briefly)

Focus Group Session Two

Communicating about cell phone issues

Getting re-started

Question Seven

- Selected more general pieces of a larger scale survey we have been carrying out

Question Eight

- What issues about cell phone safety or science more generally have you thought about during the time between sessions?
- What concerns or questions do you have at this stage?

SAR testing and accountability

How can we be sure that SAR measurements are fair comparisons

- of different models?
- between different testing places/ methods?

Questions such as these are an essential part of building a valid and reliable scientific case

Standardising SAR methodology

The basic measurement is done with an actual model or a computer generated model of a human head. All of the following must follow exact guidelines (and be reported on)

- exact positioning of the phone with respect to the model
- tested on both left and right hand sides of model
- use of specified non-metallic holder to eliminate any hand/phone effects
- exact composition of fluid inside model must be followed (matched as closely as possible to actual head tissue densities etc)
- temperature closely controlled to match body temp
- exact dimensions and shape of probes to measure electric fields (eliminates probe/ boundary effects)
- new battery used for each test, and tested for full power before and after test run
- testing done at high, middle and low frequency channels for each transmission mode … and more

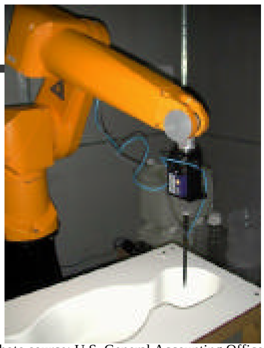


Photo source: U.S. General Accounting Office

A probe attached to a mechanical arm is directed to take SAR measurements throughout a human-shaped mould. The mould is filled with a liquid mixture that simulates the electrical properties of human tissue.

http://www.gao.gov/new.items/d01545.pdf

Photo source: U.S. General Accounting Office

The device pictured is designed to hold a mobile phone in various positions against the model. During SAR testing, the mobile phone is set to emit radio-frequency energy at its maximum power level

Measurement errors

- An 'error' is not a mistake!
- It is physically impossible to take absolutely identical measurements, even using the same equipment, in the same way, on the same item
- SAR testing protocols specify a long list of possible sources of measurement error that must be managed and reported on so that extent of data uncertainty is obvious

Official reporting of science findings

- Scientists need to convince other scientists that their research is sound before it will be accepted for publication in a research journal - this 'refereeing' process takes time.
- Most scientists do not publish their findings anywhere until they have this consensual support.
- Where public accountability is important (e.g. government reports/ standards work) scientists may need to negotiate the content of their reports.

Question Nine

Thinking about this accountability information, which ideas were unfamiliar?

- Strict methodology specifications
- Controlling experimental error
- Debating findings with other scientists first
- Being accountable to official bodies (e.g. standards setting bodies)

Question Ten

Does knowing about these constraints and the reasons for them alter the way you feel:

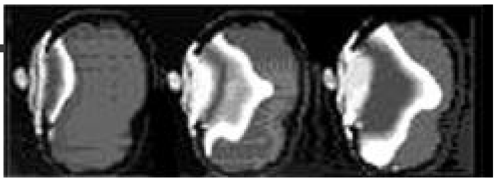
A. about cell phone safety?
B. about the way any other science issues of concern to you are addressed?
C. about the independence and accountability of scientists?

Question Eleven

- In your opinion, would people trust scientists more if they reported in more detail about the ways that they manage these sorts of constraints in their research? Why or why not?

Navigating the information minefield

- The following excerpts are all from the internet.
- *They have been chosen to represent different features and challenges of information that is shared in this way*
- We are interested in your views about how convincing each argument is for YOU, and how you have judged that:



Actual Thermal Images:
Senate Business and Professions Committee April 24, 2000: Senator Hayden presents actual photos of Radiation entering an Adult Brain, as well as the Brain of a 5-year old child: The depth of penetration is markedly more in the child than the adult. Proving radiation from cell phones penetrates the human brain. **Source:www.thegeomancer.netfirms.com**

"I think we have to be sensible about using cell phones; they should be for essential use only. Children have thinner skulls, smaller heads and their nervous systems are still developing, which makes them far more vulnerable to electro-magnetic radiation emitted mostly from the cell phone aerial…..
There is new evidence of health effects from cell phones coming out all the time. We can no longer pretend that the only effects are minor heating effects - yet this is the assumption that New Zealand standards are based on."

Sue Kedgley, Green Party Health Spokesperson, 11 May 2000
www.greens.org.nz

Cell Phones Linked Directly To Cancer - Again
November 11, 1998

An electronics expert has claimed that some people who use mobile phones heavily have started to develop cancer. Researcher Alisdair Phillips made the claim during a legal hearing brought by scientist Roger Coghill, who is trying to force retailers to put health warnings on mobile phones. Mr Phillips told the court: "I have received frequent reports from regular phone users telling of headaches, loss of concentration, skin tingling or burning and twitching. The complaints can involve eye tics, short-term memory, buzzing in the head at night and other effects such as tiredness. "
www.crystalinks.com

"There is strong evidence that extreme low frequency (ELF) and radio frequency microwaves (RF/MW) are associated with accelerated aging (enhanced cell death and cancer) and moods, depression, suicide, anger, rage and violence, primarily through the alteration of cellular calcium ions and the melatonin/ serotonin balance."

Dr Neil Cherry, Lincoln University - taken from a June 1998 report
http://earthfiles.com

Identifying links between cancer and environmental exposure of any kind is surprisingly difficult because of the absence of a single cause of cancer and for a variety of other reasons. Even if mobile phones had no connection to cancer, thousands of users would develop brain cancer every year, given the hundreds of millions of mobile phone users around the world and given so-called background rates of brain cancer (in the United States, it strikes about six in 100 000 people per year). Identifying an effect of cell phones against this background of the disease requires carefully designed studies.
When investigating suspected carcinogens, health agencies rely mostly on two sorts of studies: epidemiology studies, which involve statistical analyses of health records, and standardized tests, made on animals. On neither front does recent evidence support links between mobile phones and brain cancer.
Kenneth Foster, University of Pennsylvania, John Moulder, Medical College of Wisconsin www.spectrum.ieee.org

Some biophysicists speculate that the electromagnetic fields generated by mobile phones could interfere with the body's sensitive electrical activities. For instance, one hypothesis proposes that the fields induce small movements in the positively charged calcium ions that activate key receptor sites on cell membranes. Under the right conditions, even a weak field could significantly increase or decrease the membrane's permeability. This would alter the concentrations of ions and free radicals in the cell and possibly lead to higher rates of DNA damage.

In 1995 Lai and his colleague Narendra P. Singh provided some evidence for this hypothesis. They exposed rats to low-power microwaves for two hours, then extracted the DNA from the rats' brain cells. They found a greater number of breaks in the DNA strands of the exposed rats than in those of a control group. But other researchers' attempts to replicate these results have failed. A group led by Joseph L. Roti Roti of Washington University found no changes in DNA strand breaks in half a dozen similar experiments.

Scientific American, September 2000 **www.sciam.com**

Question Twelve

A. Which of these arguments do you find
- convincing
- not convincing

B. Which **features** of each argument helped you to decide?

Final thoughts: Q13

During the discussion overall, has anything changed about:

A. Your understanding of cell phone issues?

B. Your feelings about cell phone issues?

C. Your feelings about scientists' work in investigating health and environmental issues more generally?

(please explain briefly)

APPENDIX FOUR: SIX RESEARCH PROJECTS

Information about six research projects on the possible effects of cell phones on human health, presented in first focus group session

Research Project One

David De Pomeroi and team – University of Nottingham, UK.
The researchers beamed microwaves at tiny creatures called nematode worms. (These were chosen because the ways their cells work are well understood and their biology is simpler than that of bigger, more complex creatures.) In one experiment the researchers found that when the young forms of the nematode worm (called larvae) were exposed to an overnight dose of microwaves, they wriggled less but grew 5 percent faster than the control group (which were not exposed to microwaves).

This suggests that microwaves might be speeding up cell division in the nematode larvae. The group now plans to investigate whether a similar effect can be found by observing mammal cells. If similar effects are found, this would raise fears about possible links to cancer.

Research Project Two

Henry Lai – University of Washington, Seattle.
A team in Seattle has researched the effects of microwaves on the stress levels of laboratory-bred rats. Rats exposed to microwaves showed changed behaviours that included a tendency to binge on alcohol and taking longer than usual to learn the location of a submerged platform in cloudy water. These findings have been taken as evidence that exposure to microwaves altered the brain functions of the rats to disrupt the production of chemicals involved in memory and alertness (called neurotransmitters)

Research Project Three

Michael Repacholi and research group – Royal Adelaide Hospital, Australia
This group spent 18 months exposing mice to emissions that mimicked those of mobile phones. The group used mice that had been genetically engineered to increase their susceptibility to a type of cancer called lymphoma (which some researchers have suggested is linked to mobile phone use). They found that twice as many mice exposed to the radiation developed lymphomas as in the control group (similar types of mice, not exposed to microwaves)

Research Project Four

Brooks Air Force Base – San Antonio, Texas, USA
These researchers carried out a study similar to that done by Repacholi and his team (research project three). A difference was that they used mice genetically engineered to be susceptible to breast tumours. The mice were exposed to the radiation for 20 hours a day for 18 months.
This group did not find any increase in tumour rates in the exposed mice compared to the control group.

Research Project Five

Lennart Hardell – Orebro Medical Centre

A study was made of 209 people with brain tumours and a control group of 425 people without brain tumours.

The researchers found that mobile phone users were no more likely to develop tumours than non-users. Of those with tumours however, mobile phone users were 2.5 times more likely to develop tumours close to their ‘phone ear’ than non-users. There were only 13 mobile phone users with tumours in the study group so the result may not be statistically significant.

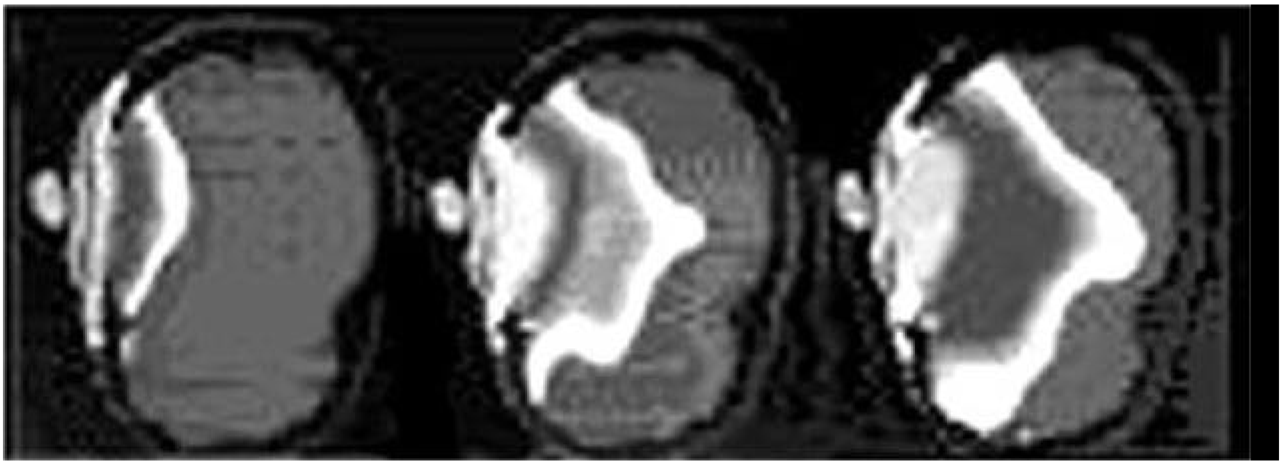
Research Project Six

George Carlo – Wireless Technology Research, Washington DC
These researchers compared 450 people with brain tumours with a control group of 425 people who did not have brain tumours. They found no general link between brain tumours and mobile phone use. However the researchers did identify a smaller group of 30 people who had a particular type of tumour called a neurocytoma. 40 percent of this group of 30 were mobile phone users. In the control group without neurocytomas, only 18 percent were mobile phone users. This difference is statistically significant.

APPENDIX FIVE: INFORMATION FROM THE INTERNET

Internet excerpts presented in the second focus group sessions

Example One: Thermal Images



Senate Business and Professions Committee April 24, 2000: Senator Hayden presents actual photos of Radiation entering an Adult Brain, as well as the Brain of a 5-year old child: The depth of penetration is markedly more in the child than the adult. Proving radiation from cell phones penetrates the human brain.
Source:www.thegeomancer.netfirms.com

Example Two: Sue Kedgley

"I think we have to be sensible about using cell phones; they should be for essential use only. Children have thinner skulls, smaller heads and their nervous systems are still developing, which makes them far more vulnerable to electro-magnetic radiation emitted mostly from the cell phone aerial…..

There is new evidence of health effects from cell phones coming out all the time. We can no longer pretend that the only effects are minor heating effects - yet this is the assumption that New Zealand standards are based on."
Sue Kedgley, Green Party Health Spokesperson, 11 May 2000
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Example Three: Personal Stories of effects

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November 11, 1998
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scientist Roger Coghill, who is trying to force retailers to put health warnings on mobile phones. Mr Phillips told the court: "I have received frequent reports from regular phone users telling of headaches, loss of concentration, skin tingling or burning and twitching. The complaints can involve eye tics, short-term memory, buzzing in the head at night and other effects such as tiredness. ”
www.crystalinks.com

Example Four: Dr. Neil Cherry

“There is strong evidence that extreme low frequency (ELF) and radio frequency microwaves (RF/MW) are associated with accelerated aging (enhanced cell death and cancer) and moods, depression, suicide, anger, rage and violence, primarily through the alteration of cellular calcium ions and the melatonin/serotonin balance.”

Dr Neil Cherry, Lincoln University - taken from a June 1998 report
http://earthfiles.com

Example Five: Foster and Moulder

“Identifying links between cancer and environmental exposure of any kind is surprisingly difficult because of the absence of a single cause of cancer and for a variety of other reasons. Even if mobile phones had no connection to cancer, thousands of users would develop brain cancer every year, given the hundreds of millions of mobile phone users around the world and given so-called background rates of brain cancer (in the United States, it strikes about six in 100 000 people per year). Identifying an effect of cell phones against this background of the disease requires carefully designed studies….

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Kenneth Foster, University of Pennsylvania, John Moulder, Medical College of Wisconsin **www.spectrum.ieee.org**

Example Six: Questions and hypotheses

“Some biophysicists speculate that the electromagnetic fields generated by mobile phones could interfere with the body's sensitive electrical activities. For instance, one hypothesis proposes that the fields induce small movements in the positively charged calcium ions that activate key receptor sites on cell membranes. Under the right conditions, even a weak field could significantly increase or decrease the membrane's permeability. This would alter the concentrations of ions and free radicals in the cell and possibly lead to higher rates of DNA damage.

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failed. A group led by Joseph L. Roti Roti of Washington University found no changes in DNA strand breaks in half a dozen similar experiments.
Scientific American, September 2000
www.sciam.com

APPENDIX SIX: INDIVIDUAL FEEDBACK SHEETS

Individual Feedback Sheets Used in the First and Second Focus Group Sessions

Session One

Question One:
What is it about cell phones that could make them dangerous to your health?
First thoughts:

Question Two:
Do you think we have been told the truth about cell phone safety? Why/why not?
First thoughts:

Question Three:
Do you think it is possible for scientists to give a definitive answer on how safe cell phones are? Why? Why not?
First thoughts:

Question Five: Different sorts of research (see appendix four)

Research project	**A. Is the research believable? Y/N**	**B. Reasons you think this (your thoughts/feelings)**
Project One: Nematode worms		
Project Two: Rat behaviour		
Project Three: Susceptibility of mice to lymphomas		
Project Four: Susceptibility of mice to breast tumours		
Project Five: People with and without brain tumours		
Project Six: People with and without neurocytomas		

Question Five cont'd:
Which of the possible types of health effects concerns you most?
Why is that?

Question Six:
During this discussion today, has anything changed about

6A. Your understanding of cell phone issues?
6B. Your attitudes to cell phone issues?
6C. Your ideas about science in general?
6D. Your attitudes to science in general?

Session Two

Question Eight:

8A. What issues about cell phone safety and/or science more generally have you thought about during the time between sessions?

8B. What concerns and/or questions do you have at this stage?

Question Nine:
Thinking about this accountability information, tick the box for any of the ideas that were unfamiliar to you before today:

9A. Strict methodology specifications	☐
9B. Controlling experimental error	☐
9C. Debating findings with other scientists first	☐
9D. Being accountable to official bodies (e.g. standards setting bodies)	☐

Question Twelve: Information from the Internet (see appendix five)

Internet material	**A. Is the information convincing? Y/N**	**B. Which features of the information helped you decide?**
Example One Thermal images *(Geomancer website)*		
Example Two: Sue Kedgley *(Green Party website)*		
Example Three: Personal stories of effects *(Crystal Links website)*		
Example Four: Dr. Neil Cherry *(Earth Files website)*		
Example Five: Foster and Moulder *(University website)*		
Example Six: Questions and hypotheses *(Scientific American website)*		

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