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**An Interface Between Science And Law: What is  
science for members of New Zealand's  
Environment Court?**

A thesis submitted in fulfilment of the requirements for the degree of

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by

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## **Abstract**

This study investigates the interface between science and law with reference to models of science described by members of New Zealand's Environment Court. The aim of the research is to identify differences and consistencies between the members of the Court in the way that they articulate their understanding of science and of scientific evidence. This research also aims to locate those individual models of science within a wider philosophical discourse concerning the nature of science.

The research adopts a qualitative and interpretivist approach that focuses on understanding the detail of contextual interactions arising from interviews with eight Environment Judges and 13 Commissioners. The interview group comprised all of the judges of the Court during the research period (1999 – 2000) and all but one permanent Commissioner.

The analysis of interviews shows a wide range of views concerning the scope and nature of science. Criteria significant to each individual's model of science have been identified as a series of micro themes. Those micro themes differ between individuals as to the combinations of criteria significant when locating the boundary between science and non-science.

The analysis of interviews also identifies three macro themes that describe whether and how individuals differentiate science, technology and expertise. That analysis identifies a group of interviewees, comprising both judges and commissioners, that equates science with expertise without distinction as to any knowledge component or process considerations. The analysis of interview responses adopts a boundary-work approach that identifies how individuals locate the boundary between science and non-science through their articulation of the micro themes significant to their model of science.

The study contributes to the discourse concerning the relationship of science and law within modern society. That discourse commonly addresses the appropriate legal framework to assess questions involving scientific expertise and invariably

describes the legal process and the role of expert and decision maker within that process. However, that discourse rarely articulates the meaning of the terms science, scientist, or technology, assuming that science is a self-evident concept, its meaning having universal application and acceptance. This research challenges that approach and identifies wide differences in the models of science held by individual decision makers and differences in their expectations of evidence from expert witnesses.

Aside from the implications of the research results for the discourse concerning the relationship of science and law, this research also has practical implications for the evaluation of expert scientific evidence within an adversarial system of law, and for expert evidence before the Environment Court. Suggestions to improve communication both within the Court and between the Court and parties appearing before it are made with a view to identifying consistent and fair expectations of experts and their evidence.

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# INDEX

<b>CHAPTER 1 INTRODUCTION</b> .....	<b>1</b>
1.1 Background .....	1
1.2 Outline of thesis .....	7
<b>CHAPTER 2 KNOWLEDGE SYSTEMS IN SCIENCE</b> .....	<b>10</b>
2.1 Introduction .....	10
2.1.1 <i>Social construction of science</i> .....	12
2.2 <b>Boundary-Work: science v non-science</b> .....	<b>17</b>
2.3 <b>Essentialist Perspectives of Science</b> .....	<b>26</b>
2.3.1 <i>Science in the Enlightenment</i> .....	26
2.3.2 <i>Logical Positivism</i> .....	28
Falsification and Popper .....	29
Science as a revolutionary process.....	32
Merton's norms and the modern paradigm .....	36
2.4 <b>Boundary-work and the social construction of science</b> .....	<b>41</b>
2.4.1 <i>Boundary-work in action</i> .....	41
Monopolisation .....	41
Expansion.....	44
Expulsion .....	45
Protection .....	46
2.4.2 <i>Objectivity</i> .....	48
Objectivity and science .....	48
Feminist critiques of objectivity .....	53
Science and social context .....	56
2.4.3 <i>Consensus</i> .....	61
2.4.4 <i>Cultural context of science</i> .....	66
2.5 <b>Boundary-work and the interface of science and law</b> .....	<b>69</b>
2.5.1 <i>Law is scientific</i> .....	74
2.5.2 <i>Law is a social science</i> .....	78

2.5.3	<i>The Law should become scientific</i> .....	80
2.5.4	<i>Law is not science</i> .....	82
2.5.5	<i>Science and legal decision making</i> .....	86
<b>2.6</b>	<b>Conclusion</b> .....	<b>90</b>
<b>CHAPTER 3 SCIENCE IN THE COURTROOM</b> .....		<b>93</b>
<b>3.1</b>	<b>Introduction</b> .....	<b>93</b>
3.1.1	<i>History of expert testimony</i> .....	96
<b>3.2</b>	<b>Science in law: rules of expert evidence</b> .....	<b>102</b>
3.2.1	<i>Common law rules</i> .....	102
3.2.2	<i>Opinion evidence</i> .....	104
3.2.3	<i>Teamwork and objectivity</i> .....	104
3.2.4	<i>Novel scientific evidence</i> .....	109
3.2.5	<i>The decision in Daubert</i> .....	112
<b>3.3</b>	<b>The New Zealand position</b> .....	<b>115</b>
3.3.1	<i>Scientific evidence in the Environment Court</i> .....	116
3.3.2	<i>Assessment of Risk</i> .....	119
3.3.3	<i>Burden and Standard of Proof</i> .....	120
3.3.4	<i>Admissibility and Reliability of Evidence</i> .....	122
3.3.5	<i>Precautionary Approach</i> .....	125
3.3.6	<i>Environment Court Practice Note</i> .....	128
<b>3.4</b>	<b>Conclusion</b> .....	<b>131</b>
<b>CHAPTER 4 RESEARCH QUESTIONS AND METHODOLOGY</b> .....		<b>132</b>
<b>4.1</b>	<b>Research Questions</b> .....	<b>132</b>
<b>4.2</b>	<b>Research methodology</b> .....	<b>133</b>
<b>4.3</b>	<b>Qualitative Research</b> .....	<b>134</b>
<b>4.4</b>	<b>Research Validity</b> .....	<b>135</b>
<b>4.5</b>	<b>Research Method: Interviews</b> .....	<b>136</b>
	Interview questions .....	137

<b>4.6</b>	<b>Planning the research</b> .....	<b>139</b>
	Ethical considerations .....	141
	Recruiting interviewees.....	142
	The interviews .....	144
4.6.1	<i>Managing the data</i> .....	144
	Analysis of Interviews.....	145
<b>4.7</b>	<b>Issues Relating to Validity and Reliability</b> .....	<b>146</b>
<b>4.8</b>	<b>Summary</b> .....	<b>148</b>
<b>CHAPTER 5 RESULTS: PERCEPTION OF SCIENCE</b> .....		<b>149</b>
<b>5.1</b>	<b>Introduction</b> .....	<b>149</b>
<b>5.2</b>	<b>Analysis</b> .....	<b>150</b>
<b>5.3</b>	<b>Key Themes</b> .....	<b>152</b>
5.3.1	<i>Macro themes</i> .....	152
5.3.2	<i>Micro themes</i> .....	155
<b>5.4</b>	<b>Continuum Model</b> .....	<b>158</b>
5.4.1	<i>Fact v Opinion</i> .....	158
5.4.2	<i>Hard v Soft continuum</i> .....	162
5.4.3	<i>Other types of continuum</i> .....	164
<b>5.5</b>	<b>Fact/Proof/Certainty</b> .....	<b>167</b>
<b>5.6</b>	<b>Empirical Measurement/Data</b> .....	<b>172</b>
5.6.1	<i>Empiricism</i> .....	173
5.6.2	<i>Data and Measurement</i> .....	176
<b>5.7</b>	<b>Process</b> .....	<b>181</b>
5.7.1	<i>Science is the process</i> .....	182
5.7.2	<i>Science involves a process</i> .....	183
5.7.3	<i>Replication</i> .....	186
5.7.4	<i>Process linked to knowledge</i> .....	187
5.7.5	<i>Research, testing or experimentation</i> .....	188

5.8	<b>Objectivity</b> .....	189
5.9	<b>Knowledge</b> .....	192
5.10	<b>Traditional association</b> .....	197
5.11	<b>Academic qualifications</b> .....	201
5.12	<b>Scientific Community</b> .....	206
5.13	<b>Science as Improvement, Prediction or Explanation</b> .....	212
5.13.1	<i>The Utility of Science</i> .....	212
5.13.2	<i>Science as explanation</i> .....	214
5.13.3	<i>Science for prediction</i> .....	216
5.14	<b>A Philosophical Question</b> .....	217
5.15	<b>Science Within a Hierarchy of Expert Evidence</b> .....	218
5.15.1	<i>Positive Valuation of Science</i> .....	219
	Intellectual Superiority.....	219
	Importance of Science.....	221
	Integrity of Science .....	223
	Reliance.....	224
	Weight.....	226
	Applied v Theoretical Science .....	228
	Science v Culture .....	230
	Science not special .....	232
5.15.2	<i>Preference for Qualifications</i> .....	235
5.16	<b>Decision Making</b> .....	238
5.16.1	<i>Writing decisions</i> .....	238
5.16.2	<i>Consensus</i> .....	240
5.17	<b>Summary</b> .....	244
	<b>CHAPTER 6 DISCUSSION</b> .....	246
6.1	<b>Evidence of Boundary Work</b> .....	246
6.1.1	<i>The meaning of science</i> .....	249

6.1.2	<i>Separating science from non-science</i> .....	251
6.1.3	<i>Models of science: Judges</i> .....	253
6.1.4	<i>Models of science: Commissioners</i> .....	257
6.1.5	<i>Models of science: consistency in the Environment Court</i> .....	259
<b>6.2</b>	<b>Essentialist views</b> .....	<b>260</b>
6.2.1	<i>Empiricism</i> .....	261
6.2.2	<i>Logical positivism</i> .....	262
	Popper .....	262
	Mertonian norms .....	263
6.2.3	<i>Science as a social construct</i> .....	265
6.2.4	<i>Continuum models</i> .....	265
6.2.5	<i>Scientific community</i> .....	267
6.2.6	<i>The utility of science</i> .....	268
6.2.7	<i>Objectivity</i> .....	269
6.2.8	<i>Law and science</i> .....	271
6.2.9	<i>Valuing science: the significance of boundaries</i> .....	272
6.2.10	<i>Implications of this research</i> .....	274
6.2.11	<i>Environment Court decision making</i> .....	277
6.2.12	<i>Environment Court practice</i> .....	281
	Expectations of expert witnesses .....	282
	Recognising difference.....	283
6.2.13	<i>Questions pending</i> .....	284
<b>6.3</b>	<b>Final comments</b> .....	<b>285</b>
	<b>APPENDIX 1 - THEMES</b> .....	<b>288</b>
	<b>APPENDIX 2 – DATA TABLES</b> .....	<b>292</b>
	<b>APPENDIX 3 – FRAMEWORK FOR INTERVIEW QUESTIONS</b> .....	<b>296</b>
	<b>REFERENCES</b> .....	<b>299</b>
	<b>Legislation</b> .....	<b>299</b>
	<b>Case Law</b> .....	<b>299</b>
	<b>Secondary Materials</b> .....	<b>300</b>

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

This research investigates the interface between science and law as located by individual decision makers within New Zealand's Environment Court. The aim of this research is not to address the way in which science is interpreted or applied within any given decision making forum. Rather, it is to discover how a specific set of legal decision makers identify that interface and whether there are consistencies among themselves and with those who comment on the role of science in society.

There is a considerable body of research and academic writing that addresses the relationship between science, technology and law. That body of work is described in chapters 2 and 3 of this thesis but can be summarised as concerning the role of science and scientists in the common law adversarial system that operates in the Commonwealth countries and in the United States of America. That discourse addresses the appropriate balance between the provision of expert opinions and the judge and or jury system for deciding questions of fact and of law. The relationship of science and law is also regulated through legal evidential rules that attempt to maintain that legally accepted balance between experts and decision makers. I consider it significant that none of the writing that addresses the relationship between science and law actually defines what is meant by science. The discourse about an appropriate legal framework to assess questions involving scientific expertise invariably describes the legal process and the role of expert and decision maker within that process. However, that discourse rarely articulates the meaning of the terms science, scientist or technology. It appears from that body of academic writing that science is considered such a self-evident term with universal application that no contextual explanation is necessary. This research challenges that approach and sets out to discover just what individuals who are part of New Zealand's judicial system, namely the Environment Court, think about science and whether there is any consistency in their views. I have been unable to locate any other research that explores the views of legal decision makers about science, so the discussion about consistency of those views is with reference to models of science described in literature concerning the philosophy

and sociology of science. The consistency of those views is also explored with reference to other decision makers that comprise the Environment Court.

My interest in the interface between science and law stems from my personal and professional background, firstly as a reluctant science learner and later as a struggling science teacher. Having shown reasonable aptitude in the subjects of History, English, French and Latin and no particular strength in general science, I chose to pursue a career in medicine and therefore opted for Chemistry, Physics and Biology at senior school. I discovered that the writing skills that served me well in English also supported a passable performance in Biology and the combination of an adequate control of mathematics with a good memory was sufficient for a pass in Chemistry. Those skills did not help with any progress at all in Physics, which I replaced during mid seventh form (year 13) with French. It should have been a signal for my future educational direction that I achieved a higher mark for French after only five months than I managed for either Chemistry or Biology following two years of senior school study. I make these comments to explain that by the time I entered Otago University, having enrolled in Chemistry, Biology, Psychology and History, I had no real understanding of the content, process or philosophy of science. Science (and I generalised Chemistry, Biology and Psychology as science) was little more than a difficult prerequisite for a future in medicine. The reality of my grades quickly dictated a change in direction towards teaching but I persevered with Chemistry, Biology, and History to eventually complete undergraduate degrees majoring in Chemistry and History.

As with my progress with science subjects in school, my university science qualifications reflected an ability to memorise formulae and to reproduce practice exams. I had little or no understanding about the context or relevance of the various courses that I attended. It was not until I attended classes at Hamilton Teachers' College that I first confronted the need to actually think about science – together with the very real need to understand at least the basics of what I was required to teach. Although I did not entirely appreciate it at the time our class was fortunate to have the intellectual stimulation and confrontation from a teacher who was passionate about learners and learning in science. Dr Mark Cosgrove was involved with research being done by Dr Roger Osborne and others in the Learning in Science Project (LISP). That research built on a premise that learning

happens within a context that includes the learner's pre-existing accumulation of knowledge and understanding. The LISP research incorporated a social construction of knowledge approach to the teaching and learning of science, aiming to discover the learner's pre-existing understanding of a given concept in order to guide the learner to extend that understanding in a direction consistent with that of the science community.<sup>1</sup> As student teachers we were challenged to articulate our understanding of science concepts involving a number of simple, related electrical circuits. For the first time it was not sufficient for me to apply a learned formula in order to arrive at the requisite numerical result. Rather, I was encouraged to predict which lamps would glow brightest (if any) and more importantly to explain why. It was both comforting and unnerving that my classmates, together with other tertiary science graduates, had a number of different explanations for the observations of those simple circuits. Comforting, because my explanation could not be the only wrong one, and unnerving, that so many of us could complete tertiary qualifications in the physical sciences and yet vary so much in both our predictions and our explanations of simple concepts taught in junior science. To this day, my ability to accurately predict the outcome of variously drawn electrical circuits endures as an example of genuine understanding that is sadly not reflected in my responses to questions on various other science topics from either of my children.

That process of identifying our pre-existing understanding of electrical current and then challenging that understanding by means of increasingly complex, but testable propositions, was the basis for a model of learner focussed teaching that recognised the socially constructed nature of knowledge. Although far from easy to consistently implement in large and heterogeneous secondary school classrooms that model had some basic principles. Firstly identify what the learner already knows or believes about the concept. Then provide a number of different problems that allow the learner to test their own predictions and to modify their views in light of their observations. That process of prediction, explanation and observation, within a climate of lively classroom debate, proved to be very successful in shifting learners toward the science view being both sought and promoted by the teacher.

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<sup>1</sup> See Chapter 2.4 for a discussion of the socially constructed nature of science.

Throughout the six years that I taught, both full time and part time, as a science, chemistry, biology and horticulture teacher, I continued to be associated with researchers who were committed to discovering more effective ways of teaching and learning in science.<sup>2</sup> That research invariably began by investigating the starting point for learners, whether pre-schoolers or tertiary graduates, and then developing a teaching package that built from those pre-existing views. A feature of all of that research was the range of different views held by learners (and often their teachers as well) about different concepts comprising the school science curricula in New Zealand. Just because a student had not encountered a concept as part of their formal education did not mean that the student had no view about that concept or a preferred explanation for it. In addition, among students who had previously encountered the concept in formal education there were still a range of very different views and explanations, often with very little in common with the views of the science community.

When I first started as a law student at Waikato School of Law in 1992, I again found that many of the most effective law teachers began by encouraging students to identify their own views before introducing legal theory by way of a problem-solving approach. Learning the law through a contextual approach was a strength of the law school's programme that encouraged debate and acknowledged the socially constructed nature of knowledge.

I was also fortunate to obtain a part time research assistant position with Doug Arcus who is a prominent figure in the environmental law bar. At that time Doug was practising as a barrister primarily working for applicants in various complex resource consent and plan change matters. That research position gave me first hand experience of the relationship between client, expert advisor and legal counsel. It also alerted me to the importance of an expert witness who is able to effectively communicate the strengths of the client's application while also suggesting appropriate mitigation in respect of any weaknesses. Doug's choice of

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<sup>2</sup> For example research by: Dr Mark Cosgrove into teaching and learning electricity; Drs Valda Kirkwood and Malcolm Carr into teaching and learning concepts on energy; Dr Alister Jones into teaching and learning in physics; Dr Beverley Bell into teaching and learning about animals; and Dr Michael Forret into teaching and learning electronics.

expert witness, and it was invariably his choice rather than the client's, related not to the individual's qualifications but to their previous ability to communicate effectively and persuasively when appearing before the Court. A history of thorough preparation together with an ability to demonstrate confidence when giving evidence under cross-examination were particularly important considerations in that choice. Another important factor was the reliability of expert reports that form the basis of subsequent briefs of evidence. Neither client nor counsel was ever happy to discover unexpected and unpleasant news first from the briefs of opposing expert witnesses.

Towards the end of my six years working with Doug, his practice began to move towards a greater emphasis on decision making through his appointment as hearings commissioner for numerous local authority hearings to decide matters under the Resource Management Act 1991 ("RMA"). That role again involved the management and assessment of, often large, volumes of expert evidence but with a change in focus to decide applications in terms of the statutory criteria set out in RMA. During that time my role changed from assisting with preparation of legal submissions or opinions for clients towards the accurate recording of verbal exchanges during hearings and the organisation of material presented by participants in light of the key issues identified by Doug. That change in focus required me to consider not only the written format of information to be provided in support of a given position, but also the actual presentation of that information and its impact on the decision maker.

During my employment with Doug I also retained a close working association with Waikato School of Law, initially working as a tutor and then as a lecturer with teaching responsibilities in Environmental Law, Public Law and Legal Method. This research was first conceived during my time as a law lecturer and I was fortunate to have the advice and encouragement from academics with strengths in Public Law and Environmental Law.<sup>3</sup>

During my time as a law student and then in the following years as an academic I maintained a close personal connection with science educators and researchers as

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<sup>3</sup> In particular, Margaret Wilson, Kaye Turner and Barry Barton.

well as a professional connection with the School of Science and Technology, being a member of that School's Board of Studies and teaching a Legal Studies component of a third year Chemistry paper. In light of my background and growing interest in the relationship of science and law it was an easy progression when considering research topics suitable for study towards a Doctor of Philosophy qualification, to explore an aspect of that interface between science and law. My choice of the Environment Court as specific location of that interface relates both to my own interest in resource management law and to decisions in which the Environment Court specifically addressed the weighting of scientific evidence that was challenged by opposing expert witnesses.<sup>4</sup>

The choice also recognised the specialist role of the Environment Court in deciding cases involving expert evidence concerning the effects on the environment from proposed activities.

The interviews from which the data supporting my research findings is based were carried out in 1999 and 2000. Prior to the data collection process I began an extensive literature review that is fully described in Chapters 2 and 3 of this thesis. Some of the material comprising Chapter 3 was published in the New Zealand Journal of Environmental Law<sup>5</sup> and my preliminary research findings were first presented at the WOCATE<sup>6</sup> conference held in Braunschweig, Germany, in 2000. Those findings were subsequently published in 2004.<sup>7</sup>

In 2001 I made a further career change to enter private practice with Harkness Henry & Co in Hamilton again specialising in resource management law. That change reflected my increasing preference for the practical aspects of law together with the task and client focussed nature of private practice. Despite my move away from academia, I was determined to complete this research, partly in light of the significant time I had spent on the literature review and data collection stages,

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<sup>4</sup> For example *McIntyre v Christchurch City Council and Bell South* [1996] NZRMA 289.

<sup>5</sup> Forret J "Scientific Evidence and Environmental Litigation in New Zealand" (1998) 2 NZJEL 39.

<sup>6</sup> World Council of Associations for Technology Education,

<sup>7</sup> Forret J "The Law and Technologists: Implications for the Technology Curriculum" (2004) XXX Jnl Technology Studies Issue 4, (electronic).

but also in light of the generous response of the Environment Court in giving up their time to participate in the interviews. In addition the results of this research provide unexpected insights into the matters of significance to the Court when deciding matters involving expert evidence and contribute a different dimension to the discourse concerning the interface of science and law.

## 1.2 Outline of thesis

The aim of this research is to investigate the models of science held by decision makers comprising the New Zealand Environment Court. That specific aim evolved from a more generalised interest in a number of matters as follows:

1. My experience of teaching and learning in science as described above;
2. My knowledge of research findings showing a wide range of views about many aspects of science held by learners of all ages and educational achievement;
3. My interest in resource management law as a public law process;
4. Proposed changes in the United Kingdom to legal rules regarding the provision of expert evidence and the accreditation of expert witnesses;<sup>8</sup>
5. Public controversy in New Zealand around the potential health effects, particularly on children, from close proximity to high frequency electromagnetic radiation associated with telecommunications structures;
6. The line of legal authority cited in the Environment Court's decision in *McIntyre v Christchurch City Council and Bell South*<sup>9</sup> that specifically addressed issues relating to the assessment of expert evidence and novel scientific evidence;
7. A lack of any discussion in legal decisions or by legal academics about the nature of science or of scientific witnesses both of which terms were used in the context of exploring the appropriate role of science within a common law judicial system.

Chapter 2 comprises a literature review that summarises models of science described by philosophers of science, scientists, educationists and legal commentators. In Chapter 2 I introduce the concept of boundary-work that has

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<sup>8</sup> Lord Woolf, *Access to justice: final report to the Lord Chancellor on the civil justice system in England and Wales*. (London: HMSO, 1996).

<sup>9</sup> [1996] NZRMA 289.

been adopted and adapted by legal commentators such as Thomas Gieryn and Gary Edmond as a means of demonstrating the way in which science and scientific evidence is constructed within a legal context. While describing the classical, essentialist approaches to the epistemology of science, I argue for recognition of the socially constructed nature of science with reference to the boundary-work undertaken by each individual involved in the legal process, whether as witness, counsel or decision maker.

Chapter 3 also comprises a literature review that summarises the development of expert evidence within the common law. That development has given rise to legal rules of evidence that direct the presentation and assessment of expert evidence in general and scientific expert evidence in particular. Chapter 3 also sets out the development of environmental law in New Zealand and the role of the Environment Court as a significant decision making forum with jurisdiction to decide matters under the RMA that will invariably involve scientific and technical evidence from expert witnesses. Also set out in Chapter 3 are the relevant statutory criteria governing the assessment of evidence under the RMA together with the body of case law relating to expert evidence.

Chapter 4 contains the research questions underpinning this research and the methodology adopted to answer those questions. I describe the elements and validity of qualitative research and explain how this interpretative study meets research validity and reliability requirements. Chapter 4 details the specific method of interpretative investigation by means of semi-structured interviews and explains how ethical and practical considerations were addressed.

The interview results are detailed in Chapter 5. Those results demonstrate the socially constructed nature of knowledge as it applies to scientific and technical evidence. The results show both commonalities and differences between members of the Environment Court as they describe their understanding of the meaning of science and articulate the reasons for their choice of location for the boundary between science and non-science. Chapter 5 also sets out the criteria relevant to each individual's model of science, reflecting their boundary-work when interpreting and assessing expert evidence. That boundary-work is also

evident in the results of interview questions concerning individual valuation of science and expert evidence.

Chapter 6 comprises a discussion of the results in light of the research questions and the theoretical framework outlined in Chapters 2 and 3. Consistencies and differences between views expressed by members of the Court and those described in Chapter 2 are described in light of a boundary-work approach that illustrates the socially constructed nature of science. Chapter 6 also includes a discussion of the significance of these research findings for decision making within the Environment Court, the wider court system in New Zealand and the institutions with policy-making and regulatory decision making functions that all involve assessment of expert evidence. Finally, Chapter 6 identifies questions that could form the basis for research to further explore the interface between science and law.

## CHAPTER 2

### KNOWLEDGE SYSTEMS IN SCIENCE

#### 2.1 Introduction

Research into learning in science carried out by the Learning in Science Project (LISP) team identified that learners have their own models of science before they ever receive any formal instruction in science at school.<sup>10</sup> Those models represent learners' attempts to make sense out of the world around them. The LISP team, and other science education researchers,<sup>11</sup> found that the process of identifying and understanding those models is the first step in enabling learners to accept a different model of science – normally a model preferred by educators on behalf of the scientific community. I have accepted those research findings and have assumed that adult decision makers will also hold individually different views about what is and what is not science.

In this chapter I introduce the concept of boundary-work as a mechanism for analysing how individuals articulate their view of science. Boundary-work is an approach developed by Thomas Gieryn<sup>12</sup> and adopted by legal commentators such as Gary Edmond<sup>13</sup> that describes how individuals within the legal system, including judges, policy makers and advocates, discriminate between issues relevant and irrelevant to the assessment of scientific information. Those boundaries between the relevant and the irrelevant will vary between individuals and can depend on the purpose of that assessment.

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<sup>10</sup>For example see Osborne, R and Freyberg, P (eds) *Learning in science: The implications of children's science*. (Auckland: Heinemann, 1985).

<sup>11</sup> See Cosgrove, M *Learning Science From Technology* DPhil Thesis (Waikato: University of Waikato, 1989) and Driver, R *The pupil as a scientist* (Milton Keynes: Oxford University Press, 1983).

<sup>12</sup> Gieryn, T "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists" (1983) 48 *American Sociological Review* 781,

<sup>13</sup> Edmond, G "Science in Court: Negotiating the Meaning of a 'Scientific' Experiment During a Murder Trial and Some Limits to Legal Deconstruction for the Public Understanding of Law and Science" (1998) 20 *Sydney LR* 361.

An analysis of boundary-work is particularly applicable to discourses within law because of the predominance of written reasoning articulated in judicial decisions, policy documents, expert evidence and in the submissions of advocates. That wealth of written material makes legal decisions accessible for analysis of the boundary-work carried out either in the protection, or promotion of an individual's view of science.

That there are a number of widely accepted and yet different models of science becomes apparent in any search for a universally accepted and applied definition of science. Even amidst the philosophy of science section in the library, a book containing a chapter with the promising title 'What is Science'?<sup>14</sup> does not have a suitable quotable definition. The available definitions of science<sup>15</sup> tend to approach the matter in one of two ways. Either science is defined according to the way in which it becomes incorporated into the body of knowledge known as science, or it is defined in terms of the activities that scientists do.

The scientific paradigm as it has generally been perceived in modernity consists of a system of rational thought that is directed at the explanation and prediction of phenomena related to the physical world. That view of science very much involves the concept of an objective scientist, who by experimentation and analysis can produce, or rather, uncover, new scientific facts. Those facts can then, by a process of consensual agreement within the scientific community, become incorporated into the wider body of scientific knowledge. By employing logical reasoning in a process that separates the subject of the scientist from the object of research, scientific endeavour will uncover universal truths about the physical world. During the late twentieth century, however, there has been increasing criticism of the role of science and technological development within society and its institutions. By criticism, I mean critical analysis, of both the methods of science and of the way in which new knowledge becomes accepted.

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<sup>14</sup> Ravetz, J R *Scientific Knowledge and its Social Problems* (London: Oxford University Press, 1971) 11.

<sup>15</sup> The references to some of the following definitions I shamelessly adopt from Jane Gilbert's excellent thesis chapter entitled "The Nature of Scientific Knowledge". Gilbert, J *Thinking 'otherwise': re-thinking the problem of girls and science education in the post-modern* (University of Waikato: DPhil Thesis, 1997).

This critical analysis challenges our understanding of the accepted paradigm and is described by some academics as reflecting a new Post Modern style of thought that appears in discourses in the arts, literature and the social sciences.

My research begins from an acknowledgement that scientific knowledge is not independent of the culture and values of the individuals or groups that produce it. Science is part of the social context that informs its motivation, direction and application and scientists are no more able to be isolated from their research methods, results or conclusions than are any other individuals. Studies in the 1970s and 1980s by researchers such as Bloor, Barnes, Feyerabend, Latour and Woolgar<sup>16</sup> have contributed to a view of science as being a representation of the social construction of knowledge. That view is supported by evidence that identifies how individuals vary in their explanations, understandings and expectations of science and scientific experts depending on their own boundary drawing criteria.

#### 2.1.1 *Social construction of science*

The modern paradigm of science has certain features that make science recognisable as a discipline separate from philosophy, law or the arts. Some of those features pertain to the method of science and some pertain to specific criteria, or values. Still other features relate to the goals of science. That is, that the pursuit of scientific research is not a random enterprise, but rather, a continuing pursuit for a 'truthful' explanation and understanding of the natural world. This pursuit has been successful. It has resulted in a huge body of knowledge that has enabled technological developments, which endure and on which our daily lives rely. The enduring quality of scientific knowledge has contributed to the status that the discipline has within modern society and also to the confidence that those, both within and without the scientific community have in its methods and outcomes. This confidence has partly been responsible for

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<sup>16</sup> Barnes, B *Interests and the Growth of Knowledge* (London: Routledge and Kegan Paul, 1977), Bloor, D *Knowledge and Social Imagery* (London: Routledge and Kegan Paul), 1976, Feyerabend, P *Against Method* (London: Verso, 1975), Latour, B *Science in Action* (Cambridge, Mass: Harvard University Press, 1987), Latour, B and Woolgar, S *Laboratory Life: The Social Construction of Scientific Facts* (London: Sage, 1979).

stimulating research into the practice of science. Philosophers, historians and sociologists of science continue to compare the reality of the paradigm with the actuality of practice and have provided many criticisms suggesting that confidence in science based on the traditional concepts of objectivity and truth is badly misplaced. These criticisms broadly concern the objectivity of science as it is perceived in its various forms. All of the modern critiques of science, both as an activity, and as a body of knowledge, relate to the inherent subjectivity of the research process and production of knowledge. These critiques challenge the traditional notion of a scientist who is separate from the process of investigation and of a body of knowledge that is independent of the scientific community that produced it. In describing these critiques, I comment on the various ways in which the process of science, as a social activity that is pursued by individuals that function within and because of the society in which they live, is inconsistent with the paradigm of science that is familiar to the wider community. In doing so, I am conscious of a danger that in deconstructing the process of science, it is possible to forget that enduring body of knowledge on which present and future research is based. My purpose is not to negate the existence or the value of scientific research or its outputs. Rather, it is to focus the reader on the differences between the 'model' and the reality of science, and to identify the implications of those differences.

Part of the critical analysis of science has been focused on the role of the scientist. There has been considerable research to expose the myth of the 'objective' scientist. Some of this work has been contributed by feminist researchers, for example Donna Haraway and Sandra Harding<sup>17</sup> who identify the gender influences that necessarily apply to all endeavour, and no less so to scientific endeavour. Likewise, Bruno Latour<sup>18</sup> and Michel Foucault<sup>19</sup> identify the way in which language is manipulated to produce desired outcomes and to withstand dissent. Other critics have challenged scientists' capacity for objectivity given the

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<sup>17</sup> Harding, S *The Science Question in Feminism* (NY: Cornell University Press, 1986) and Haraway, D 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective' (1988) 14 *Feminist Science* (3) 575.

<sup>18</sup> Latour, B *Pasteurization of France* (Cambridge Mass: Harvard University Press, 1988).

<sup>19</sup> Foucault, M *The Archaeology of Knowledge* (London: Routledge, 1972).

very political environment that surrounds the funding of research within both the private and university sectors. Research positions in today's environment are likely to represent an individual's principal source of income for herself and her family. Security of tenure thus has an important economic component which distinguishes modern scientific research from the traditional position in which science was purely an intellectual pursuit, the luxury of the independently wealthy. Associated with the problems identified with objectivity of the researcher are those that can also be levelled at the motivation for and direction of scientific research. No longer is research guided purely by the curiosity of the researcher, within the boundaries of technological capacity. Today, research is predominantly motivated by the need to lure potential funders, or more directly by the strategic plan of the funding sources. Even within universities, postgraduate students are constrained by the interests and capabilities of the available supervisors and the facilities available at the institution. Here too, the source of funding will have a profound effect on the type of research project undertaken and the equipment available.

Another source of criticism arises out of research into the epistemology of science. What constitutes scientific knowledge? Some writers argue that the central feature of scientific knowledge is its public and consensual nature,<sup>20</sup> but the degree of consensus and mechanisms for achieving consensus are far from transparent and involve just as much social interaction as do any other political activities within our society. Likewise, the transmission of scientific knowledge between the various fields within science and to those who commissioned the research (the funders) is also the subject of debate. This is a debate that is particularly relevant to the law as the courts are increasingly involved in hearing testimony on issues concerning novel scientific theories and in some cases will be considering testimony generated purely for the courtroom. Such testimony may be required to explain, verify or predict the significance of a technological development and because of the dialectic nature of law, will necessarily involve

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<sup>20</sup> For example Ziman J *Public Knowledge: The social dimension of science* (Cambridge: Cambridge University Press, 1968).

testimony in dissent. Sheila Jasanoff<sup>21</sup> argues that the dialectic is an important mechanism to ensure that there is adequate scrutiny of the scientific community and its claims, however, the degree to which the science of those claims can be transmitted to those outside the community has been challenged.<sup>22</sup>

It is disconcerting for a researcher in law that there is no single, accepted definition of science. That is particularly so as the law has been criticised for privileging scientific testimony over other forms of testimony, for example narrative testimony that is a feature of the knowledges of many indigenous peoples, including those of the South Pacific and particularly Maori.<sup>23</sup> The rejection of narrative forms of knowledge has been typical of the development of thought within Modernity, however, academics in Post Modernity have argued that elements of the narrative method pervade all aspects of social interaction, including science, and that exponents of the scientific method rely on narrative in order to validate what is knowledge in science.<sup>24</sup>

A lack of consensus regarding a definition of science is also a problem for law when it comes to the screening out of non-scientific testimony. By privileging science over other knowledge systems the law has accepted some criteria for decision making. There is a difficulty, however, if even the scientific community itself cannot agree on what it is that should be privileged and at what stage the boundaries of science can be expanded to incorporate new theories and ‘facts’ into the acceptable basket of knowledge. This difficulty also extends to the expert witnesses themselves who propound the evidence in question. Their evidence

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<sup>21</sup> Jasanoff, S “Beyond Epistemology: Relativism and Engagement in the Politics of Science” (1996) 26 *Social Studies of Science* 393 and Jasanoff, S “What Judges Should Know About the Sociology of Science” (1966) 32 *Jurimetrics Jnl* 345.

<sup>22</sup> For example by Breyer, S. “The Interdependence of Science and Law.” 280 *Science* no. 5363, 537 and Brewer, S “Scientific Expert Testimony and Intellectual Due Process” (1998) 107 *Yale LJ* 1535.

<sup>23</sup> For example, Whorf, B *Language, thought, and reality; selected writings*. (Cambridge: Technology Press of Massachusetts Institute of Technology, 1956), Lanning, G “Maori issues-tangata whenua evidence and consultation” (1998) 2 *BRMB* 153.

<sup>24</sup> See Lyotard, J *The Postmodern Condition: A Report on Knowledge* (Minnesota: University of Minnesota, 1984).

will reflect and promote their own model of science within variable boundaries. The boundaries are variable depending on the criteria valued by an individual, for example experimental data or research publications, and on the context in which an individual's model of science is presented. In the end, courts and other legal decision makers have a duty to decide. In order to make decisions, decision makers must resort to criteria, and those criteria will naturally differ depending on the substance of the matter at issue, and on the nature of the decision maker herself.

This chapter introduces the concept of boundary-work to describe the socially constructed nature of science. Examples of boundary-work, both historical and modern are given to demonstrate the way in which the social context of science is articulated by individuals in light of their own intellectual framework. That framework being informed by various philosophical, political, economic, religious and other values touching the social and physical environment of the individual. This Chapter then reviews a number of models of science prominent in modern thought, together with their philosophical framework derived from Enlightenment views about science. Those models include logical positivism and the views articulated by Karl Popper, Thomas Kuhn and Robert Merton. Also reviewed are critiques of the modern paradigm, that demonstrate boundary-work by various individuals and interest groups inherent in the social context of science. Those critiques include reference to the work of John Ziman and to feminist theorists Evelyn Fox Keller, Donna Haraway and Sandra Harding. The study of science as a community of thought is central to the research of Ziman, and also to the analysis of power relationships and exclusive boundaries by Haraway and Harding. The concepts of objectivity and consensus and how those concepts underpin the socially constructed nature of science are described as further examples of boundary-work. This chapter also refers to the contextual approaches to science that are evident in indigenous models of science, where there is a greater emphasis on cultural and spiritual contexts for knowledge.

Finally, this chapter considers the interface between science and law as viewed by different legal commentators. Those commentators have been divided into 4 broad categories: those promoting a view that the law is scientific; those

describing the law as a social science; those proposing that the law should strive to be scientific; and those differentiating the law from science as being distinctly separate knowledge constructs. The chapter concludes that an analysis of the interface between science and law can be enhanced by a boundary-work approach. Such an approach reminds the reader to look for boundaries being constructed by the writer in order to separate relevancies from the irrelevancies in the writer's model of science. A boundary-work approach is also reflexive and requires the reader to consider his or her own model of science when filtering the relevant from the irrelevant.

## 2.2 **Boundary-Work: science v non-science**

In the early 1980s a number of writers began to use the concept of boundary-work to describe the socially constructed nature of science.<sup>25</sup> Boundary-work describes the process by which science is characterised so that it is distinguished from other non-science activities. Thomas Gieryn noted that philosophers and sociologists of science have struggled to effectively define and demarcate science. Characteristics deemed essential to the performance of science, can be found in non-science or conversely can be found lacking in some examples of activity accepted as science. However, despite the failure of academics to successfully demarcate science in terms of unique and identifiable criteria, the process of demarcation is routinely carried out on a day to day basis within the wider community. Educational leaders design science curricula that include the study of astronomy but exclude the study of astrology. The Courts adopt the rules of evidence that include expert scientific testimony from physicists but not from psychics. The inability to actually define science does not prevent the performance of or reliance on science within modern society.

Gieryn and his colleagues were interested in the way that science was "sold" by scientists in order to enhance and protect the cognitive authority of modern

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<sup>25</sup> Gieryn, T "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists" (1983) 48 *American Sociological Review* 781, Woolgar, S "Interests and Explanation in the Social Studies of Science" (1981) 11 *Social Studies of Science* 365, and Shapin, S "History of Science and its Sociological reconstructions"(1982) 20 *History of Science* 157.

science. Boundary-work describes that process and developed from an analysis of the social construction of science by scientists by way of the language and argument used to promote and protect their specialist areas. Gieryn described boundary-work as;

an effective ideological style for protecting professional autonomy: public scientists construct a boundary between the production of scientific knowledge and its consumption by non-scientists (engineers, technicians, people in business and government). The goal is immunity from blame for undesirable consequences of non-scientists' consumption of scientific knowledge.<sup>26</sup>

That description arose from Gieryn's analysis of the debate arising from a 1982 report produced by the US Committee on Science, Engineering and Public Policy, which was a sub-committee of the National Academy of Sciences (NAS). The report suggested that there was a link between the rapid increases in Soviet military strength and the degree to which scientific and technological information was available within the international community. A panel of experts, including representatives of science, industry and government was established to investigate the effect on national security of technology transfer to adversary nations by open scientific communication.<sup>27</sup> The panel concluded that scientific communication should remain free of government constraint for a number of reasons.

It was the language and reasoning of scientists before the NAS panel that gave rise to Gieryn's description of boundary-work. He identified a common rhetorical style whereby certain characteristics are attributed to science for the purpose of constructing a social boundary that distinguishes the non-scientific from scientific.

The identification of boundary-work within disciplines has been developed by other researchers looking at the way in which science is portrayed from those

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<sup>26</sup> Gieryn, T "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists" (1983) 48 *American Sociological Review* 781, 789.

<sup>27</sup> Gieryn, (1983) 790.

within and without the scientific community. It has also been applied to the discourse of other communities of intellectual endeavour where rhetoric is used to establish boundaries that promote and protect the interests of the members.<sup>28</sup>

Boundary-work recognises that science, like religion and philosophy, is a social construction arising not only from scientific methodologies and an institutional framework, but also from language, culture, rhetoric and symbols.<sup>29</sup> The degree of legitimacy arising from science, and particularly from specific research and researchers, will depend in part on the effectiveness of the discourse that establishes boundaries excluding competing ideas.

The concept of science having boundaries that can separate science from non-science or good science from not so good science, is a common theme in policy debates concerning environmental issues. Scientists, regulators and interest groups have been described as attempting to draw clear boundaries between science and policy, even when such boundaries do not really exist.<sup>30</sup> The attempts may be motivated by a desire to influence the allocation of decision making authority or to attach legitimacy to decisions that are likely to either directly or indirectly affect research funding. An article in the *New Zealand Resource Management Journal* illustrates boundary-work in the arena of environmental policy making.

Experience has shown that the value of scientific input is often overlooked or underestimated by many involved in resource management decision-making. In this paper the sound application of good science is promoted to underpin policy, particularly to encourage both the scientific and resource management fraternities to apply good basic science and as

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<sup>28</sup> Abbott, A *The System of Professions* (Chicago: University of Chicago Press, 1988) A study of constructed boundaries as part of interprofessional competitions for jurisdictional control over tasks.

<sup>29</sup> Cross, A "The Flexibility of Scientific Rhetoric: A case study of UFO researchers" (2004) 27 *Quality Sociology* 34.

<sup>30</sup> Nigge, K-M "Seismotectonic Boundary Work: A Case Study of Seismic Hazard Assessment in the Regulation of Nuclear Energy in Canada" (1996) Paper given to the Annual Meeting of the Society for Risk Analysis-Europe. See also Jasanoff, S "Contested Boundaries in Policy-Relevant Science" (1987) 17 *Social Studies of Science* 195-230.

appropriate seek innovative science-based solutions to our many difficult resource management issues.<sup>31</sup>

Hatton has a clear perception of good science and good basic science which is different from bad science or not good science. For him there is a boundary between the good and the not good, but he does not identify that boundary. Instead, the link is drawn between good science and the ability to provide innovative solutions to resource management issues via policy development. His apparent purpose is to promote the legitimacy of science as the appropriate inspiration for resource management policy by emphasising the usefulness of science. Hatton's own experiences and values contribute to his model of science and the boundaries he draws to both protect and promote the elements of science most useful to him as a policy-maker. He also assumes that his boundaries coincide with those of his readers.

Constructivists such as Gieryn argue that boundary-work is the way in which science has achieved public acceptance and a public image. It is not a tool confined to the description of the history and philosophy of science. Rather, it is the way in which modern researchers articulate their findings and argue for the protection and promotion of their own research interests and against the interests of competitors. Boundary-work is particularly evident in the language of expert testimony but can be detected whenever there is argument supporting or opposing a particular issue. When identifying the models of science held by legal decision-makers an analysis of boundary-work is a helpful tool to illustrate the social construction of science as it happens at the individual level. A boundary-work approach is also helpful in that it encompasses the many different views about the nature of science and demonstrates how those views are adapted to meet the social environment of the holder. Boundary-work happens in all aspects of the philosophy and practice of science. Gieryn identifies two different perspectives in interpreting the boundaries between science, technology and society.<sup>32</sup>

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<sup>31</sup> Hatton, C "The Role of Scientific Research in Natural Resource Management. A Resource Manager's Perspective." (2004) 25 *Resource Management Jnl.*,

<sup>32</sup> Gieryn, T "Boundaries of Science" in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 393.

Essentialism involves the identification of unique, necessary and invariant qualities that differentiate science from other knowledge systems. The work of Popper, Merton and Kuhn is characteristic of essentialism in that each of these theorists has strived to identify essential criteria that can distinguish science from non-science. Where boundary-work done by essentialists is directed at finding the essence of what is, as opposed to what is not science, constructivist studies of science try to explain the cognitive authority of science. That explanation focuses on the rhetoric of science without attempting to attribute essential characteristics or to become involved in the demarcation or definition of science. Rather, the unique features of science can be identified amongst its representations with boundaries between science and non-science constructed from social interests in claiming, expanding, protecting or restricting the cognitive authority of science.<sup>33</sup>

Gieryn reports an example of boundary-work from research done by Star and Griesemer.<sup>34</sup> This research built on the work of Star into how diversity and cooperation can coexist within science. Star introduced the idea of a “boundary object” to explain how there can at the same time be diversity and cooperation between different groups pursuing a joint goal. The research of Star and Griesemer studied the interface between professionals and amateurs providing data to a Museum of Vertebrate Zoology. A standardised specimen form was the boundary object that linked the professional scientists and the amateur naturalists. The form was prepared by biologists working at the museum so that specimen data could be accurately recorded. The form was deliberately kept short and simple so that non-professionals could easily fill it out, yet it ensured that there was sufficient information to make each specimen scientifically usable for the professionals. Star and Griesemer identified boundary-work demarcating professional scientist from amateur naturalist in a number of subtle ways. The institution of the museum itself separated the scientific authority of the scientists

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<sup>33</sup> Gieryn, (1995) 405.

<sup>34</sup> Star, S and Griesemer, J “Institutional ecology, translations and boundary objects: Amateurs and professionals in Berkeley’s Museum of Vertebrate Zoology” (1989) 19 *Social Studies of Science* 387-420 in Gieryn, T “Boundaries of Science” in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 393.

from the experiential knowledge of the amateurs. However, the amateurs were vital to the museum's success because they provided the wealth of specimens and information essential to growth of the scientific knowledge basket. What the amateurs lacked in cognitive authority, they gained in numbers and in proximity to the data source. The standardised methods for gathering and handling specimens and for recording information sustained the boundary between the work of the professionals and that of the amateurs, while also allowing that boundary to be bridged so that the goals of the museum could be achieved through the cooperative effort of both groups.

Metaphors can also act as boundary objects that can bridge the boundary between diverse groups pursuing a common goal. Schön maintains that many difficulties in handling social and scientific controversies have more to do with the way in which the goals are framed than with the options selected to achieve those goals.<sup>35</sup> He gives the alternative metaphors for addressing a slum; either as a disease (that must be cured) or as a natural community (that must be protected or restored). Depending on the metaphorical choice various parties will be cooperative or combative with respect to the selection of options available for management of the slum issue.

The specialised language of science is also constructed in such a way that it promotes the intellectual authority of science. Everyday objects and ideas attract their own particular and different language within science so that the differences between science and non-science can be clearly identified. For example, the term 'animal' to the lay person equates to 'mammal' for a scientist, and mud snail (or Titiko) to a shell fish gatherer becomes *Potamopyrgus antipodarum* for a zoologist. The detailed scientific dictionaries and tables, handbooks of scientific interpretation and special courses on technical writing all reinforce a view of scientific language as being special and unavailable to 'outsiders'.<sup>36</sup> Bazerman's

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<sup>35</sup> Schön, D "Generative Metaphor: A perspective on Problem-Setting in Social Policy" in Ortony, A (ed) *Metaphor and Thought* (Cambridge: Cambridge University Press, 1979) 254-284.

<sup>36</sup> Bazerman, Charles. 2000. *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*. WAC Clearinghouse Landmark Publications in Writing Studies: [http://wac.colostate.edu/aw/books/bazerman\\_shaping/](http://wac.colostate.edu/aw/books/bazerman_shaping/) Originally Published in Print, 1988, by University of Wisconsin Press, Madison, Wisconsin.

study of scientific writing warns that there are various reasons to distrust scientific language. Those reasons largely reflect the notion that scientific language is no different to other types of language. It is a system that enables assumptions and representations to be articulated within language. It is designed to establish and maintain the authority of science and to exclude and marginalize non-science. Scientific language is also used to persuade and manipulate in order to promote the interests of competitive individuals and groups within the scientific community. In summary, Bazerman comments that:

[S]cientific formulations are a human construction and thus are heir to all the limitations of humanity. Scientific formulations, giving us no direct access to things in themselves, seem to do all the social work of being human with no overt means of doing the empirical work which has been considered the work of science. The appearance of reality projected in scientific texts is itself a social construction.<sup>37</sup>

While Bazerman and others refer to the role of language in achieving intellectual supremacy for science within modern society, that position was strongly contested in the past and remains open to attack from time to time on various fronts. Gieryn alludes to the 1980s litigation in the United States over the teaching of creationism,<sup>38</sup> rather than evolution, in schools and there has been vigorous debate in some New Zealand classrooms over the genetic engineering component in senior biology courses.<sup>39</sup>

Gieryn illustrates a historic example of boundary-work in science from the writings of John Tyndall (1820–1893) who was Professor and Superintendent at the Royal Institution in London.<sup>40</sup> Tyndall was involved in promoting science over religion as *the* authoritative knowledge form in order to both secure financial

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<sup>37</sup> Bazerman, (2000) 294-295.

<sup>38</sup> Gieryn, T “Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists” (1983) 48 *American Sociological Review* 781, 783-784.

<sup>39</sup> Personal communication, P Vernon (January 2004).

<sup>40</sup> Gieryn, T “Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists” (1983) 48 *American Sociological Review* 781, 784 – 787.

support for research and researchers and also to establish community acceptance and understanding of that research. In order to justify financial support for science, as opposed to other non-science endeavours, Tyndall needed to challenge the intellectual authority of Victorian religion and to marginalize the financially beneficial, practical advances of Victorian engineering and mechanics. He did so by attributing selected characteristics to science that demarcated it from religion or mechanics while also establishing a rationale for the intellectual superiority of science.

Tyndall positively distinguished science from religion in a number of different ways. He argued that science was useful because it inspired technological progress, that in turn improved the material conditions of society. Religion, on the other hand was useful only to the extent that it provided emotional comfort to its adherents. He emphasised the empirical nature of science and its link to experiment and observation, as opposed to the unseen and spiritual nature of religious truths. Tyndall promoted the sceptical nature of science with its reference to observable facts of nature and its flexibility to adapt where theories are not borne out by those facts. Conversely he characterised religion as dogmatic and antiquated. And finally, he described scientific knowledge in terms of objectivity, being free from private interest, bias or prejudice and easily distinguished from the subjective and emotional nature of religion.

Tyndall's rhetoric changed noticeably when he argued for the intellectual superiority of science over technology. He emphasised the role of scientific knowledge as the foundation for technological creativity. The following example is typical of his language:<sup>41</sup>

Let the self-styled practical man look to those from the fecundity of whose thought he, and thousands like him, have sprung into existence. Were they inspired in their first inquiries by the calculations of utility? Not one of them.

He also emphasised the role of experimentation in science as offering the power of explanation that is missing from the work of mechanics and engineers. He

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<sup>41</sup> Tyndal, J (1902: 221-22) in Gieryn, (1983) 786.

promoted the theoretical nature of science and the role of research in finding causal principles that go beyond the observable.

...the visible world [is] converted by science into the symbol of an invisible one. We can have no explanation of the objects of experience, without invoking the aid and ministry of objects which lie beyond the pale of experience.<sup>42</sup>

He highlighted the profit-driven motives of technology and compared those with the goal of science to discover the truth about the natural world, describing the acquisition of knowledge for its own sake as being a more noble attribute of human culture.

Tyndall's writing and public lectures are helpful examples of boundary-work because they demonstrate how a prominent nineteenth century scientist used language to both promote science and to demarcate it from non-science in the competition for research funding and public status. His arguments considerably changed depending on his adversary. Against religion he emphasised the practical and useful nature of science and experimentation. However, against technology he emphasised the theoretical, motiveless and cognitive nature of science. He was able to construct a view of science within particular audiences that would best meet his own needs and the needs of scientists for whom the Royal Institution supported. His success was no doubt influenced by the effectiveness of boundary-work employed by his competition.

Boundary-work is also the subject of Edmond's analysis of the Lindy Chamberlain murder trial.<sup>43</sup> His particular focus was the 'zoo experiment' in which the prosecution arranged for captive dingos to be observed for their ability to extract kids (goats) from a jumpsuit analogous to that worn by baby Azaria before her disappearance. Edmond demonstrates how legal advocates employed boundary-work in order to benefit one party or another rather than to show what is or is not science. The experiment was subject to criticism for being unscientific,

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<sup>42</sup> Tyndal, in Gieryn, (1983) 786.

<sup>43</sup> Edmond, G "Science in Court: Negotiating the Meaning of a 'Scientific' Experiment During a Murder Trial and Some Limits to Legal Deconstruction for the Public Understanding of Law and Science" (1998) 20 Sydney LR 361.

being largely a comparison with the visual appearance of Azaria's clothing, and the credibility of investigating scientists and technicians was challenged by the defence during cross-examination as the methodology was deconstructed. However, the defence also embraced elements of the experiment that supported their case, (for example the number of domes left unopened) thus drawing scientific and credibility boundaries around some results while at the same time rejecting the scientific status of the experiment.<sup>44</sup>

A boundary-work approach enables an analysis of how individuals construct and use their models of science. Boundary-work not only happens at the wider, 'political' or macro face of science, where the boundaries between science and non-science are constructed. Boundary-work also occurs on an individual micro level, where specific criteria determine the boundaries for each individual's model of science. Studies of models proposed to identify the essential characteristics of science, are all about identifying qualifying criteria that set those boundaries. Non-essentialist, or social constructionist approaches look at the macro boundary-work and identify the social and political nature of defining boundaries. From either approach, a boundary-work analysis enables a contextual study of how individuals construct and use their models of science. The following summaries of essentialist perspectives of science describe the philosophical framework the underlies modern models of science.

## 2.3 **Essentialist Perspectives of Science**

### 2.3.1 *Science in the Enlightenment*

Traditional models of science often depict scientists as objective gatherers of information, who by following a common method of science and by applying common principles of logic, will produce findings that can be replicated by any other scientist and that will represent the reality of nature. The basis for this paradigm can be found in the writings of Enlightenment philosophers, Rene Descartes (1596-1650) and Francis Bacon (1561-1626) and in the writing on rationality by the German philosopher, Immanuel Kant (1724-1804). Both Descartes and Kant proposed that knowledge exists externally and independently of human thought, but can become knowable by the operation of a universal

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<sup>44</sup> Edmond, (1998) 379.

reason. Thus, there is a reality external to the human mind, which is only knowable when reason is applied. Reason was believed to exist universally and independently of human thought; as forming the organisational framework of human thought; and as existing identically in every individual, or 'subject of knowledge'.<sup>45</sup> The exercise of reason produced *a priori* laws of nature that can be shown to be objectively true by reference back to this 'natural' and universal reason.<sup>46</sup> By this separation of mind from body (and thus from nature) it was possible to present science and scientists as the neutral and objective uncoverers of 'true' knowledge. The Cartesian version of epistemology was embodied by the rationalist theorists who propose that humans acquire knowledge about the natural world primarily by thinking and that the qualities characteristic of scientific knowledge are those relating to the formation of theories from the logical organisation of data gained from observations.<sup>47</sup>

Bacon, who was also a lawyer and a central figure in the development of English Common Law, proposed a philosophy that emphasised the importance of the nature of matter itself. Previously, the Greek and medieval astronomers and mathematicians worked within a paradigm that divided the concept of 'form' or organisation, from matter or nature. Knowledge was perceived as the result of studying the forms of nature, where 'form' was the underlying principle that determined the organisation of matter, the mind, and nature itself.<sup>48</sup> For Bacon, the rational knower could not only understand nature through the contemplation of its forms, but he (and for Bacon, a rational knower could only be a he) could also control nature by an understanding of the nature of matter itself. This understanding could be obtained by careful observations of the patterns of matter

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<sup>45</sup> Gilbert, J *Thinking 'other-wise': re-thinking the problem of girls and science education in the post-modern* (University of Waikato: DPhil Thesis, 1997) 130.

<sup>46</sup> Kant accepted the existence of an objective and independent reality but considered that the reality of matter was itself unknowable. What the mind could know, was only a representation of reality framed within the mind by the universal framework of reason. See Hung, E *The Nature of Science: Problems and Perspectives* (London: Wadsworth, 1997) 450.

<sup>47</sup> Musgrave, A *Common-Sense, Science and Scepticism: A Historical Introduction to the Theory of Knowledge* (Cambridge: Cambridge University Press, 1993).

<sup>48</sup> Gilbert, J *Thinking 'other-wise': re-thinking the problem of girls and science education in the post-modern* (University of Waikato: DPhil Thesis, 1997) 178.

in a process where the operation of the mind was seen as being completely separate and independent of the reality of matter. Bacon considered that there was a correct scientific method to follow in order to properly collect data about the real world. His method had four steps:<sup>49</sup>

- a) Observation and experimentation to collect the raw material for theorising;
- b) Classification of data in order to identify the patterns in nature;
- c) Generalisation of patterns to form theories about the organisation of matter;
- d) Testing of the generalisations in order to eliminate exceptions and to verify the theories.

Empiricist theorists who emphasised the prior existence of the real world over any knowledge of it later developed the Baconian philosophy. For empiricists, the essence of scientific knowledge could only be produced from observations about the world. Observations are derived from human experience via the senses. Thus, scientific theories were perceived as the best available representations of the organization of reality. From these beginnings developed the modernist view of science, which proposes a disjuncture between the rational mind – being the subject of scientific knowledge, and between the matter of the body – which becomes the object of scientific knowledge. Both the Cartesian and empiricist models of science identified certain, not necessarily universal, characteristics essential the practice of science, for example rational thought, objective observation and experimentation. Those characteristics were adapted and adopted by the logical positivist schools of thought, however the focus for these theorists became the process by which the body of knowledge representing science both grew and changed.

### 2.3.2 *Logical Positivism*

The Baconian emphasis on the control of matter enabled the goals of science to be increased to include both the explanation of and the control of the natural world. It was then a small step to equate the pursuit of true knowledge, that is, scientific knowledge, with the control of the natural environment in order to facilitate

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<sup>49</sup> Hung, E *The Nature of Science: Problems and Perspectives* (London: Wadsworth, 1997) 267.

progress and freedom for individuals.<sup>50</sup> It would be incorrect, however, to infer that the rationalist and empiricist approaches to science have resulted in any universal philosophy of science. The main criticism of these two philosophies has been that they do not reflect how science actually operates. Scientists do not sit about all day meditating on the nature of matter and nor do they randomly collect and classify data in order to discover laws of nature. Most of the accounts of scientific knowledge that are obtained from working scientists include elements of both the empiricist and rationalist approaches. Such descriptions often depict scientific knowledge as a combination of information produced out of observation and experience to produce a body of knowledge that is organised by the application of rational thought. These types of descriptions are consistent with the logical-positivist account of scientific knowledge. Logical-positivism is a philosophical movement that began in the 1920s and is associated with a group of scientists and philosophers, which became known as the 'Vienna Circle'.

The writing of the Austrian philosopher, Ludwig Wittgenstein (1889-1951) influenced the group. Wittgenstein argued that the reality of matter could be represented in the human mind by the application of rational thought and then communicated to others through language. The logical positivists distinguish scientific knowledge from other forms of knowledge (for example common sense) by the set of rules that frame the relationships between 'empirical facts' (which are deduced from experience by observation and experimentation) and 'logical facts' (derived from the application of logic). Logical positivism, as it is applied to science, is a reasonably successful strategy for combining the elements of rationalism and empiricism because science deals with those elements that are measurable, or definable, according to accepted rational criteria. Thus, 'empirical facts' are likely to be verifiable within existing systems of logic.

### Falsification and Popper

The logical-positivist movement was probably the strongest attempt at a unified theory of scientific knowledge in modern times, and on the face of it this epistemology of science does seem to provide a theory of science that incorporates the essential characteristics that are identified as important by

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<sup>50</sup> Santos, B *Toward a new common sense* (New York: Routledge, 1995).

working scientists. The weakness of the theory, however, is that like both the empiricist and rationalist approaches, logical-positivism relies on the existence of an inherent and rational 'human nature' as well as on the *a priori* existence of a universal rationality of organisation of matter that is external to the process of human thought.<sup>51</sup> Scientific theories relied for their verification on a process of inductive logic whereby the experiences obtained from a variety of observations were transformed into predictive theories using inductive logic. However, a problem with induction is that the predictions can only be verified against empirical data. The predictions cannot be shown to be true for all matter and for all time; they only remain true for untested matter by the acceptance of logical reasoning. The Austrian philosopher, Karl Popper (1902-1994) proposed an alternative epistemology to explain the nature of scientific thought that would avoid the problem of verification of theories that accompanies the application of inductive logic. Popper proposed that scientific theories are never ultimately provable, but must remain tentative hypotheses that survive as the best explanations of empirical observations. The 'best' theories are those that survive rigorous testing against the reality of the natural world and such theories can be accepted into the body of scientific knowledge while they continue to be the closest approximation of the 'truth' of nature and until they are disproved by subsequent experimentation.<sup>52</sup> Popper proposed that scientific knowledge gets its authority, not by the application of inductive logic, but rather by the negative operation of deductive logic. He describes the scientific method as a process of producing 'imaginative insights' (whose origin was immaterial) called hypotheses, or theories. From the theory a number of observational consequences can be predicted by applying principles of deductive logic. Those consequences can then be tested against the reality of the world by experimentation.<sup>53</sup> By this method the evaluation of the theory lies in its resistance to falsification. Thus, there was a mechanism by which scientists could police the boundaries of science. Any claim masquerading as science could readily be excluded from the rightful body of scientific knowledge as soon as it could be shown to be false. The

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<sup>51</sup> Gilbert, J *Thinking 'other-wise': re-thinking the problem of girls and science education in the post-modern* (University of Waikato: DPhil Thesis, 1997) 194.

<sup>52</sup> Popper, K *Conjectures and Refutations* (London: Routledge and Kegan Paul, 1963).

<sup>53</sup> Hung, E *The Nature of Science: Problems and Perspectives* (London: Wadsworth, 1997) 342.

incorporation of a requirement for testing into the model also ensured that results would be revisited by other experimenters and under different conditions increasing the likelihood that false claims would be discovered and rejected. Popper named this method the “hypothetico-deductive” method of scientific enquiry.<sup>54</sup>

Popper’s hypothetico-deductive method has also been very influential in modernist approaches to the epistemology of science because it emphasises the rigour of scientific experimentation and enhances the image of objectivity. According to Popper, ‘good’ science has no vested interest in promoting false or weak theories because the scientific method demands an ongoing campaign of experimentation in order to expose weakness and rout out false theories. For Popper, a major scientific achievement could never be the verification of a theory or hypothesis, but rather its falsification. Thus, if the aim of science is to find the theories that provide the best approximation of reality by eliminating those which cannot be true, then all scientists (who are imbued with the same universal rationality as all human beings) will be neutral towards their findings and will ensure that their research can easily be replicated by others. Any theory that either was not subject to rigorous testing or did not hold true under that testing would therefore remain outside of the boundaries of science. The difficulty with this philosophy, however, is that it does not match with historical evidence of how scientists work. There are numerous examples of theories that have been ‘falsified’ by subsequent experiment and far from being abandoned completely, the theories are adapted to meet the challenge.<sup>55</sup> Latour argues that the normal response to criticism of a scientific hypothesis is a retreat into increasingly technical language and then into increased instrumentation to obtain findings that on the one hand support the hypothesis, and on the other reject it, depending on whether one is a proponent or opponent.<sup>56</sup> Latour illustrates this process very clearly with an example of scientific controversy over the nature of a molecule

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<sup>54</sup> Popper, K *The Logic of Scientific Discovery* (London: Hutchinson, 1972).

<sup>55</sup> Kuhn describes this process as part of ‘normal science’. Kuhn, T *The structure of scientific revolutions (2nd ed)* (Chicago: Chicago University Press, 1970).

<sup>56</sup> Latour, B *Science in Action* (Cambridge, Mass: Harvard University Press, 1987).

claimed to be growth hormone.<sup>57</sup> The controversy was first aired in the pages of scientific journals where support tended to vary according to the credentials of the scientists involved. Articles supporting and opposing the proposed molecular identity then became increasingly more technical and detailed and finally the methods of experimental analysis were altered to provide finer and finer correlations with the 'reality' of the world. Latour notes, that even then 'reality' was a graphical representation of molecular activity and that representation was consensually agreed as accurate. This particular controversy ended when the parties were able to modify their hypotheses and accept that the molecule in question was not growth hormone, but they did so in a way that reputations could remain intact. There are also numerous examples from the history of scientific research that demonstrate the determined support and commitment to a theory by its proponent, even in the face of a wealth of data that points to its falsity. The eighteenth century chemist Joseph Priestley (1733-1804) defended his phlogiston theory of combustion right to the time of his death even though the experiments of Lavoisier, in 1775, provided much stronger evidence for a process that involved the addition of something (oxygen) during combustion.<sup>58</sup> Such commitment to one's work is understandable given the time spent on developing the theory and the public nature of science. Having published what is believed to be a new and reliable addition to the body of scientific knowledge, no-one is going to readily abandon that work at first challenge, and once the process of defence begins a proponent will have considerable interest in maintaining her reputation within the scientific community.

#### Science as a revolutionary process

One of the harshest critics of Popper's falsification theory, was Thomas Kuhn. Kuhn argued for a theory of scientific knowledge that more closely approximated the practice of science. According to Kuhn, science proceeds within conceptual frameworks, or paradigms. Once a paradigm is accepted there will be a period of what he terms, 'normal science'.

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<sup>57</sup> See Latour, (1987) chapter one.

<sup>58</sup> Hung, E *The Nature of Science: Problems and Perspectives* (London: Wadsworth, 1997) 373-4.

Kuhn developed the idea of a ‘scientific paradigm’ in the 1960s as a response to other attempts to formulate a universal philosophy of science.<sup>59</sup> For Kuhn, a paradigm is a comprehensive or ‘generic theory’ which is shared by members of a scientific community and which forms the conceptual framework within which scientists operate.<sup>60</sup> Kuhn proposed that while there could be several paradigms concerning the same aspect of the natural world in operation at one time, these would be in competition with each other so that eventually one paradigm would be accepted by the majority of the scientific community and would come to replace the other (or others) as the framework which formed the basis of a period of normal scientific activity. For example, Ptolemy’s geocentric theory of planetary motion was a paradigm that was accepted for 14 centuries as it was able to explain the observable motions of the heavenly bodies. It was not until the sixteenth century that the Copernican heliocentric theory replaced the Ptolemaic paradigm. For all the time that the Ptolemaic paradigm was dominant, astronomers observed, measured and described planetary motion within a framework that had the Earth at the centre of the universe. Thinking about the structure of the universe was bound by that framework which placed the Earth at its centre and this thinking did not change until the number of anomalies became so great that the paradigm was too contorted to remain intact. I use the term ‘paradigm’ in a similar way, but to describe the framework which defines how we, as non-scientists, perceive the operation of science. I suggest that the scientific paradigm is a framework with borders within which we conceptualise the role and reality of science, but that this paradigm is only a representation of a way of thinking, as was Ptolemy’s geocentric theory of planetary motion.

During periods of normal science, members of the scientific community will be involved in developing theories that will support the paradigm and in factual scientific investigations. For Kuhn, paradigms not only determine what will be accepted as fact, but they also will generate new problems for investigation. During periods of normal science there will be considerable progress in the

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<sup>59</sup> Kuhn, T *The structure of scientific revolutions (2nd ed)* (Chicago: Chicago University Press, 1970).

<sup>60</sup> Hung, E *The Nature of Science: Problems and Perspectives* (London: Wadsworth, 1997) 368-370.

gathering of facts and in the postulating and testing of hypotheses to explain the problems. For some paradigms there will be evidence collected that contradicts the paradigm. Usually new theories will be produced that can either explain away or accommodate these inconsistencies, but periodically, so many of these anomalies arise that the paradigm can be said to be in crisis. At this time, new theories will be developed and eventually one of these will be accepted as a successful replacement of the earlier paradigm, in a process that Kuhn describes as 'scientific revolution'.<sup>61</sup>

The success of Kuhn's epistemology of science lies in its ability to represent the process of science with reference to historical developments. While Popper's theory is perhaps a normative representation of 'good' science, Kuhn is able to link the practice of science with its history of theoretical innovation. Reflective testing of hypotheses using deductive logic is still recognised as a necessary justification of theories, however, progress is achieved by the formulation of new hypotheses to explain the problems generated by the paradigm. Kuhn also develops the idea of a paradigm that forms a framework within which all of the representational theories and empirical facts about the real world can be generated. Elements of the Kuhnian paradigm can be found in Latour's 'railroad' metaphor for describing science. Latour belongs to the anti-positivist and social-constructivist school of thought and sees science as being entirely socially constructed according to specific political interests.<sup>62</sup> Latour argues that the characteristics of science that are most significant in epistemology, are linked to the organisation of laboratories and research publications.<sup>63</sup> His railroad metaphor reads as follows;

When people say that knowledge is "universally true", we must understand that it is like railroads, which are found everywhere in the world but only to a limited extent... To shift to claiming that locomotives can move beyond their narrow and expensive rails is another matter...

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<sup>61</sup> See Kuhn, T *The structure of scientific revolutions (2nd ed)* (Chicago: Chicago University Press, 1970) and Hung, (1997) chapter 26.

<sup>62</sup> Gilbert, J *Thinking 'other-wise': re-thinking the problem of girls and science education in the post-modern* (University of Waikato: DPhil Thesis, 1997) 199.

<sup>63</sup> Latour, B *Pasteurization of France* (Cambridge Mass: Harvard University Press, 1988).

The magicians try to dazzle us with “universal laws” which they claim to be valid even in the gaps between the networks.<sup>64</sup>

In this metaphor, the railway lines interlink within a railroad system, or paradigm, and form the knowledge context for science. The locomotives are the theories and these are confined to the railway lines and cannot traverse the territory between tracks until new tracks are laid. Thus, the laws that are claimed to be universally applicable can only be so within the railroad system and those individuals that control the placement of the tracks, will also control both the direction of travel and the surrounding territory. This metaphor is useful for emphasising the degree to which the framework of the dominant scientific paradigm will determine the knowledge that is accepted by the scientific community. It also challenges a strictly rationalist approach to the epistemology of science by suggesting that the conceptual framework, which includes the physical and social environment, will affect the method of experimentation and also the interpretation of data and unless that conceptual framework is identical for everyone, there is a challenge to the objectivity of science. Kuhn also considered the nature of the objectivity of science, and accepted that differences between individuals must necessarily result in different choices of method and of analysis. For Kuhn, the essence of science lies in a common value system that includes the following five characteristics; accuracy; consistency; breadth of scope or application; simplicity; and innovation (or the capacity to generate new problems).<sup>65</sup> Kuhn suggests that even given individual differences in the way that these values are effected; there will be a normal distribution of outcomes due to the size of the scientific community and that this distribution may justify reliance on scientific explanation.<sup>66</sup> I find that suggestion to be helpful when deciding on what basis to rely on science. Although there is no universally accepted definition of either the method or philosophy of science, there are commonalities that are consistent with Kuhn’s values of science and those values fit within the boundaries of my own model of science. Individually, the characteristics of science can be, and are, criticised for their imperfections, however, the scientific enterprise as a whole has sufficient

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<sup>64</sup> Latour, (1988) 226.

<sup>65</sup> Kuhn, T *The Essential Tension* (University of Chicago Press: Chicago, 1977) 322-323.

<sup>66</sup> Kuhn (1977) 331-334.

coherence and consistency to provide reliable knowledge that is acceptable to the scientific community and is helpful for legal decision makers. The proviso being that boundary-work undertaken by both those giving and receiving scientific information must be recognised as an intrinsic element reflecting the social context of science.

### Merton's norms and the modern paradigm

The scientific paradigm that is most commonly described in Post Enlightenment (post-seventeenth century) or modernist thought has the following essential features. Science is described as a process that involves theorising and testing of those theories. The process of theorising involves the collection and measurement of data and that data is collected by the operation of the senses. Theorising also involves rational thought whereby principles of logic that are universal to humankind are applied to formulate the best explanations of the physical world. Another feature essential to the scientific paradigm in modernist thought is that of the objective and therefore 'true' nature of scientific knowledge.

The goals of science that were proposed in the 1940s by Robert Merton, a sociologist of science, are frequently referred to as a reasonable representation of the paradigm of academic science within Modernity.<sup>67</sup> These goals became known as the Mertonian Norms and can be summarised as follows:

- Communalism - a notion of science as public knowledge that is freely available to all;
- Universalism - an agreement that scientific knowledge should be assessed on its merits and not by reference to the status of its producer.  
This norm requires the assumption of objectivity and neutrality of the subject of science as distinct from the object of the research;
- Disinterestedness- describes a perception that scientists are motiveless with respect to their research.

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<sup>67</sup> Ziman, J *Public Knowledge: The social dimension of science* (Cambridge: Cambridge University Press, 1968) 9.

Originality - agreement that science is a process of discovering the unknown and scientific knowledge is the result of that process;

Scepticism - the idea that knowledge should not be taken on trust but carefully scrutinised for errors of fact or argument.<sup>68</sup>

The extent to which those norms contribute to an individual's model of science varies according to the individual's own values and social environment. For example, John Ziman emphasises the importance of the quest for 'true' knowledge and the role of rational thought, however for him, the goal of consensuality remains science's defining feature.<sup>69</sup> Ziman argues that the public availability of knowledge and the goal of consensuality are fundamental to and distinctive of science. By public availability he does not restrict his meaning to publication of research, rather, he argues:

The objective of science is not just to acquire information nor to utter all non-contradictory notions; its goal is a consensus of rational opinion over the widest possible field.<sup>70</sup>

In accepting that these norms reflect the modern scientific paradigm, Ziman highlights the assumption that there is some form of rationality that is common to the thinking of scientists.

The modern paradigm is also demonstrated in the views of scientists and their mentors when trying to articulate their models of science. Carl Sagan, a scientist who has done much to popularise science via his many books, describes science in terms of the way in which scientists operate.

I maintain that science is part and parcel humility. Scientists do not seek to impose their needs and wants on Nature, but instead humbly interrogate Nature and take seriously what they find. We are aware that revered scientists have been wrong. We understand human imperfection. We

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<sup>68</sup> Merton, R *The Sociology of Science* (Chicago: Chicago University Press, 1973).

<sup>69</sup> Ziman, J *Public Knowledge: The social dimension of science* (Cambridge: Cambridge University Press, 1968) 9.

<sup>70</sup> Ziman (1968) 9.

insist on independent and - to the extent possible - quantitative verification of proposed tenets of belief. We are constantly prodding, challenging, seeking contradictions or small, persistent residual errors, proposing alternative explanation, encouraging heresy. We give our highest rewards to those who convincingly disprove established beliefs.<sup>71</sup>

The Nobel Prize winning medical researcher, Sir Peter Medawar, describes science as “knowledge hard won in which we have much more confidence than we have in opinion, hearsay and belief.”<sup>72</sup> He notes that the characteristics of science include its organisation as deductively ordered knowledge and its predictive capability. Medawar also argues that progress in science is dependent on scientists retaining confidence in each other so that researchers can use and test each other’s work without fear of dishonesty behind data and analysis.

Medawar’s focus on the organisation of scientific knowledge and method is also reflected in the definition proposed by Marion Namenwirth, a biologist. She writes that “[s]cience is a system of procedures for gathering, verifying, and systematising information about reality.”<sup>73</sup>

The goal of science, and particularly the scientific theory, as a mechanism for describing the universe is central to mathematician and physicist Stephen Hawking’s model of science.<sup>74</sup> Like Medawar and Namenwirth, Hawking emphasises that the explanatory purpose of science, that is reflected in the ever-increasing body of scientific knowledge, is the uniting theme for the disparate disciplines within the scientific community.

Freeman Dyson is another physicist who emphasises the explanatory goal of science via the formulation of universal theories. Dyson describes scientific endeavour as an art form because of the elegance and architectural quality of

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<sup>71</sup> Sagan, C *The Demon-Haunted World* (London: Headline Book Publishing, 1996) 35.

<sup>72</sup> Medawar, P *The Limits of Science* (Oxford: Oxford University Press, 1984) 3.

<sup>73</sup> Namenwirth, Marion “Science Seen Through a Feminist Prism” in Bleier, Ruth (ed) *Feminist Approaches to Science* (New York: Teachers College Press, 1991) 29.

<sup>74</sup> Hawking, S *A Brief History of Time*. (London: Bantam, 1988).

scientific theories and their mathematical proofs.<sup>75</sup> He suggests that the chief reward for many scientists is not power nor money, but “the chance of catching a glimpse of the transcendent beauty of nature.”<sup>76</sup> Dyson also acknowledges the importance of the scientific community in the growth of scientific knowledge. He eloquently describes science as follows:

My message is that science is a human activity, and the best way to understand it is to understand the individual human beings who practise it. Science is an art form and not a philosophical method. The great advances in science usually result from new tools rather than from new doctrines....Science flourishes best when it uses freely all the tools at hand, unconstrained by preconceived notions of what science ought to be. Every time we introduce a new tool, it always leads to new and unexpected discoveries, because Nature’s imagination is richer than ours.<sup>77</sup>

This passage usefully illustrates that modern scientists have diverse views about the nature of science and that these views can include classical Cartesian concepts such as the existence of a separate, discoverable body of scientific knowledge. It is likely that rules concerning the process of science, for example the Mertonian Norms, will provide the boundaries that separate Dyson’s art from Michelangelo’s.

Perhaps physicist Richard Feynman provides the most helpful and accessible attempt at a popular definition of science.

What is science? The word is usually used to mean one of three things, or a mixture of them. I do not think we need to be precise – it is not always a good idea to be too precise. Science means, sometimes, a special method of finding things out. Sometimes it means the body of knowledge arising from the things found out. It may also mean the new things you can do when you have found something out, or the actual doing of new things. This last field is usually called technology – but if you look at the science

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<sup>75</sup> Dyson, Freeman “The Scientist as Rebel” in Cornwall, *J Nature’s Imagination* (Oxford: OUP, 1995) 1.

<sup>76</sup> Dyson (1995) 10.

<sup>77</sup> Dyson (1995) 11.

section in *Time* magazine you will find it covers about 50 percent what new things are found out and about 50 percent what new things can be and are being done. And so the popular definition of science is partly technology too.<sup>78</sup>

His reference to technology is interesting in that this is the only description of science from the scientist writers that I have considered that includes the application of scientific knowledge. It becomes clear from the rest of Feynman's work that the process of theorising to build the body of scientific knowledge is the key element in his model of science, however his popular description recognises that for non-scientists it is the application of science that is its true value.

In New Zealand (and most other western countries) science and technology are separated as distinct disciplines within the education system. However, science and technology have significant interrelationships. John Gilbert describes technology in terms of 3 components; technical, organisational and cultural.<sup>79</sup> The technical aspect comprises the knowledge, including scientific concepts and data collected by the scientific method. Technology knowledge is the knowledge required in order to solve a practical problem. The organisational aspect relates to the issues that need to be addressed in order to sell and distribute a particular product. The cultural aspect addresses the goals, values, creativity and progressive nature of technological outputs. This paper, and other papers written concerning technology education, clearly describes technology and science as fundamentally different. Academic commentaries from within other disciplines also differentiate science from technology. Jasanoff et al have published a substantial *Handbook of Science and Technology Studies*<sup>80</sup> whose title implies a difference between the two concepts. In addition, the terms are used in everyday language to indicate difference between the 2 disciplines. For example, the University of Waikato formerly had a School of Science and Technology rather than just a School of Science. I note that the University has now changed the

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<sup>78</sup> Feynman, R *The Meaning of it all: Thoughts of a Citizen Scientist* (Mass: Helix Books, 1998)

<sup>79</sup> Gilbert, John "The interface between science and technology in schools" (1994) Samepapers 143.

<sup>80</sup> Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) -820 pages in total.

name to the School of Science and Engineering. That change may more accurately reflect the type of technology studies being offered, or it may be a marketing strategy to attract student enrolments. Either way, the title reflects the disjuncture in academic perception between science and its application.

## 2.4 **Boundary-work and the social construction of science**

### 2.4.1 *Boundary-work in action*

The social constructivist critiques of the modern paradigm of science begin by deconstructing the boundaries to that paradigm. The approaches vary depending on the philosophical or political framework that is adopted, but essentially the critiques challenge how and why the boundaries that determine what is within and without legitimate science are established.

Gieryn identifies 4 types of boundary-work done by scientists and these categories have been adopted by a number of other researchers applying the approach to various knowledge claims.<sup>81</sup> He does not claim that these categories are exhaustive but they provide a useful structure for analysing science and scientific rhetoric and are clearly evident in the arguments promoted in favour of recognising science as being socially constructed.

### Monopolisation

Monopolisation involves the protection of professional authority and resources by dominating the cultural representation of science to the exclusion of anything that does not comply.<sup>82</sup> Gieryn uses an example from the work of Shapin and Schaffer which analyses the 17<sup>th</sup> century epistemological debate between Robert Boyle and Thomas Hobbes.<sup>83</sup> Shapin and Schaffer show how Boyle was able to assert the authority of his experimental approach to the study of pneumatics, over the traditional rationalist approach to theoretical physics that was promoted by Hobbes. Superficially, the debate concerned theories about the existence and

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<sup>81</sup> Gieryn, T "Boundaries of Science" in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 393,

<sup>82</sup> Gieryn (1995) 393, 424.

<sup>83</sup> Shapin, S and Schaffer, S *Leviathan and the air pump: Hobbes, Boyle and the experimental life* (Princeton NJ: Princeton University Press, 1985)

application of a vacuum. However, the significance of this debate was in the boundary-work employed by each of the key players which ultimately established experimentalism as the authoritative and authentic source of knowledge.

Boyle had characterised science as seeking the truth about matters of fact, where facts could be observed following experiment according to set procedures.<sup>84</sup> The authenticity of those facts was achieved because experiments were replicated and collectively witnessed by multiple observers. Primitive laboratories enabled experimentalists to share their findings, to test apparatus and to develop a scientific discourse that described the aim, method and results of the experiment. That discourse focussed on matters of fact. Any interpretations or hypotheses relating to explanations for those facts were treated as undecidable until they could be verified by further facts arising from experiment.

For Boyle, any knowledge not based on observable fact fell outside of legitimate sources of knowledge. Such illegitimate sources included private and personal experience, religion and philosophy. Philosophers of science such as Hobbes articulated Boyle's perception of non-science. Hobbes' view of science embodied the realm of certain knowledge formed from rational deductions that gave rise to irrevocable and universal laws. Such laws were grounded in geometry and provided causal explanations that did not depend on observable facts. Deductive logic gave rise to certain knowledge and applied equally to the study of nature and politics.

Neither Hobbes nor Boyle included religion inside their boundaries of science. For Hobbes, theologians, together with other professional groups including experimenters, impeded the pursuit of certain truth. Such groups provided competing grounds for knowledge and could not deliver the universal assent commanded by rational philosophy. On the other hand, Boyle excluded religion for the opposite reason. Theologians did not participate in experimental inquiry. Their knowledge was based on a certainty arising from study of sacred texts rather than testable facts grounded in nature.

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<sup>84</sup> Shapin, S and Schafer, S (1985) 153.

Shapin and Schaffer argue that Boyle won this boundary-work skirmish by establishing experiment and observation as key indicia of authentic science.<sup>85</sup> It followed that only those from within the experimental community, and who thus either worked from Boyle's laboratory, or built one for themselves, could challenge claimed facts. Not surprisingly, only those committed to Boyle's experimental approach were permitted to attend his experiments or, eventually, to be admitted to the Royal Society itself.<sup>86</sup> On the other hand, Hobbes was portrayed as a dogmatist and his certain knowledge was unable to engage the support and influence of the leaders of Restoration England. His tradition of logical deduction was temporarily excluded from the boundaries of science in favour of a certain, technical and collective approach to knowledge grounded in observable fact. That objective and non-contentious approach was particularly attractive to Restoration England and its desire for "a peaceful society between the extremes of tyranny and radical individualism".<sup>87</sup> The success of Boyle's boundary-work is a testament to his ability to establish the authority of his experimental approach by aligning with the political leaders of the time. The social and political conditions of the time supported a move away from philosophical debate towards the certainty of observable and testable fact. In that way, Boyle was able to establish experiment as the single source of authentic knowledge, effectively monopolising everything within the boundaries of science.

A modern example of monopolising boundary-work surrounds the outrage that was expressed by the international environmental science community following publication of a book challenging scientific predictions arising from climate change.<sup>88</sup> Bjorn Lomborg is a Danish political scientist and statistician who analysed a wealth of publicly available statistical data from organisations such as the United Nations, the World Wildlife Fund and the World Bank. He challenged what he described as the "Litany" popularly accepted within the environmental community that predicts an imminent environmental Apocalypse. The book

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<sup>85</sup> Shapin, S and Schafer, S (1985) 341.

<sup>86</sup> Shapin, S and Schafer, S (1985) 222.

<sup>87</sup> Shapin, S and Schafer, S (1985) 341.

<sup>88</sup> Lomborg, B *The Skeptical Environmentalist: measuring the real state of the world* (Cambridge University Press, 2001)

resulted in a wealth of critical responses to which Lomborg duly replied, admitting a few instances in which data was incorrectly cited, but largely defending his research.<sup>89</sup> Lomborg's opponents lodged a complaint of scientific dishonesty with the Danish Committee of Scientific Dishonesty (DCSD). That complaint was "fabrication of data, selective citation, deliberate misuse of statistical methods, distorted interpretation of conclusions, plagiarism, deliberate misinterpretation of others results." The report of the DCSD<sup>90</sup> concluded that the book is a "deviation from Good Scientific Practice". However, critics of the report and the response to Lomborg, such as Professor Arthur Rorsch of Leiden University, in the Netherlands, have reviewed the written discussion between Lomborg and his opponents and have not found any specific references to the accusations that support the DCSD conclusion. Professor Rorsch comments that the "DCSD has made itself instrumental to the opponents to censor a critic."<sup>91</sup> Professor Rorsch also comments that:

...it was rather difficult to deduce from the rhetorical writings of Lomborg's opponents concrete accusations, as stated in the complaint mentioned above. 27 accusations could be inferred, of which only two, if further sustained, might cut ice. These two might indicate selective citation. (The book contains over 2900 annotations and references.)<sup>92</sup>

Irrespective of Lomborg's conclusions regarding the implications of climate change, the furious debate that ensued following publication of his book is an example of boundary-work by the scientific community to maintain a monopoly over the scientific discourse on climate change.

### Expansion

Expansion describes the boundary-work done by insiders of a particular world view when seeking to expand the boundaries of their cultural authority into areas

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<sup>89</sup> Rorsch, A, "Good Scientific Practice and the Lomborg Affair in Denmark" <http://john-daly.com/guests/rorsche/htm> 11 February 2004

<sup>90</sup> Danish Committee of Scientific Dishonesty "Decision regarding complaints against Bjorn Lomborg" [www.forsk.dk/uvvu](http://www.forsk.dk/uvvu)

<sup>91</sup> Rorsch, A, "Good Scientific Practice and the Lomborg Affair in Denmark" <http://john-daly.com/guests/rorsche/htm> 11 February 2004, p 2.

<sup>92</sup> Rorsch (2004), 2.

already occupied by others. Expansion of the boundaries of science can commonly be seen in boundary-work involving the interface between science and technology. The 19<sup>th</sup> century industrial revolution, and the accelerated progress of technological development since, has brought about an inextricable connection between academic approaches to science and the professions associated with technology. The tensions associated with political agendas that rest on science, for example space and weapons research, and the various funding sources, for example private enterprise and government, has led to an expansion of science to encompass technological applications as both motivation for and the result of scientific research.

Gieryn illustrates boundary-work at this interface with technology using a 1982 report produced by the US Committee on Science, Engineering and Public Policy, or the National Academy of Sciences (NAS).<sup>93</sup> That report included technology and its outputs within the boundaries of science when justifying public support, meaning public funding, of science, but excluded technology when protecting the autonomy of scientists from the threat of government regulation. That threat was posed because of a growing fear about the potential for international proliferation of nuclear capacity arising from open debate within the scientific community. A similar threat of regulation today looms out of the expansion of biochemistry to encompass generic engineering and the ethical and cultural debate associated with that expansion.

### Expulsion

Expulsion is the boundary-work done by insiders to expel non-real members from their midst.<sup>94</sup> The purpose of such efforts is to protect the authority of science against challenge and to ensure internal regulation of agreed norms. Expulsion is most commonly seen in public debates arising from allegations of corruption or deception against a scientist. Gieryn describes the process by which Sir Cyril

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<sup>93</sup> Gieryn, T “Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists” (1983) 48 *American Sociological Review* 781, 789 – 792.

<sup>94</sup> Gieryn, T “Boundaries of Science” in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 393, 432.

Burt was (posthumously) expelled from the scientific community following allegations that he concocted statistics and created false academic references supporting his research in the field of developmental psychology.<sup>95</sup> The potential for expulsion both encourages acceptance of theoretical and practical norms within the scientific community and offers an opportunity for restorative public relations campaigns aimed at maintaining confidence in the scientific community's ability to both identify and expel impostors.

The degree to which expulsion can be actually achieved in the 21<sup>st</sup> century, however, is not so clear. With the birth of the internet, researchers are able to publish their work and to reach others with similar views. The DCSD attempted to exclude Lomborg from the international scientific community by censoring his work as deviating from good scientific practice. However that censorship did not end the academic debate that arose from publication of his research. Lomborg has continued to publish and lecture and he was a keynote speaker at the 2003 New Zealand Resource Management Law Association Conference.

### Protection

Perhaps the most common type of boundary-work by scientists involves protection of the resources and cultural privileges enjoyed by the scientific community. Such boundary-work can involve prevention of the control of science by outsiders, and conversely, the sole control of science and its cultural authority by its legitimate members.<sup>96</sup> The struggle for control of science is particularly apparent at the boundary between science and politics during the process of policy making.<sup>97</sup> There is a very close nexus between the relevance of science to political decision making and the authority attaching to science by virtue of its legitimation in policy. On the other hand, science can and does legitimise policy, but only because scientific knowledge is valued for its objectivity and is differentiated from other interest groups. Scientists risk losing control over their research agendas and a blurring of that boundary with politics

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<sup>95</sup> Gieryn (1995) 432- 434.

<sup>96</sup> Gieryn (1995) 434-436.

<sup>97</sup> Jasanoff, S "Beyond Epistemology: Relativism and Engagement in the Politics of Science" (1996) 26 Social Studies of Science 393.

unless effective protection work is not maintained. Jasanoff summarises the tensions between science and politics within environmental policy making as follows:

When an area of intellectual activity is tagged with the label “science,” people who are not scientists are *de facto* barred from having any say about its substance; correspondingly, to label something “not science” [e.g., mere politics] is to denude it of cognitive authority.<sup>98</sup>

While scientists may or may not have an interest in any given policy outcome, they will have a professional interest in defining their authority over knowledge claims, particularly where there is competition in terms of policy direction.

A case study by Nigge demonstrates the role of boundary-work in establishing a separation between science and policy by the Atomic Energy Control Board (AECB) in the regulation of nuclear energy in Canada.<sup>99</sup> The case study follows the controversy between a citizens’ group and the regulator before the AECB over renewal of the licence for the Pickering Nuclear Generating Station near Toronto in 1994-1995. The citizens’ group raised questions about earthquake hazards at the Pickering site and offered alternative interpretations of data that predicted the earthquake risk was much higher than was assumed in the design of the plant. In the ensuing debate, both the citizens’ group and the regulatory agency differently depicted the assessment of seismic hazards as an objective and purely scientific activity. Both groups emphasised the independence of their experts while recognising an inherent uncertainty in assessing seismic hazards and supporting their particular position as being scientifically correct. The AECB chairmen (themselves scientists) distinguished credible contributions to the debate on the basis of successful peer review and publication in order to limit authoritative claims to the science community. This had the effect of negating less conventional claims about the higher seismic hazard associated with the plant.

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<sup>98</sup> Jasanoff, S quoted in Gieryn, T “Boundaries of Science” in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) 436.

<sup>99</sup> Nigge, K “Seismotectonic Boundary Work: A case study of seismic hazard assessment in the regulation of nuclear energy in Canada” a paper presented to the 1996 Annual Meeting of the Society for Risk Analysis-Europe (<http://www.riskworld.com/Abstract/1996/araeurop/ab6ad092.htm> 18/7/2004).

For those purposes the subjective assessments contained in the various publications that arose from the uncertainty and disagreement inherent in seismic hazard assessment were treated as irrelevant. In this example boundary-work was effectively employed to protect the scientific position advanced by the regulator over that promoted by the citizens' group.

By means of boundary-work techniques such as monopolisation, protection, expansion and expulsion, scientists throughout the ages have been able to police the direction and rate of scientific development. The scientific community could ensure that only knowledge properly tested and accredited would secure its rightful place in the body of scientific knowledge.

One of the key characteristics used by scientists wishing both to protect and to expand the boundaries of science has been the concept of objectivity. Provided research was carried out by an objective scientist and that research could be independently replicated, the research could be described as scientific. However, the claim to objectivity has also become one of the weaknesses in the models of science described thus far because it ignored the individualism inherent in human thought – even scientific thought.

#### 2.4.2 *Objectivity*

##### Objectivity and science

The notion of objectivity in science has been important within traditional paradigms of science for establishing boundaries around the independence and transferability of knowledge. In order for observed and predicted 'facts' to describe the truth of the natural world, and thus fall inside the boundaries of science, it was important that they be consistent in time and independent of the observer or predictor. The truth that was desired in science was the type that is universal over time and place, rather than the type of truth that can be linked temporally with each individual. Thus, the Enlightenment vision of a common rationality of thought that operates independently of the subject did fit with the observed consistency of scientific 'facts'. To ensure that facts were universal it was important that they be neutral and free of any theoretical bias, for such bias could taint their consistency. Bacon saw that the road to neutrality of fact was

through careful attention to observation and method and that if an observed fact was established using an impartial method, then the result would be objective, and thus independent of the subject. Such an approach fitted with Descartes' notion of thought where the independent and rational knower is independent of the natural environment, so that any thinking subject, who was presented with the same data and employed the same method, would obtain the same result. Conversely, knowledge gained other than by objective and independent observation was outside the boundaries of science and belonged to the realm of religion, superstition or politics.

This focus on the need for an impartial method of science was also important practically. There were initially no scientific reports so that the communication of scientific knowledge happened from personal observation of experiments. This had obvious limitations for the numbers and frequency of demonstrations that could be given and for the degree to which experiments could be replicated and thus form the basis for further research. Bacon recognised that in order to facilitate joint research projects and sharing of information, it was important that scientists avoid partiality to theory and adopt a method that was designed to provide objectivity.<sup>100</sup> It is also significant that the conception of objectivity in the seventeenth century is rather different from the conception dominant at the end of the nineteenth century. For Bacon, objectivity meant the removal of partiality from experimental observations. By the nineteenth century, however, objectivity had come to mean the absence of subjectivity. To be objective was to have a "view from nowhere" where the identity of the knower was completely irrelevant to the knowledge itself.<sup>101</sup> This absence of the subject was certainly not critical to Bacon's claim to objectivity as that objectivity was very much related to credibility associated with social status of the observer, and with the special skills and instruments employed.

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<sup>100</sup> Daston, L "Baconian Facts, Academic Civility, and the Prehistory of Objectivity" in Megill, A (ed) *Rethinking Objectivity* (Duke University Press, 1994) 37, 49.

<sup>101</sup> Fox Keller, E "The Paradox of Scientific Subjectivity" in Megill, A (ed) *Rethinking Objectivity* (Duke University Press, 1994) 315.

The development of the nineteenth century concept of objectivity was again partly related to philosophical considerations and also to practicality. The separation of the subject from the object of his knowledge was consistent with the Cartesian separation of the thinking mind from the physical experiences of the body. If all men possess the power of rational thought, then the nature of the subject becomes irrelevant to the analysis of data that is received and it is the method that determines whether the observation is legitimate knowledge or not. The erasure of the subject also happened as a consequence of the expansion of scientific endeavour. For example, Robert Boyle recognised the importance of accurate observations for the replication and acceptance of scientific findings, and was one of the first scientists to employ the scientific report as a mechanism for accurate dissemination of information. Boyle commented that the report was designed so that “the person I addressed them to might, without mistake, and with as little trouble as possible, be able to repeat such unusual experiments...”<sup>102</sup> In writing the report, the subjectivity of the writer is disguised by the uniformity of the report and subjectivity is transferred to the reader. Rules that governed the format of the report enabled the depersonalisation of the observer so that the report, and the knowledge that it evidenced, became part of public authority. Eventually, the emergence of a consistent and rigorous format, together with systems that monitored the publication and distribution of reports further enhanced the objective (that is, ‘subject-free’) nature of science. The report and acceptance of it, was equated with the scientific truth that it evidenced.<sup>103</sup>

The development of instrumentation also enhanced the subject-free image of science. Instruments could represent experimental observations by providing empirical data and in time, these instruments came to be representations of the scientific ‘truth’ itself. Heat energy was represented by the measurement on a thermometer, pressure by the measurement on a manometer and so on until the data could be directly equated with the phenomenon under observation. This degree of equivalence between observation and the measured data is especially

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<sup>102</sup> Shapin, S “Pump and Circumstance: Robert Boyle’s Literary Technology,” (1984) 14 *Social Studies of Science* 481, 490.

<sup>103</sup> Fox Keller, E “The Paradox of Scientific Subjectivity” in Megill, A (ed) *Rethinking Objectivity* (Duke University Press, 1994) 318.

obvious in modern science where instruments are capable of detecting and recording observations that are far outside the range of human perception. The representation of brain activity in an electroencephalograph, and the structure of molecules from nuclear magnetic resonance ('nmr') spectroscopy, being but two examples. Not only have the instruments become equivalent to the behaviour of natural phenomena themselves, but they also serve to remove any influence of the human observer from the experimental process and thus add to the perceived objectivity. Fox Keller<sup>104</sup> describes this transfer from subject observer to instrument, as the "growth of the metasubject" whereby the actual observer becomes invisible behind the representation provided by the data, the report, and the scientific community. Such erasure of the subject also fitted with, and reinforced, enlightenment theories on the nature of knowledge, in which the 'truth' of nature exists independently of human thought, and is there to be discovered using the logic of rational thought and the method of scientific investigation.

In relatively modern times, the notion of objectivity as neutrality and of science as being subject-free has come in for considerable academic criticism. Scientists are not automatons that exist free of the influences of their surrounding environment. Rather, their social interactions inform their research choices and determine the boundaries surrounding what for them is inside and outside the realm of science. Modern academic discourse addresses various versions of objectivity in the process of deconstructing the traditional scientific paradigm. That process does not set out to remove the concept of objectivity from the nature of scientific endeavour, but to reconsider what objectivity may represent when the boundaries of science are differently drawn.

Megill<sup>105</sup> suggests four different interpretations of objectivity that are found in modern academic discourse and he describes the sense in which each interpretation is used. The "Absolute Sense" of objectivity<sup>106</sup> describes the ideal envisaged by Immanuel Kant in *Critique of Pure Reason* in 1781. In the absolute

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<sup>104</sup> Fox Keller (1994) 320.

<sup>105</sup> Megill, A (ed) *Rethinking Objectivity* (Duke University Press, 1994).

<sup>106</sup> Megill (1994) 1.

sense, objectivity has come to represent things the way they really are. It represents an ideal of knowledge as a faithful and undistorted image of reality. In twentieth century terms, this means the recognition of universal criteria, against which claims to reality can be tested and then accepted by all rational thinkers.<sup>107</sup> Until the emergence of Kuhn, in the 1960s, this absolute sense of objectivity was adopted by philosophers of science to describe science as a process whereby specific theoretical statements could be tested against universal laws using the logic of inference from observation. Theories were described as being adopted or rejected according to their consistency with the epistemological framework.<sup>108</sup> The academic debate tended to centre on the process by which theories which were consistent with the universal laws came to be adopted; whether the truth of theories could ever be verified using the logic of induction from universal laws, or whether the truth could only ever be the goal of a system of testing designed to eliminate false theories.<sup>109</sup> Within the verification versus falsification debate, the focus was on the comparison of the new with a universally accepted epistemological framework. Much of the controversy and criticism of Thomas Kuhn following the publication of *The Structure of Scientific Revolutions* in 1962 related to his implied challenge to objectivity as understood in this absolute sense. By suggesting that scientists choose between competing theories, Kuhn was implying that there is no purely rational or neutral mechanism in operation. Rather than the existence of a set of universal truths, under which all future theories developed incrementally, Kuhn introduced a notion of paradigmatic crisis, during which scientists developed a preference for the theory of best fit with the observations of reality.<sup>110</sup>

While challenging the accepted boundaries of science, Kuhn also offered a theory that could enable the community of science to expand despite the existence of theoretical inconsistency or uncertainty.

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<sup>107</sup> For example, universal laws concerning gravity or the conservation of mass.

<sup>108</sup> Megill, A (ed) *Rethinking Objectivity* (Duke University Press, 1994) 3.

<sup>109</sup> See for example Popper, K *Conjectures and Refutations* (London: Routledge and Kegan Paul, 1963).

<sup>110</sup> Kuhn, T *The structure of scientific revolutions (2nd ed)* (Chicago: Chicago University Press, 1970).

The “Disciplinary Sense” of objectivity<sup>111</sup> claims consensus among members of particular research communities as its standard of objectivity. Thus there are no universal criteria for validating scientific activity, but rather, authoritative intra-disciplinary criteria. It is arguable that Kuhn’s description of normal science is a type of disciplinary objectivity with scientists united under a particular paradigm.

Megill’s third category is the “Dialectical Sense of Objectivity”.<sup>112</sup> Where Absolute Objectivity seeks to exclude subjectivity and Disciplinary Objectivity seeks to contain subjectivity, in the Dialectical Sense, the objects (or knowledge) are constituted as objects in a dynamic relationship between subject and object. In other words, there is room for subjectivity of the knower. The Dialectical Sense emphasises the active character of the knowing subject and recognises that knowledge production happens in the course of active participation in the world around us and not purely by theoretical contemplation.

The “Procedural Sense of Objectivity”<sup>113</sup> aims to exclude subjectivity by imposing an impersonal method of investigation. The Procedural sense focuses on the data by removing individual choice and variation from the system of data collection.

#### Feminist critiques of objectivity

There are many versions of feminism and there is debate between theorists concerning all aspects of feminist theory, including the subject matter, methodologies and goals.<sup>114</sup> There is also debate concerning the concept of objectivity and its role in the production of knowledge. What seems to be generally accepted and argued by feminist theorists is that the classical model of science has been dominated by male researchers who perceive all aspects of their research through their own, male, eyes. The dominance of scientific research questions, methods, data collection and theorising by men has both alienated

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<sup>111</sup> Megill, A (ed) *Rethinking Objectivity* (Duke University Press, 1994) 5.

<sup>112</sup> Megill (1994) 7.

<sup>113</sup> Megill (1994) 10.

<sup>114</sup> Gilbert, Jane Thinking ‘other-wise’: re-thinking the problem of girls and science education in the post-modern (University of Waikato: DPhil Thesis, 1997).

women from the process and produced a body of knowledge that reflects male interpretations of the world around them. Helen Longino<sup>115</sup> argues that all aspects of scientific research involve decisions and choices. On a macro level, researchers choose their research questions and then their framework for that research. Within individual research projects, each scientist chooses the data to include and exclude from results and identifies the avenues “worth” further investigation. The criteria used to make those choices will depend both on the values of the particular scientific discipline or community and on those values of the researcher. Longino argues that knowledge, including scientific knowledge, is constructed out of and within each individual’s experiences in society, including gender related experiences. However, Longino argues that there is still room for the concept of objectivity within science even when knowledge is perceived as socially constructed. She suggests a change in focus to consider science as a practice that is undertaken by social groups.<sup>116</sup> By viewing the production of scientific knowledge as a group activity involving the critical assessment and modification of individual efforts by the scientific community, individual subjective preferences become insignificant. Thus the entire body of knowledge attracts a level of objectivity from the scientific method and peer review process employed by the scientific community.

Evelyn Fox Keller argues that feminist criticism of the gender biased history of science can usefully help improve the objectivity of science.<sup>117</sup> Fox Keller advocates for a process of deconstructing the history and process of science in order to uncover subjectivities previously ignored. She suggests that a critical historical analysis of science will provide an understanding of the influences behind choices that led to the acceptance or rejection of both theories and theoretical orientations. By examining the history of science Fox Keller argues that feminists can bring a “whole new range of sensitivities, leading to an equally new consciousness of the potentialities lying latent in the scientific project”.<sup>118</sup>

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<sup>115</sup> Longino, H *Science as Social Knowledge* (New Jersey: Princeton University Press, 1990)

<sup>116</sup> Longino (1990) 66-67.

<sup>117</sup> Fox Keller E “Feminism and science” in Harding S and Barr J (eds) *Sex and scientific enquiry*. (Chicago: Univ of Chicago Press, 1987) 29.

<sup>118</sup> Fox Keller (1987) 29, 39.

Donna Haraway and Sandra Harding are described as radical feminist theorists.<sup>119</sup> They argue for deconstruction of past scientific process but also for positive alternatives to the dominant notions of objectivity.<sup>120</sup> Both Haraway and Harding refer to “situated knowledge” as a more accurate representation of knowledge. They argue that all knowledge is known by the knower from the situation of that knower and therefore reflects that knower’s own social experiences. Harding advocates a “strong objectivity” approach from standpoint theory.<sup>121</sup> Essentially strong objectivity is an approach that examines all of the subjective assumptions underlying research from the standpoint of those previously excluded from being the knowing subject. That is, groups previously unrepresented (particularly women) should review research, both past and present, to identify different standpoints and thus enlarge the boundaries of the knowledge umbrella.

Feminist theorists’ approaches to objectivity are many and varied as would be expected. They agree that knowledge is socially constructed and thus reflects the dominant interest group involved in that construction. However, the notion of objectivity becomes awkward unless it can be redefined to encompass the existence of subjectivity that must attach to each individual researcher. The fact that male gendered past research has developed apparently neutral and universal applicable results suggests that there is a degree of objectivity that can exist. The goal then seems to be to ensure that the subjectivities underlying research can be identified and broadened to include all parts of society. In that way, the goals and direction of research will widen and to return to Latour’s railroad metaphor, the system of tracks will be more extensive with fewer gaps in between.

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<sup>119</sup> See Gilbert, Jane *Thinking ‘other-wise’: re-thinking the problem of girls and science education in the post-modern* (University of Waikato: DPhil Thesis, 1997) and Fox Keller, E and Longino, H (eds) *Feminism and Science* (New York: Oxford University Press, 1996).

<sup>120</sup> See for example Haraway, D *Modest\_Witness@Second\_Millennium. FemaleMan,,\_Meets\_OncoMouseTM* (NY: Routledge, 1997) and Harding, S “Rethinking Standpoint Epistemology: What is ‘Strong Objectivity’?” in Fox Keller, E and Longino, H (eds) *Feminism & Science* (New York: Oxford University Press, 1996).

<sup>121</sup> Harding, S “Rethinking Standpoint Epistemology: What is ‘Strong Objectivity’?” in Fox Keller, E and Longino, H (eds) *Feminism & Science* (New York: Oxford University Press, 1996).

### Science and social context

Helen Longino describes the social context of scientific knowledge as follows:

Treating reasoning as a practice reminds us that it is not a disembodied computation but takes place in a particular context and is evaluated with respect to particular goals. I argued that evidential reasoning is always context-dependent, that data are evidence for a hypothesis only in light of background assumptions that assert a connection between the sorts of thing or event the data are and the processes or states of affairs described by the hypotheses. Background assumptions can also lead us to highlight certain aspects of a phenomenon over others, thus determining the way it is described and the kind of data it provides. Background assumptions are the means by which contextual values and ideology are incorporated into scientific inquiry. While not all such assumptions encode social values, their necessity to evidential reasoning means that the basic components of methodologies – logic and observation – are not sufficient to exclude values from proper inquiry. The role of background assumptions, however, poses a new problem. Scientific inquiry is not characterized by the expression of a multitude of individual subjective preferences. If scientific inquiry is to provide knowledge, rather than a random collection of opinions, there must be some way of minimizing the influence of subjective preferences and controlling the role of background assumptions.<sup>122</sup>

That passage reflects the approach of modern theorists concerning the epistemology of science. Subjectivity is present in all aspects of the scientific endeavour to a greater or lesser degree. At the individual level, researchers will be influenced in their research methods, questions and underlying assumptions depending on their own research experience and their academic training.<sup>123</sup> Choice of research topic is guided partly by individual interest, which could be

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<sup>122</sup> Longino, H *Science as Social Knowledge* (New Jersey: Princeton University Press, 1990) 215-216.

<sup>123</sup> Cetina, K “Laboratory Studies: The Cultural Approach to the Study of Science” in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 140.

motivated by any number of factors, but more importantly by the interests of the supervisor and institution. In today's academic environment, research interests are strongly guided by research funding. Scientific research in New Zealand has historically been undertaken within 3 broad sectors. Industry funds and supports its own research and development teams that have a focus on the particular outputs sought. The universities support research within their science faculties and that funding traditionally arose from public funding of a grant to the institution. In addition, there was further government-supported research in institutions such as the Ruakura Agricultural Research Centre and the DSIR.<sup>124</sup> In other countries, military and aerospace research would also come within this latter category. All of those sectors are now subject to funding competition with private industry and the government research fund, FRST<sup>125</sup> being the principal sources. Institutions are required to compete for available funding and tend to develop research strategies and focuses in order to improve their funding applications. The way in which institutions encourage research projects to be tailored to funding objectives is demonstrated in the following extract from a report by Professor Kamp to the School of Science and Technology Board of Studies:

Currently most of the current (sic) PGSF [Public Good Science Fund] contractors in the School are involved in contributing to various industry sector research strategies, which will probably be very important in shaping the nature of future priority PGSF research areas. Any staff that can foresee any possible involvement in PGSF work are encouraged to become aware of what could be happening in their research sectors, and if possible contribute to the definition of the R&D priorities, if only to ensure that there are areas one can bid for in the future. The other activity that is important is to develop linkages with potential industrial partners who could be End-users of your research activities. These linkages need to be in place by the time that nature of the next bidding round is clarified,

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<sup>124</sup> Department of Scientific and Industrial Research. The equivalent bodies are now Crown Research Institutes (CRIs).

<sup>125</sup> Foundation for Research, Science and Technology.

because there will not otherwise be enough time to set up meaningful relationships.<sup>126</sup>

Professor Kamp's report clearly illustrates the importance of external funding sources to the direction of present and future scientific research. It is a very far cry from any classical view of scientific development involving independent researchers with complete academic freedom to spend their time testing and reviewing their own and others' research work.

In western capitalist societies, profit has become the dominant motive for scientific research. Even in medical research, whether direct in terms of drug companies, or indirect in terms of significantly reduced public expenditure for illness sufferers, profit has become the dominant motivation for research directions.

To a lesser extent individual scientists and research teams have personal motivations for their project directions and desired outcomes. Curiosity will always be an important motivation for any type of research, however, personal credit in the promotion and sharing of knowledge is also an important motivation. Personal credit now comes in the form of salary and promotion but those material benefits accrue from the prestige arising from the scientific consensus and debate surrounding published findings. Historically, scientists acquired credit for their work by having the right to name their theory or discovery<sup>127</sup> and there are numerous examples of particular theorems, substances and organisms named by and after their acknowledged discoverer. Hull suggests that the practice of giving nearly all of the credit to the first scientist that publishes a particular contribution was mainly to encourage early publication and facilitate further research from other scientists.<sup>128</sup>

Hull argues that scientists also acquire substantial credit for their work when it is approved and adopted by other scientists. In order for a scientist to have work

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<sup>126</sup> Kamp, P Report to School of Science and Technology Board of Studies, University of Waikato. (7 September 1998).

<sup>127</sup> Hull, D *Science as a Process* (Chicago: University of Chicago Press, 1988)

<sup>128</sup> Hull (1988) 352.

acknowledged as an original contribution, that work must be accepted as both original and of value. To establish that support, scientists must show that their work rests on previously accepted research, a process that involves citing other work with approval. Those citations in turn confer credit on the authors of the supporting research and define the boundaries of the scientific community.<sup>129</sup> Inevitably, there will be a tension between the need to publish research, in order to obtain credit and acceptance from the scientific community, and the desire to keep research findings secret. The need for secrecy is reinforced in a profit motivated competitive climate where there may be numerous research groups independently working towards a particular outcome. Such competition is inevitable in industrial research, for example biotechnology and pharmaceuticals where the applications can be financially lucrative. However, any sustained secrecy becomes counterproductive if the research findings are challenged, particularly in a legal forum, and no independent support is available from the wider science community.

Scientific research that is widely accepted within the science community also attracts credit to that community. Historically, scientists have held significant positions of prestige<sup>130</sup> and carried influence within government. In recent times, that influence has continued to be exercised by the scientific community itself. During the twentieth century, the work of physicists in developing the atomic bomb produced enormous political power for the United States. Following the Second World War, research groups continued to enjoy the credit of war time developments and occupied a privileged position within society, akin to the business sector. Scientists and their institutions were able to provide the personnel, skills and knowledge that facilitated various public and private sector elites to achieve their goals and in return were rewarded with resources not available to other groups in society.<sup>131</sup> Scientists also replaced lifetime public servants in governmental organisations setting up their own research programs

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<sup>129</sup> Hull (1988) 319.

<sup>130</sup> For example Sir Isaac Newton became Master of the Royal Mint.

<sup>131</sup> Cozzens, S and Woodhouse, E "Science, Government, and the Politics of Knowledge" in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 527.

and gaining appointments to the various institutes and boards charged with approving research applications and allocating funding. Cozzens and Woodhouse argue that the close relationship between scientists and those determining government policy enables the dominant political ideology to be incorporated into scientific knowledge and effectively implemented into society as part of the social construction of knowledge.

Some commentators have criticised the notion of objectivity within science by identifying the various personal motives that influence scientists and publishing accounts of academic fraud that shake the objective foundations of the classical model of science. Broad and Wade<sup>132</sup> describe how the normal motivations of ambition, money and personal acclaim operate within the community of science. The allocation of government grants is influenced by the academic success (number of publications) of particular scientists and their research teams. Government grants then provide laboratories and resources and support graduate research students who can then increase the rate of production of the research papers. Such publications can also attract the attention of committees that award scientific prizes which will also raise the prestige of the research team when applying for further funding. Broad and Wade argue that the significance of publication records encourages fraud and unethical behaviour within the scientific community. They define scientific fraud to include any aspect of deceit knowingly carried out by a researcher. That includes “cooking the data in an experiment”<sup>133</sup> through to misdirecting credit from the research of a subordinate. Their book is full of examples of scientific publications that are plagiarised, inaccurate and even entirely fabricated and is itself an example of boundary-work aimed at limiting the expansion of the scientific community. The book serves to remind readers that any model of science describing a system of objective, rational inquiry and thought can only ever be a model that represents the overall endeavour. Scientists, like other members of modern (and historical) society are individual human beings who will be motivated by a variety of different things.

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<sup>132</sup> Broad, W and Wade, N *Betrayers of the Truth: Fraud and Deceit in the Halls of Science* (London: Century Publishing, 1983).

<sup>133</sup> Broad, W and Wade, N *Betrayers of the Truth: Fraud and Deceit in the Halls of Science* (London: Century Publishing, 1983) 19.

They must necessarily have that motivation or there would be no growth in research but personal or financial motivation does not mean that scientific findings will necessarily be flawed or different from the findings of someone differently motivated. However, it is reasonable to recognise that the scientific community deserves no greater (nor lesser) position within our society by virtue of the claim to objectivity alone.

#### 2.4.3 *Consensus*

The role of the scientific community is also very significant in classical models of science. The collective knowledge of the scientific community is the baseline against which new ideas are tested and examined. While the public at large may be sceptical about the results of an isolated research group, acceptance by the scientific community is a signal of the legitimacy and even truth of those research findings. The ability of scientists to seriously address and test scientific theories and specific data effectively confers the role of validating and legitimising research to their own community. That community also provides the organisational framework for the transmission of information and for the education of new scientists, thus maintaining a monopoly on the production of authoritative knowledge. Universities and large research organizations are responsible for the majority of prestigious research publications and also bear responsibility for nurturing new scientists with the collective wisdom, skills and values accepted by that community. Ziman argues that the goal of science is not only to increase the collective body of knowledge, but also “achieve maximum degree of consensuality”.<sup>134</sup> Consensuality is achieved by obtaining the “consensus of rational opinion over the widest possible field - but within the boundaries of the accepted community.”<sup>135</sup>

Non-scientists are neither technically nor organisationally positioned to undertake that validating role and therefore rely on the accessible views available to outsiders. In a legal forum, those accessible views come from expert witnesses and from published research papers. Judicial authorities based on precedents set in other decisions commonly require support for novel scientific research, either

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<sup>134</sup> Ziman, J *Reliable Knowledge* (Cambridge: Cambridge University Press, 1978) 6.

<sup>135</sup> Ziman (1978) 5.

from refereed publications or from other experienced experts in the same field.<sup>136</sup> What qualifies as amounting to appropriate support is also guided by the same authorities. That requirement for support recognises the court's lack of expertise to assess scientific research findings without directly conferring decision making to the expert witness. However, the need to assess expert scientific evidence still poses difficulties even when the wider scientific community is called into aid as a reference point. How does the court decide between opposing expert witnesses? How does the court interpret the scope and degree of support offered to publish papers? Why should accepted and published research findings be considered the total of all truthful and reliable knowledge about the world? Are there internal politics/norms that operate to manage the research publication industry irrespective of the content of that research?

Legal decision makers must decide between alternative expert testimonies by assessing the credibility of that evidence. That assessment involves two components: the evidence itself and the credibility of the witness. Both of those components require an assessment of criteria that can be recognised as valid benchmarks. The evidence can be assessed against support from published papers and from other experts. In turn, the credibility of that support is measured against the prestige conferred on it by the scientific community itself. The indicia of prestige are reflected in the various cases as guidelines for weighting scientific evidence:<sup>137</sup>

- a) Accepted for publication;
- b) Refereed;
- c) Published in prestigious publications;
- d) Published internationally;

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<sup>136</sup> For example *Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66, *McIntyre v Christchurch City Council and Bell South* [1996] NZRMA 289. (1996) 2 ELRNZ 84, *Daubert v Merrell Dow Pharmaceuticals* 125 L. Ed 2d 469, 113S. Ct. 2786 (1993), *Frye v United States*, 293 F. 1013 (D.C. Cir. 1923) *Kumho Tire Co v Carmichael* 526 US137 (1999), *General Electric Co v Joiner* 522 US 136 (1997).

<sup>137</sup> For example: *Shirley Primary School v Christchurch City Council* [1999] NZRMA 66, *McIntyre v Christchurch City Council* [1996] NZRMA 289 and *Daubert v Merrell Dow Pharmaceuticals Inc.* (1993) 125 L Ed 2d 469.

- e) Debated in other prestigious publications. The existence of debate indicates that either the work or the author is at least worth consideration;
- f) Supported by other prestigious researchers via publication.

In turn, the prestige of the expert is assessed against the credibility of that expert within the scientific community. That process involves consideration of the expert's qualifications and research record. Again, the criteria relevant to the prestige of the publication will be relevant to the expert. In a legal forum, prestige will also be measured by the acceptance of that expert as a witness. Previously accepted evidence, consistency of approach, clarity, qualifications and professional standing will all be relevant both to the decision to instruct a given witness and the weight eventually given to their evidence.

The academic debate regarding the implications of climate change is a current example facing regulators and the public generally. The weight of scientific opinion accepts that there is evidence of global warming that will, in a geologically short time, cause sea levels to rise with catastrophic consequences for life on Earth. However, there is also a community of qualified scientists who reject those conclusions and predictions, claiming that climatic changes are a normal part of the Earth's history and that results of tests showing global warming unduly reflect the conditions around metropolitan areas, where many measurements are taken.<sup>138</sup> Dr Vincent Gray is a New Zealander who was an expert reviewer for the Report of Working Group 1, of the Intergovernmental Panel on Climate Change. Gray has published a book challenging the Working Group 1 report and his book cites a number of authorities from opposite sides of the debate.<sup>139</sup> He notes that:

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<sup>138</sup> Gray, V "The Greenhouse Delusion: Critique of Climate Change 2001: The Scientific Basis" <http://www.john/daly.com/tar-2000/summary.htm>

<sup>139</sup> For example, Houghton, J, Jenkins, G and Ephraums, J (eds) *Climate Change: The IPCC Scientific Assessment* (Cambridge University Press, 1990), Watson, R, Zimwera, M, Moss, R and Dokken, D (eds) *The Regional Impacts of Climate Change* (Cambridge University Press, 1998) and Nakicenovic, N and Swart, R (eds) *IPCC Special Report: Emissions Scenarios* (Cambridge University Press, 2000) are all authorities from the scientific community predicting adverse effects of climate change associated with global warming. On the other side of that debate are, for

Since it is virtually impossible to publish scientific material critical of the greenhouse effect in the established scientific journals, the Internet has provided the opportunity both for publication and scientific discussion which is denied us in the official press.<sup>140</sup>

Mulkay comments that scientific consensus will often depend on socio-cultural factors such as research problem selection and the application of a uniform scientific perception.<sup>141</sup> As previously discussed, funding issues have a large impact on the research problems selected but Mulkay argues that there is another subtler factor that promotes consensus from research selection. He argues that scientists choose problems that they consider are solvable. Problems that fall outside the scope of current theory and technique will be defined as 'metaphysical' or 'non-scientific'.<sup>142</sup> Any research outside that framework will be assessed as practically too complex and will find neither the peer support needed to attract funding, (applications for which must detail recent publications) nor be accepted for publication by a journal with either a prestigious reputation or a widespread circulation. That type of boundary-work protects the existing credibility and authority of science by reducing the prospect of uncertainty.

Qualifications and professional standing are also indicia of prestige. As with other hierarchical communities, qualifications are often cited with reference to the institutional source of those qualifications and the academic reputation of that institution. Ziman notes that qualifications actually mean little. As in any field there will be a wide range of competence and deficiency.<sup>143</sup> Rather, scientific reputation is important. However, any system that measures reputation by the papers accepted and published by particular institutions is valid only so long as

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example: Daly, J "Still Waiting for the Greenhouse" <http://www.john-daly.com>, Hughes, W <http://www.webace.com.au/~wsh>, Science & Environment Policy Project <http://www.sepp.org>

<sup>140</sup> Gray, V "The Greenhouse Delusion: Critique of Climate Change 2001: The Scientific Basis" <http://www.john-daly.com/tar-2000/summary.htm>

<sup>141</sup> Mulkay, M *Sociology of Science: A Sociological Pilgrimage* (Milton Keynes: Open University Press, 1991) 82.

<sup>142</sup> Mulkay (1991) 82.

<sup>143</sup> Ziman, J *Teaching and learning about science and society* (Cambridge: Cambridge University Press, 1980) 96.

there is general acceptance of its own values system. The scientific community has a hierarchy of institutions, whose qualifications and publication records attract funding and support in an iterative process. Researchers from outside the academic elite but whom have papers accepted for publication by that elite will also enjoy reflected prestige that can then be conferred on lesser publications via their research contributions. So the system operates to maintain and protect its own hierarchy and values with journal editors and referees acting as the gatekeepers. These scientists are both successes of the scientific system and protectors of that system for the scientific community, as they know it.

Ziman notes that only a very small proportion of scientific research is eventually incorporated into the body of scientific knowledge.<sup>144</sup> The advent of electronic bibliography databases and academic journals available on the internet both increases the access to scientific papers and the volume of information that is available. Thus, individual researchers need to develop their own mechanism for filtering and attributing weight to that information. It is likely that similar criteria will be applied to electronically available material as for the written word, in order to prioritise and evaluate that information. The sheer volume of material that is now accessible to even undergraduate researchers means that the status of certain publications must be maintained in order to identify what is the consensus within the scientific community. Otherwise the entire spectrum of opinion concerning any given issue is available by electronic search, with no indication of the weight of scientific support that opinion carries.

The production of scientific papers is further encouraged by the tenure and promotion system that is prevalent in many academic institutions in the Western World. Academics support their applications for appointment and promotion with evidence of their research output. That evidence is usually in the form of a bibliography of publications and conference presentations. In addition, research

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<sup>144</sup> Ziman, J *Reliable Knowledge* (Cambridge: Cambridge University Press, 1978) 130. Ziman refers to 2 studies concerning the citation rate of published academic writing. One study found that half of all papers published in more than 2100 source journals noted in *Science Citation Index* do not receive a single citation in the year following publication. A second study found that the *Bulletin of the Geological Society of America (1888 – 1969)* did not cite at all the work of 80% of the names listed in the *Bibliography of North American Geology (1785 – 1860)* see p 130 fn9.

funding for individual research groups and the university department/school may also be linked to the research outputs. Broad and Wade argue that this system encourages fraud and deceit and is not open to scrutiny of the material or intellectual achievement that is actually produced.<sup>145</sup> They argue that a promotion system that considers the quality of published material would be more realistic. That consideration would include both the status of the publication and reference to the number of citations of the works by other authors. Broad and Wade note that even a system based on citations could be manipulated and would favour a particular elite that holds accepted views. Researchers from small institutions would find it difficult to become published without a sponsor from the elite while researchers from larger institutions could easily obtain citations from their colleagues.<sup>146</sup>

The volume of published scientific material and the accessibility of that material means that it is much more difficult for lay people to identify scientific consensus. Conversely, it is much easier to locate scientific opinion in support of a particular hypothesis. That means that legal decision makers involved in the evaluation of expert evidence must adopt criteria to help attribute the appropriate weight to that testimony. It is likely that the prestige of the expert, as measured by her employing institution, qualifications, qualifying institution, publication record and status of those publications, will contribute to a decision on the 'safety' of her evidence. By safety, I refer to the acceptance of that person and her research by the mainstream scientific community. Thus the quantity of academic research that is available to those outside the scientific community reinforces the reliance on boundary-work that articulates the 'reasonable' and reliable boundary limits of science.

#### 2.4.4 *Cultural context of science*

One of the most striking examples of the epistemic authority of science can be seen at the interface with indigenous cultures. Indigenous knowledge is often described as being holistic and lacking the boundaries between types of

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<sup>145</sup> Broad, W and Wade, N *Betrayers of the Truth: Fraud and Deceit in the Halls of Science* (London: Century Publishing, 1983) 222.

<sup>146</sup> Broad, W and Wade, N (1983) 130.

knowledge that tend to characterise western science.<sup>147</sup> Traditional Maori knowledge is referred to as “Matauranga Maori” and encompasses the cultural and spiritual essence of being Maori.<sup>148</sup> That wide definition of Matauranga Maori does not easily fit within the framework of mainstream science, although there may be elements of each that coexist comfortably. To the extent that Maori maintained a technology pertaining to the natural world and that knowledge was systematised and useful, it has links with science as a knowledge base. For example, traditional knowledge enabled Maori to cultivate crops, hunt, prepare and use medicines and tools and to fashion crafts, artefacts and weapons.<sup>149</sup> As with other knowledges derived from the natural and technological worlds, to view Matauranga Maori as science requires a view of science as knowledge constructed by people. However, some commentators would argue that the socially constructed nature of indigenous knowledges is an insufficient connection with science. Mike Dickison challenges the articulation of Matauranga Maori as science because of those elements not shared by the two knowledge systems. For example, the lack of objectivity (Maori knowledge relying on religious faith), of rationality (mixing supernatural with commonsense explanations) and the lack of cooperation (with reliance on authority rather than challenge and consensus).<sup>150</sup> Dickison is sufficiently outraged at the concept of Maori science that he describes it as demeaning science as a knowledge form. He writes:

[To] contrast it with “Pakeha” science, which is wider in scope and both more detailed and more accurate in almost every case, will teach Maori children that they are heir to a “science” that is less comprehensive and often simply wrong.<sup>151</sup>

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<sup>147</sup> Michie, M and Linkson, M “Western Science and Indigenous Knowledge” Same Papers (1999), 265, 277.

<sup>148</sup> Ministry of Research, Science and Technology “The Relationship Between Matauranga Maori and Mainstream Science” (1996).

<sup>149</sup> McKinley, E, Waiti, P and Bell, B “Language, Culture and Science Education” (1992) 14 *International J Science Education*, 597, 578.

<sup>150</sup> Dickison, M “Maori Science? Can traditional Maori knowledge be considered scientific?” (1994) 5 *NZ Science Monthly*, 6.

<sup>151</sup> Dickison (1994) 7.

A similar, though less spirited approach is expressed by Cobern and Loving in a paper addressing science education from multicultural perspectives.<sup>152</sup> They conclude that science can be sufficiently clearly defined to maintain a coherent boundary with non-science for the purposes of school science curriculum development.<sup>153</sup> That boundary would exclude indigenous knowledge forms as well as art, history, economics, religion and other domains of knowledge. Making the point that privileging science over other competing knowledge forms is not the same as denying the value of those other knowledges, they stress that the boundaries of science should be protected to prevent the scientising of other knowledges in order to attain the epistemological authority attached to science.

Mere Roberts finds both similarities and differences between indigenous knowledge systems.<sup>154</sup> She argues that both western science and indigenous knowledge systems seek to provide an understanding of the natural world and its phenomena. They differ in the epistemological concepts that form the basis of those understandings, and in the societal context that applies. While each understanding is located within a different “world view” each has validity within its particular cultural context and the preferred narrative will depend on the context in which the knowledge form is articulated.

Perhaps the following comment from Laudan best describes the relationship between knowledge systems in the contest for reliability and epistemic authority.

However we eventually settle the question of reliable knowledge, the class of statements falling under the rubric will include much that is not commonly regarded as “scientific” and it will exclude much that is generally considered “scientific”.<sup>155</sup>

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<sup>152</sup> Cobern, W and Loving, C “Defining “Science” in a Multicultural World: Implications for Science Education” (1998) Paper prepared for a NARST; <http://www.wmich.edu/slscsp/148.html> 21/07/2004.

<sup>153</sup> Cobern, W and Loving, C (1998) 14.

<sup>154</sup> Roberts, M *Indigenous knowledge and western science: perspectives from the Pacific* (University of Auckland: Centre for Pacific Studies, 1996) 9.

<sup>155</sup> Laudan, L “The demise of the demarcation problem” in Cohen, R and Laudan, L (eds) *Physics, Philosophy and Psychoanalysis* (Dordrecht Holland: Reidel Publishing Co, 1983).

## 2.5 Boundary-work and the interface of science and law

Much of the legal discussion concerning the nature of science relates to identifying appropriate boundaries for scientific evidence and scientific witnesses. That discussion is found both in judicial decisions, for example the United States Supreme Court decisions in *General Electric Co v Joiner*<sup>156</sup> and *Daubert v Merrell Dow Pharmaceuticals*<sup>157</sup> and the New Zealand Environment Court decisions in *Shirley Primary School v Telecom Mobile Communications Ltd*<sup>158</sup> and *McIntyre v Christchurch City Council and Bell South*<sup>159</sup> as well as in academic writing.<sup>160</sup> Such discussion focuses on the appropriate method for determining the credibility of scientific evidence and witnesses. That credibility is often assessed with reference to the mechanisms for self evaluation that exist within the recognised scientific community; for example, the availability of published material supporting a particular analysis of results, the methodological parameters for obtaining the results and the theories supporting conclusions and predictions.

The way in which the law as an institution describes science is probably best illustrated by the legal tests that have been adopted to test the admissibility of scientific evidence in court. The most well known, and arguably most often applied examples of these tests are those from the United States decisions *Frye v United States*<sup>161</sup> and *Daubert*.<sup>162</sup> *Frye* involved the admission of evidence from a polygraph, which was a very new piece of technology at the time. The court had to decide whether the analysis of data from this new machine had sufficient basis in science to be admitted as evidence. The test that was developed accepted that science is what scientists do and is most easily identified by the scientific community. Thus the court considered that novel scientific evidence would be

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<sup>156</sup> *General Electric Co v Joiner*, 522 US 136 (1997).

<sup>157</sup> *Daubert v Merrell Dow Pharmaceuticals*, 125 L. Ed 2d 469, 113 S. Ct. 2786 (1993).

<sup>158</sup> *Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66.

<sup>159</sup> *McIntyre v Christchurch City Council and Bell South* [1996] NZRMA 289. (1996) 2 ELRNZ 84.

<sup>160</sup> These judicial decisions and their implications for legal decision making involving scientific evidence are more fully addressed in Chapter 3.2.5.

<sup>161</sup> *Frye v United States* (1923) 293 F 1013.

<sup>162</sup> *Daubert v Merrell Dow Pharmaceuticals Inc* (1993) 125 L Ed 2d 469. (1993) 113 S Ct 2786.

admissible if it was “sufficiently established to have gained general acceptance in the particular field in which it belongs.”<sup>163</sup> Such an approach is susceptible to effective boundary-work of the various interest groups in science. This test had many difficulties, as will be discussed later, but although much criticised continued to influence decisions until the 1990s.

The United States Supreme Court decision *Daubert* overturned the *Frye* general acceptance rule and elaborated on criteria to be used to assess the admissibility of any scientific evidence. This decision has been cited by the New Zealand High Court and adopted by the Environment Court<sup>164</sup> and is an interesting presentation of the court’s view of what science *is* by describing how to eliminate what science isn’t. The factors considered relevant to the assessment of “reliable” science included; general acceptability, peer review and publication of research findings, and the degree of testing and potential rate of error that attaches to the research and its methods. These factors also represent a view of science in terms of what scientists do and how they do it, leaving the assessment of those activities to the evidence of those from within the scientific community.

Some writers have argued that *Daubert* has effectively given courts a gate-keeping role when deciding on admissibility of scientific evidence.<sup>165</sup> The decision authorises the court to draw boundaries around what can be admitted as scientific evidence, whether that be in civil litigation, for example tort cases, or criminal litigation. Cranor et al argue that the evidence rules in *Daubert* can give rise to mistakes in that boundary drawing process. Judges can make explanatory mistakes by imposing improper substantive restrictions on the content of admissible evidence. They can also make mistakes of strength by imposing inappropriate standards to be met by that evidence. Such mistakes arise when the court requires more stringent standards of scientific evidence than are otherwise required of evidence in tort. Cranor et al argue that courts need to adopt evidence

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<sup>163</sup> *Frye v United States* (1923) 293 F 1013, 1014.

<sup>164</sup> See *R v Calder* unreported, High Court, Christchurch, 12 April 1995, (T 154/94), Tipping J and *McIntyre v Christchurch City Council* [1996] NZRMA 289 for example.

<sup>165</sup> Cranor, C, Fischer, J and Eastmond, D “Judicial Boundary Drawing and the Need for Context-Sensitive Science in Toxic Torts After *Daubert v Merrell Dow Pharmaceuticals Inc*” (1996) 16 Virginia Env LJ 1.

rules that are sufficiently sensitive to allow the admission of all evidence that scientists use to draw conclusions about the effects of toxic substances.<sup>166</sup>

Legal discussion does not usually consider the essential characteristics of science or the range of criteria that contribute to a perception within that discourse of a particular endeavour as being scientific. Those characteristics are often apparent in the author's discussion but are not necessarily consistent with other commentaries. Michel Gauquelin's statistical evidence in support of astrology is quoted by Barnes et al<sup>167</sup> to illustrate the way in which mainstream science erects boundaries to prevent challenge to its theoretical framework from possibilities outside that framework. Statistical evidence and empirical research are identified as fundamental criteria that should be sufficient for a new scientific revolution. Other examples given to illustrate the scientific community's resistance to new possibilities include water dousing and acupuncture, described as "empirically effective techniques [that] have been excluded from the ranks of legitimate science because they are incompatible with prevailing scientific theory."<sup>168</sup> The writers characterise the scientific community as self interestedly protecting its boundaries by resisting evidence that is inconsistent with the existing paradigm. That approach is very different from the *Frye* perception of science as being what the scientific community itself accepts or acknowledges.

The major scientific and technological advances of the twentieth century saw science attract attention as a positive and powerful model for all forms of intellectual endeavour. A scientific approach to reasoning and analysis of results was considered to be superior to any other approach and there was widespread "scientising" of research and decision making that involved the application of analysis and reason. This process of scientising can be identified in the growth of the social sciences and in the discussion of the scientific nature of law and is an example of expansionist boundary-work by research interests competing for the same level of intellectual authority, prestige and support. There is considerable

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<sup>166</sup> Cranor, C, Fischer, J and Eastmond, D (1996) 4.

<sup>167</sup> Barnes B, Bloor D, & Henry, J *Scientific Knowledge: A Sociological Analysis* (London: Athlone Press, 1996), 141.

<sup>168</sup> Barnes B, Bloor D, & Henry, J (1996), 141.

literature that describes and defends the scientific nature of the social sciences<sup>169</sup> and some of that support can be traced to the very earliest academic references to science. Respected United States jurist, Benjamin Cardozo includes the following quote from Aristotle in his argument for restatement of the common law: “As in other sciences, so in politics it is impossible that all things should be precisely set down in writing; for enactments must be universal, but actions are concerned with particulars.”<sup>170</sup> This passage indicates that Aristotle’s meaning of science extended past the natural sciences, which were very limited at the time, and included politics. That meaning is consistent with the priority Aristotle gave to matters of the mind and to the universal nature of laws uncovered by human thought and reason. However, the criteria important to Aristotle’s model of science are not the same for all advocates of a scientific approach to life. For others, a scientific approach to a given topic will involve data collection and analysis as its distinguishing feature.<sup>171</sup>

Recent academic scrutiny of science and the scientific community has arisen also from dramatic developments in fields such as electronics and genetics. The application of scientific research to space exploration, communications, and medicine has raised ethical questions that focus debate outside the scientific community. That debate draws attention to the goals, methods and regulation of science<sup>172</sup> but writers rarely identify what criteria they use to classify science. There are some common terms used to indicate a range in the scientific nature of an activity, for example differentiation between “the hard sciences” and social

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<sup>169</sup> For example: Bernal, J *Science in History* (Middlesex, England: Penguin Books Ltd, 1969), Jasanoff, S “What Judges Should Know About the Sociology of Science” (1966) 32 *Jurimetrics Jnl* 345, and Renaker, T “Evidentiary Legerdemain: Deciding When Daubert Should Apply To Social Science Evidence” (1996) 84 *Calif L R*.

<sup>170</sup> Aristotle *Politics Book II* Jowett’s translation, in Cardozo, B “The Paradoxes of Legal Science” in Hall, M (ed) *Selected Writings of Benjamin Cardozo* (NY: Mathew Bender & Co, 1947) 193.

<sup>171</sup> Goldberg, S “The central dogmas of law and science” (1986) 36 *Jnl Legal Ed*, 371.

<sup>172</sup> For example see Giddens, A *Sociology* (Cambridge: Polity Press, 1989), De Sousa Santos B, *Toward a new common sense* (New York: Routledge, 1995).

sciences, however these writers do not identify the characteristics of hard sciences or where and why the line should be drawn between the two.<sup>173</sup>

Amongst writers who advance arguments for law to be considered a science, or to adopt a scientific method, there is also a lack of definition concerning the scope or nature of science. Aarnio refers to that uncertainty as follows:

It is not so very useful to contemplate whether legal science is science or not, since the answer is decidedly dependent on how science is seen in general. This is something that does not interest a judge, lawyer, or layman who expects to hear practical answers.<sup>174</sup>

For Aarnio, the essential characteristic of legal science relates to its investigative purpose;

What is essential is the readiness of legal science at any given time to answer the questions presented in a legal community, or, in wider terms, in a civil community: “Why should we do it like this?” To answer this question, legal science must produce well-founded arguments about the content of the legal system.<sup>175</sup>

Despite Aarnio’s reluctance to debate the scientific nature of legal science, the connection of science with legal research and analysis is clearly fundamental to the approach or it would not be included in its title. Science carries such a high degree of authority that proponents of legal science continue to embrace the link regardless of their own understanding of science and of its applicability to their particular research endeavour.

The range of views concerning the relationship between science and law is very broad. Some writers strive to find analogies between the two disciplines and suggest that law is, or the very least should strive to be scientific. Others describe

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<sup>173</sup> Ceci, S and Friedman, R “The suggestibility of Children; Scientific Research and Legal Implications” (2000) 86 Cornell Law Review 33.

<sup>174</sup> Aarnio, A “The Systematisation and Interpretation of Statutes. Some Thoughts on Theoretical and Practical Legal Science” in Wintgens, L (ed) *The Law in Philosophical Perspectives* (Dordrecht: Kluwer, 1999) 14-15.

<sup>175</sup> Aarnio (1999) 15.

law as an element of social science and identify elements common to both. Some writers are emphatic that law is not science and identify the differences between the two. The particular criteria identified to categorise science are also used to distinguish technology from science in some cases. There are also writers who are extremely critical of the role of science in legal decision-making. That criticism identifies problems with the generally accepted perception of science within the legal community and questions the credibility and influence of science in legal decision-making and policy development.

### 2.5.1 *Law is scientific*

Judge Benjamin Cardozo wrote many speeches and articles proposing a scientific approach to the law. Judge Cardozo advocated restatement of the common law as a means of unifying the law and improving certainty. He considered that the system of precedent would work more efficiently where there was a single codified common law available to all judges instead of reliance on decisions that are known and accepted within a given locality. For Judge Cardozo, the process of reasoning from a given rule, application to the facts and arriving at a conclusion is analogous to the reasoning of science. He supports the concept of legal science and refers to the authority and credibility of science as positive attributes worth pursuing in law. His approval of the authority of science is demonstrated in the following comments:

The law is not an exact science, we are told, and there the matter ends, if we are willing there to end it. One does not appease the rebellion of the intellect by the reaffirmance of the evil against which intellect rebels. Exactness may be impossible, but this is not enough to cause the mind to acquiesce in a predestined incoherence. Jurisprudence will be the gainer in the long run by fanning the fires of mental insurrection instead of smothering them with platitudes... Perhaps a scientific study of legislation, its capacities and limitations, would bring us to a saner attitude.<sup>176</sup>

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<sup>176</sup> Cardozo, B “The Paradoxes of Legal Science” in Hall, M (ed) *Selected Writings of Benjamin Cardozo* (NY: Mathew Bender & Co, 1947) 253, 257.

Although Judge Cardozo advocates improving certainty in the law, he does not desire rigid decision-making. He notes that science is guided by overarching theories that guide the formulation of hypotheses. Those theories are described as analogous to the philosophical framework within the law. Rigorous testing of scientific theories is therefore analogous to the critical analysis of law, evident in the discipline of legal science.

Apart from his perception of science as involving a process of logical reasoning, Judge Cardozo also admires the objectivity of scientific research. In an article first published in the *Yale Review*, in July 1925, he referred to the formation of an Institute of Jurisprudence at Johns Hopkins University. That Institute would comprise a group of scholars with no immediate teaching duties, their role being to study the law in its context for the United States in the twentieth century. He described the research program as follows:

They have come together to meditate, to confer, to collate, to explore. They will study the law functionally, asking themselves not merely whether this or that rule has come down to us from medieval days, but whether this rule or that one is adapted to the present needs of life. So the disinterested inquiry, which has long inspired the students of the physical sciences, is spreading, we may justly believe, to the social sciences as well.<sup>177</sup>

The comments above suggest several conclusions about Cardozo's model of science. Firstly, he clearly perceives that researchers in the physical sciences have an objective approach to their study, which is not influenced by personal goals or by other experiential factors. That view of science is at odds with constructivist models that emphasise the role of each individual's environment in constructing their own understanding and perception of the world.<sup>178</sup> Individual scientists make rational choices about all aspects of their research, including the parameters for

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<sup>177</sup> Cardozo, B "Law and Literature" in Hall, M (ed) *Selected Writings of Benjamin Cardozo* (NY: Mathew Bender & Co, 1947) 391.

<sup>178</sup> See Martin, B and Richards, E "Scientific Knowledge, Controversy, and Public Decision Making" in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 506.

their hypotheses and observations. Those choices contribute to the boundaries within which each scientist and the scientific community will operate.<sup>179</sup> Judge Cardozo also distinguishes the natural sciences from the social sciences and includes law into the latter category. However, the “disinterested inquiry” of the natural sciences is still spreading into the social sciences so that is not a distinguishing feature of his model of science.

Another proponent of legal science, J W Harris, describes legal science to encompass all aspects of legal endeavour.

Legal science is that activity, widespread in countries with developed legal institutions, whose necessary objective is the systematic exposition of some corpus of legislative materials. A piece of legal science, to be such, must seek to describe what the law is on a topic by reference to relevant authoritative legislation. It may also offer historical explanations for the state of the law, or doctrine-based or policy-based criticisms of it, and recommendations for interpretation where the law is uncertain for legislative amendment where it is unsatisfactory. Legal science is to be found in textbooks and treatises, in solicitors’ advice and counsels’ opinions and, commonly, in the reported decisions of the courts.<sup>180</sup>

For Harris, legal science occurs in the law whenever there is explanation, prediction or recommendation with reference to the rules that guide the legal system. The system of rules that have evolved from the philosophical framework of the law together with a process of rational thought to produce decisions based on those rules embodies the essence of science within the law.

Aulisio Aarnio also describes legal science in terms of the reasoning process to both analyse and apply legal rules in order to solve questions. Aarnio proposes a model of legal science that is divided between “theoretical legal science” and

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<sup>179</sup> See Gieryn, T “Boundaries of Science” in Jasanoff, S, Markle, G, Petersen, J and Pinch, T (eds) *Handbook of Science and Technology Studies*, (London: Sage, 1995) 393.

<sup>180</sup> Harris, J *Law and Legal Science* (Oxford: Clarendon Press, 1979) 2.

“practical legal science”.<sup>181</sup> Theoretical legal science involves the analysis of legal concepts to give rise to numerous theoretical questions and possibilities that can then be addressed by practical legal science. Aarnio describes legal science as a social science although “its point of contact with the empirical social sciences is problematic.”<sup>182</sup> He adopts a methodological distinction between the natural sciences and the humanistic sciences, on the basis that the natural sciences explain phenomena while the humanistic sciences interpret and understand deeds and events. Legal science belongs to the humanistic division because it interprets rather than explains, and he links it to historical and literary research. His model of science includes a strong theme of logical reasoning from a theoretical framework, however the explanatory nature of the natural sciences is also a distinguishing feature. His comment that law does not entirely fit within the social sciences because of its lack of empirical content suggests that empiricism is important in his classification of a social science. That difficulty with his perception of law within his model of social science perhaps explains his later comment that questions concerning the scientific nature of legal science are “useless” and of no interest to those seeking practical legal answers.<sup>183</sup>

The boundary-work done by those who describe law as being scientific is for a variety of reasons. Many carefully identify the criteria common to both, focusing on the perceived qualities of science. Those qualities are described as positive values that enhance the legal process. The identification of law with science as a mechanism for enhancing the credibility of legal process has also been identified in the attitudes and approaches of legal decision makers. Goff argues that scientism is a common feature in trials involving expert scientific evidence.<sup>184</sup> He describes scientism as a process whereby experts are accorded special authority by virtue of their connection with science. Goff suggests that so long as those controlling the trial process (the judges) believe in a formalistic legal view of

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<sup>181</sup> Aarnio, A “The Systematisation and Interpretation of Statutes. Some Thoughts on Theoretical and Practical Legal Science” in Wintgens, L (ed) *The Law in Philosophical Perspectives* (Dordrecht: Kluwer, 1999) 19.

<sup>182</sup> Aarnio (1999) 2.

<sup>183</sup> Aarnio (1999) 14.

<sup>184</sup> Goff, C “Due Process and the Nova Scotia Herbicide Trial” in Pearce, F and Snider, L (eds) *Corporate Crime: Contemporary Debates* (Toronto: University of Toronto Press, 1995) 352, 359.

impartiality and expertise, they are also likely to attribute weight to scientific evidence and to appeal to the authority of that evidence as the basis for establishing fact and drawing inferences.

### 2.5.2 *Law is a social science*

Other legal commentators clearly identify law as a social science. Harold Lasswell<sup>185</sup> is an example from this group. He considers that the methodology of science is an appropriate mechanism for the study of law and should be applied as follows:

If scientific inquiry were comprehensively and continuously used to describe and analyse the public order of the world community or group, information would be available at any given moment to illuminate the policy decisions of all effective participants in the decision process.<sup>186</sup>

Lasswell goes on to explain that the method of science is not only appropriate to the study of science, but is an accurate reflection of the processes of legal analysis and reasoning. Lasswell comments that the “social scientist develops as a specialty a task that is inseparable from the role of every living person”.<sup>187</sup> He explains that the essential criteria of scientific method are: the development of hypotheses; empirical testing to generate data from observations; objective (as in non-preferential) statements about those data and hypotheses; and the advancement of knowledge. He notes that measurement is not an essential feature of science, however, it is a useful tool when distinguishing between alternative propositions. He also notes that science is not limited to the disciplines that involve experiment. Experimental procedures are also described as useful tools of science. Lasswell notes that propositions can still be true, even if there is no demonstrable link to causation. Lasswell is one of the few legal commentators that I have found to provide a definition of his understanding of science. He prefers a broad definition, which he claims is more consistent with the origins of science and which avoids definitions designed to emphasise and delineate

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<sup>185</sup> Lasswell, H and McDougal, M *Jurisprudence for a free society : studies in law, science, and policy* (Dordrecht, Netherlands ; Boston : M. Nijhoff, 1991)

<sup>186</sup> Lasswell, H and McDougal, M (1991) 866.

<sup>187</sup> Lasswell, H and McDougal, M (1991) 867.

particular interest groups within the scientific community. His definition is as follows:

By the term 'science' we mean a systematic body of propositions verifiable by observation, all of which are not obvious to commonsense.<sup>188</sup>

Applying that definition, Lasswell notes that everyone becomes a scientist when concerned with testing "the descriptive truth or falsity"<sup>189</sup> of general statements and thereby formulating valid records of events arising from those general statements. He notes that jurisprudence involves the serious consideration of practical generalisations in that it involves recording data and analysing process. Thus the courts, lawyers and other legal decision makers are social scientists both because of the method of their work and because of their role in predicting outcomes under various conditions.

Other writers connect law with social science by association. For example, Ceci and Friedman have been involved in research to determine the reliability of children's evidence.<sup>190</sup> Their paper describes the legal adversarial process as a social science when discussing the role of expert testimony. Ceci and Friedman differentiate between social science and hard science and refer to the "mainstream scientific community"<sup>191</sup> throughout the paper. Those references suggest that there is part of the scientific community that is not "mainstream" yet remains scientific. Without defining their criteria for mainstream or hard science, Ceci and Friedman refer to scientific publications, statistical analysis of results and mathematical modelling to differentiate their analysis of research into the reliability of child testimony and to characterise their results as a scientific examination of this element of the legal process.

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<sup>188</sup> Lasswell, H and McDougal, M (1991) 869.

<sup>189</sup> Lasswell, H and McDougal, M (1991) 867.

<sup>190</sup> Ceci, S and Friedman, R "The suggestibility of Children; Scientific Research and Legal Implications" (2000) 86 Cornell Law Review 33.

<sup>191</sup> Ceci, S and Friedman, R (2000) 34.

### 2.5.3 *The Law should become scientific*

Another group of legal commentators differentiate between their models of science and of law, but either advocate for law to adopt the methodology of science or identify, with approval, elements of science within the study of law. Lee Loevinger is an example from this group. Loevinger identifies a parallel between the dialectic model of law and the empiric method of science.<sup>192</sup> He sees both as mechanisms to gather and organise data and to provide answers for specific scientific questions. He describes the dialectic method of law as involving the testing of testimony that is given by witnesses who have made observations. That testing not only happens during the adversarial courtroom process, but also during the formulation of law in the parliamentary and select committee processes.

Loevinger describes science as similar to law in that it seeks to get agreement among scientists. He notes that the purpose of science and law is different. Science is analytical and predictive, while he describes law as a prescriptive process seeking to classify and control. However, he notes that science is an integral component of modern culture that must be understood by the law as part of the process of establishing normative principles within society. He approves of dialectic processes within law as mechanisms for testing propositions put before decision makers and he advocates the inclusion of more of the (undefined) scientific method in law.

There are also calls for the introduction of “scientific decision making” into the international legal arena.<sup>193</sup> In a note considering the role of scientific data within international environmental law policy making, the Harvard Law Review strongly advocates that scientific reasoning lead decision making in the CITES<sup>194</sup> policy making community. The note argues that:

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<sup>192</sup> Loevinger, L “Law and Science as Rival Systems” (1966) 8 *Jurimetrics Jnl* 63.

<sup>193</sup> “The CITES Fort Lauderdale Criteria: the uses and limits of science in international conservation decision making” : Note in (2001) 114 *Harvard Law Review* 1769.

<sup>194</sup> Convention on International Trade in Endangered Species of Wild Flora and Fauna.

The most important function of the Fort Lauderdale Criteria in CITES is to improve discourse of member states, by encouraging parties to frame arguments in terms of scientific data.<sup>195</sup>

The note argues further that the use of a shared scientific discourse among member states will facilitate and improve communications between the member states and thus enable agreement and compromise over issues. In addition, the use of scientific justification for decisions is predicted to make it easier for states to obtain domestic support, and thus ratification, of controversial decisions. This note claims that the Fort Lauderdale Criteria ('FLC') will provide incentives for states to undertake scientific research and therefore introduce scientific data into the decision making process. "The FLC may lead to gradual changes in the parties' views as parties come to understand opposing viewpoints and the utility of scientific data."<sup>196</sup> The implication in this statement is that scientific data is non-partisan and even value-free and will provide the unifying force to bring agreement among the member states.

John Veilleux also discusses the perception of science as a mechanism to improve the objectivity and efficiency of legal decision-making.<sup>197</sup> Veilleux supports the application of a scientific analogy to law as a means of better understanding and improving judicial law and decision-making. However, he recognises that there are many valid criticisms of the idea that law is scientific. Veilleux describes his understanding of the term scientific as meaning "objectively observable, analytically determinate or conceptually coherent".<sup>198</sup> He notes that judge-made law is like science in that there are certain characteristics commonly associated with science that are usually present in judicial decision making. Those

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<sup>195</sup> "The CITES Fort Lauderdale Criteria: the uses and limits of science in international conservation decision making" : Note in (2001) 114 Harvard Law Review 1769, 1782. The Fort Lauderdale criteria provide the framework for decisions classifying and identifying endangered species.

<sup>196</sup> "The CITES Fort Lauderdale Criteria: the uses and limits of science in international conservation decision making" : Note in (2001) 114 Harvard Law Review 1769, 1785-6.

<sup>197</sup> Veilleux, J "The scientific model in law" (1987) 75 Georgetown Law Jnl, 1967.

<sup>198</sup> Veilleux (1987) 1968.

characteristics are defined as “sceptical empiricism”<sup>199</sup> which Veilleux describes as the process of testing tentative conclusions against external evidence. Veilleux describes the scientific analogy to legal decision making as a process that involves the analysis and consideration of legal questions to produce answers. He describes the goal of “scientific solutions”<sup>200</sup> in terms of a decision-making process based on “accurate facts” and “identified rules and principles” such that the decisions would be replicated by “other scientific judges” if the essential circumstances were reproduced.<sup>201</sup>

Veilleux describes the scientific model of law-making as follows:

- an objective inquirer;
- a process of hypothesis and empirical testing; and
- a belief in some underlying coherent system that assures that the first 2 principles will produce accurate and reproducible answers.<sup>202</sup>

He notes that the second principle above is generally referred to as the scientific method. Veilleux acknowledges that there is criticism from within the scientific community of the notions of objectivity, strict empiricism and theoretical coherence that are described by the traditional model of science. However, he advocates the scientific analogy as an intellectual tool to promote and facilitate better understanding of the issues, facts and legal frameworks relevant to judicial reasoning in order to achieve consistent and predictable legal decisions.

#### 2.5.4 *Law is not science*

As with any academic debate, just as some writers strongly advocate for the law’s status as a science or for the incorporation of scientific process into legal decision making, there are also those writers that strongly reject any analogy between science and law.

Steven Goldberg, identifies a number of differences between science and law, and one of these he considers is fundamental.<sup>203</sup> Goldberg argues that despite elements

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<sup>199</sup> Veilleux (1987) 1969.

<sup>200</sup> Veilleux (1987) 1970.

<sup>201</sup> Veilleux (1987) 1970.

<sup>202</sup> Veilleux (1987) 1970-71.

differences between science and law and also separate science from the process of technology. Each of these writers notes that the intermingling of the 2 disciplines as part of the adversarial process can cause difficulties arising from their fundamental differences. Jasanoff comments that when judges independently research the scientific and technological facts in dispute, the parties no longer have unbiased and impartial gatekeepers that our judicial system guarantees. She argues that the process of excluding expert testimony or appointing court experts involves the judge as a participant in the construction of particular scientific facts. In order to avoid that determination within the legal arena, Fisk advocates that the scientific community remains alert to areas of controversy and “provides as a public service a properly structured and reviewed scientific assessment”.<sup>212</sup> Fisk defines his understanding of science as follows:

The most useful [definition] focuses on science as a body of knowledge, and includes both what is known and what remains in dispute.<sup>213</sup>

He is adamant that science is different from technology arguing that:

A particularly pernicious definition of ‘science’ is one that is taken to embrace all things technical. This leads to the false impression that the statements of, say, an ecologist or chemist, are of the same epistemological status as those of an engineer or a medical doctor. This is not the case.<sup>214</sup>

For Fisk, the knowledge component is a fundamental element in his model of science. Thus any similarities in process between legal decision-making and scientific method are similarities borne out of logical thought processes applying to both disciplines.

The concept of Reflexive Law or Autopoiesis was first introduced by Gunther Teubner in the early nineteen eighties.<sup>215</sup> Reflexive Law describes the analysis of

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<sup>212</sup> Fisk, D “Environmental Science and Environmental Law” (1998) 10 *Journal of Environmental Law* 3, 7.

<sup>213</sup> Fisk (1998) 3.

<sup>214</sup> Fisk (1998) 3.

<sup>215</sup> For example Teubner G “Autopoiesis in Law and Society: A Rejoinder to Blankenburg.” (1984) 18 *Law and Society Review*, 301-311 and “After Legal Instrumentalism? Strategic Models

a system (being a legal system) as the self-reproduction of itself out of its components. It is a concept of self-definition and self-reference in terms of the elements that give rise to that system. Teubner modelled his concept on the complex systems typical of cybernetics and biology.<sup>216</sup> He draws analogies between systems theories and scientific theories and argues that legal models can be tested through legal practice in an analogous way to the testing of scientific theories. However, his central theme is that law is a system separate from science, politics and technology. Those systems have their own reasoning and logic and their separation is important to maintain a functioning society. Teubner has a very clear concept of the ideological boundaries that maintain the autonomy of those systems.

Still other writers are very suspicious of the role of science in modern society and challenge the perceived authority of science as being more trustworthy or reliable than other types of evidence or judicial determination itself. Barnes et al argue that the authority of science within society is of such value to scientists that there is a very strong incentive to guard the existing boundaries of science closely and to avoid the intrusion of whatever may detract from that reputation.<sup>217</sup>

#### 2.5.5 *Science and legal decision making*

Whenever there is an interaction between science, scientists and decision-makers within a legal context, boundary-work will be in operation so that those giving and those receiving information will process that information against a framework of values, rules and expectations that will vary depending on boundaries borne out of personal experience. The givers of information package their opinions for ease of understanding and to enhance persuasion. The receivers of information perform their assessment in light of their own interpretation of legal rules, scientific principles (as presented in testimony) and personal judgment as to the

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of Post-Regulatory Law (EUI Working Paper 100/84).” in: Gunther Teubner (Hrsg.), *Dilemmas of Law in the Welfare State*.

<sup>216</sup> Calliess, G “Lex Mercatoria: A Reflexive Law Guide to an Autonomous Legal System” (2001)

17 German Law Journal at <http://www.germanlawjournal.com/article.php?id=109>

<sup>217</sup> Barnes B, Bloor D, & Henry, J *Scientific Knowledge. A Sociological Analysis* (London: Athlone Press, 1996), 140.

appropriateness of where to draw boundaries. Edmond<sup>218</sup> argues that both the construction and deconstruction of scientific knowledge in the adversarial system of law are informed by the vantage point of the observer. He challenges Jasanoff's support for the adversarial system as a means of deconstructing scientific evidence to provide a robust test for the reliability of that evidence.<sup>219</sup> Edmond argues that even where the adversarial process facilitates the deconstruction of scientific evidence, the value of that process for the epistemological legitimacy of the decision will depend on the extent and awareness of the deconstruction as well as the context and values framework of the decision-maker.<sup>220</sup> Cross-examination is a persuasive tool developed within the legal system. Its function in testing credibility of evidence is more about persuading about the correctness of one's view rather than exposing the constitution of scientific evidence. Any dents to credibility will attach to the individual witnesses and/or their institutions rather than to public faith in science. In addition, deconstruction within the legal process will reflect access to resources. The party with better resources will be able to purchase a more rigorous level of deconstruction. Edmond rightly, in my opinion, notes that the process of deconstruction and reconstruction that happens as a scientific witness is cross-examined and then as the decision-maker makes sense of the narrative, happens through the perspective of the individuals involved.<sup>221</sup> That perspective differs as between the participants within a hearing and will also differ between hearings as the context changes. The published decision will ultimately reflect the narrative perceived and preferred by the decision-maker.

Commentators such as Cranor argue for a more context based approach to assessing scientific evidence to ensure that there is both procedural fairness and a

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<sup>218</sup> Edmond, G "Science in Court: Negotiating the Meaning of a 'Scientific' Experiment During a Murder Trial and Some Limits to Legal Deconstruction for the Public Understanding of Law and Science" (1998) 20 Sydney LR 361, 378.

<sup>219</sup> Jasanoff, S "What Judges Should Know About the Sociology of Science" (1993) 77 *Judicature* 77, 78.

<sup>220</sup> Edmond, G "Science in Court: Negotiating the Meaning of a 'Scientific' Experiment During a Murder Trial and Some Limits to Legal Deconstruction for the Public Understanding of Law and Science" (1998) 20 Sydney LR 361, 378.

<sup>221</sup> Edmond (1998) 393.

greater likelihood of achieving a correct outcome.<sup>222</sup> Cranor challenges the interpretation of admissibility rules for expert evidence in toxic tort cases. He argues strongly that all relevant evidence, being evidence considered relevant by scientists, should be admitted in order to increase the chances of obtaining the correct outcome. That approach will make judges' jobs more difficult because there will be a greater requirement to evaluate and weigh evidence without relying solely on legal boundaries without reference to context.

Brewer also addresses the issue of boundary-work in assessing scientific expert testimony.<sup>223</sup> He concludes that in order to avoid making an epistemologically arbitrary choice about which of competing scientific experts should be believed, decision-makers must understand the cognitive methods of science. Because judges and other legal decision-makers do not often understand science in that sense, they rely on other indicia of expertise in order to assess credibility for example, credentials, reputation and demeanour. Brewer identifies an emerging new norm of "intellectual due process" within the legal system that requires decisions not to be made arbitrarily from an epistemic point of view.<sup>224</sup> Brewer adapts Hart's analysis of epistemic deference to identify when it is appropriate for a decision-maker to defer to an expert witness.

According to Hart:

[T]he reason for belief constituted by a scientific authority's statement [that some proposition is true] is in a sense peremptory since it is accepted as a reason for belief without independent investigation or assessment of the truth of what is stated. It is also content-independent since its status as a reason is not dependent of the meaning of what is asserted so long as it falls within the area of his special expertise.

...To be an authority on some subject matter a man must in fact have some superior knowledge, intelligence, or wisdom which makes it reasonable to

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<sup>222</sup> Cranor, C, Fischer, J and Eastmond, D "Judicial Boundary Drawing and the Need for Context-Sensitive Science in Toxic Torts After *Daubert v Merrell Dow Pharmaceuticals Inc*" (1996) 16 Virginia Env LJ 1, 75.

<sup>223</sup> Brewer, S "Scientific Expert Testimony and Intellectual Due Process" (1998) 107 Yale LJ 1535.

<sup>224</sup> Brewer (1998) 1539.

believe that what he says on that subject is more likely to be true than the results reached by others through their independent investigations, so that it is reasonable for them to accept the authoritative statement without such independent investigation or evaluation of his reasoning.<sup>225</sup>

Hart identifies that when deciding whether to defer to an expert it is important to distinguish between believing a proposition and believing a person. The decision-maker is deferring to the expert because the decision-maker does not have the cognitive understanding to decide the issue. The decision-maker may, however, have the means to decide whether or not the expert's testimony can be accepted. Brewer illustrates the difference between knowledge and understanding with the following example adopted from the work of Miles Bunyeat:

The important difference between knowledge and understanding is that knowledge can be piecemeal, can grasp isolated truths one by one, whereas understanding always involves seeing connections and relations between the items known. "The only part of modern physics I understand is the formula  $E=mc^2$ " is nonsense. "The only part of modern physics I know is the formula  $E=mc^2$ " is merely sad.<sup>226</sup>

Brewer argues that Hart's analysis of epistemic deference does not help in providing non-experts with criteria to identify appropriate experts. He notes that there is no bright line that separates expertise from non-expertise in the same way that there is no bright line separating night from day or black from white. That does not mean that there is no difference between these concepts. Rather, a selection process in which decision-makers define the expertise boundary must take place in every assessment of expert testimony.

Brewer adopts the following variation of Hart's theory of deference to explain how a non-expert can be justified in accepting expert testimony:

For A to be an epistemic authority for B on some subject matter, B must judge that A has some sufficient knowledge, intelligence, or wisdom

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<sup>225</sup> Hart, H "Essays on Bentham" *Studies in Jurisprudence and Political Theory* (1982), 261-262.

<sup>226</sup> Brewer, S "Scientific Expert Testimony and Intellectual Due Process" (1998) 107 *Yale LJ* 1535, 1591.

which makes it reasonable to believe either that what A says on that subject is more likely to be true than the results reached by B through B's independent investigations, or is no less likely to be true than the results that would be reached by B through B's independent investigations.<sup>227</sup>

From that structure the non-expert decision-maker must still determine: a) what elements of the testimony are science; b) what scientist satisfies the epistemic confidence level; c) what testimony is rationally pertinent; and d) where there is doubt about c, who can answer that doubt. Brewer concludes that in order to achieve intellectual due process, a decision-maker must apply epistemic non-arbitrariness to the assessment of expert testimony. That means that the decision-maker must have both legal authority and epistemic competence with the basic tools of scientific analysis, being biology, genetics, statistics, economics or epidemiology.<sup>228</sup> Given that Brewer is predominantly concerned with scientific testimony during toxic tort cases, his basic scientific tool kit is predictably specialised. The practical difficulty will concern how any competent judicial or administrative decision-making body deciding environmental issues could assume that level of epistemic competence without being extremely specialised and to that extent Brewer is essentially calling for the establishment of a specialist science court.

## 2.6 Conclusion

The wide range of views about the appropriate relationship between science and law also reflects a wide range of views about the nature of science. For some, the essential feature of science is knowledge and that is both the defining difference from and advantage to decision making within law.

For other commentators, the essential element of science is its objective and value-free nature. Within this group the perception of objectivity is either a quality to which the law should aspire or a defining difference and reason for exclusion from the decision making process.

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<sup>227</sup> Brewer (1998) 1588.

<sup>228</sup> Brewer (1998) 1677 and 1679.

The relationship between science and law is clearly complex and involves consideration of a range of different perspectives. Decision-makers will be involved in deconstructing and reconstructing scientific knowledge in order to formulate convincing reasons to support their decisions. For those decision-makers with a value-free perception of science the reconstruction of a scientific narrative within the decision, will tend to strengthen myths that social and political factors contaminate proper scientific practice.<sup>229</sup> Such an approach continues to be challenged by those in both the scientific and critical legal studies communities who recognise that no discipline, including science, can be entirely objective or value free.

Models of science that emphasise the importance of empiricism and scientific method are also prominent in the debate concerning the relationship of science and law. Again, the dominant elements in each writer's model of science are used either to distinguish or support the association of science and law as appropriate to the process of legal decision making.

The role of science in legal processes is determined by the courts, via the process of precedent, by policy makers and by the influence of expert witnesses. The research into boundary-work, by Gieryn and others, has found that scientists manipulate the language of science in order to protect or promote the scope of particular theories. Their research has also found that boundary-work is done by decision makers who must filter the ever increasing volume of scientific evidence in order to make reasoned and justifiable decisions. That information filtering process happens when certain evidence is preferred according to the values of the decision maker. An aim of this research is to discover whether boundary-work operates at a deeper level, independent of the specifics of any testimony. In short, whether the individual models of science held by legal decision makers set the boundaries against which scientific testimony is weighed quite apart from any argument and opinion evidence in a given debate. If an individual holds certain characteristics as essential to their model of science, the weight given to expert

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<sup>229</sup> Edmond, G "Science in Court: Negotiating the Meaning of a 'Scientific' Experiment During a Murder Trial and Some Limits to Legal Deconstruction for the Public Understanding of Law and Science" (1998) 20 Sydney LR 361, 401.

scientific evidence, even if that evidence is consistent between witnesses, is likely to be limited if those characteristics are missing. Individuals employ boundary-work to differentially select between alternative options and then to justify or promote those selections. That process may also happen when information is first assessed for its consistency with that individual's own model of science. The range of different models and views concerning the nature of science described in this chapter suggests that individual legal decision makers will have different models of science. Just what those models are, how they differ between individuals and the implications of those differences for assessment of expert scientific evidence underpin the research methodology and results detailed in the following chapters.

## CHAPTER 3

### SCIENCE IN THE COURTROOM

#### 3.1 Introduction

In Chapter Two, a number of different approaches to the understanding of science are described as articulated from members of science community, by academic critics and by legal commentators. Those different conceptualisations of science reflect different standpoints each with a variety of features significant for that epistemological approach. Those differences are described with reference to the historical development of science within society. This chapter traces the historical development of science and expertise within the New Zealand legal framework. In law, there are rules that govern the presentation, acceptance and value of expert evidence and, in some cases that of scientific evidence specifically. Those rules have a historical basis but have flexibility that can allow new areas of expertise to be adapted to modern problems within the modern legal system.

The process by which the courts have incorporated science and scientists into environmental litigation has evolved over many centuries and mirrors both the integration of science into the wider community and the boundary-work associated with its increasing specialisation. From an early time the courts recognised the specialist nature of science and tended to defer to scientists in the acceptance of their testimony. Judicial decisions have also displayed a degree of confidence in the ability of science to discover the answers and to conquer adversity. In her book, *Science at the Bar*<sup>230</sup> Sheila Jasanoff gives an example from the nineteenth century case of *Fletcher v Bealey*<sup>231</sup>. In that case the court refused an injunction to prevent the dumping of waste adjacent to a river which was used downstream by a paper processing factory that required a pure source of water. The court held that the danger to the plaintiff from the leachate was not sufficiently imminent to satisfy the common law test and that;

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<sup>230</sup> Jasanoff, S *Science at the Bar* (Cambridge: Harvard University Press, 1995).

<sup>231</sup> Jasanoff (1995) 36. See *Fletcher v Bealey* (1885) 28 Ch.D 688.

in ten years time it is highly probable that science (which is at work on the subject) may have discovered some means for rendering this green liquid innocuous.<sup>232</sup>

Such confidence in the productivity of science extends to the community at large, so that where there is no agreed scientific solution to an issue (which may only be an issue because there is some scientific investigation in process) there is considerable pressure on the courts to take a precautionary “wait and see” approach until the issue is “settled”.

Scientific expertise is periodically enlisted in the local authority planning process to provide appropriate guidelines and rules for district and regional plans. Such rules can relate to water quality, discharge and contaminant levels, and noise levels, for example. Science also features in the resource consent process, where applicants are required to provide an assessment of effects on the environment that will arise from the proposed activity<sup>233</sup> and such assessments are increasingly being provided by experts in science, planning, engineering and landscape design, to mention but a few. Science also enters into the litigation arena more directly as expert testimony. This testimony may be founded on either accepted or unproven scientific theories and can lead to situations where the courts are not only involved in making decisions on the case before them, but also become a public forum for scientific debate.

The implications of continuing scientific investigations for public and environmental health also inform and inflame public debate and stimulate the type of controversy and outrage that was evident in public opposition to the proposed siting of telecommunications installations adjacent to local schools. Such public outrage, which is fuelled by a genuine concern about harmful future effects on children’s health, does not often reflect the accepted findings of mainstream

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<sup>232</sup> *Fletcher v Bealey* (1885) 28 Ch.D 688, 700 in Jasanoff 36.

<sup>233</sup> Resource Management Act 1991 Fourth Schedule.

science<sup>234</sup> and places considerable pressure on our environmental decision makers, especially where a contrary view is preferred.

The Environment Court has followed the lead of other courts within our own and other jurisdictions when approaching the question of uncertain scientific implications. Although not bound by the legal rules of evidence, the Court has adopted a pragmatic approach that enables decisions to be made and those decisions to be founded on a firm base of judicial authority. That decision-making approach requires the Court to interpret expert evidence in light of its interpretation of relevant local authority policy and plan documents, previous judicial decisions and the statutory framework.

This chapter outlines the history of expert evidence within common law jurisdictions and explains how and why the boundaries between science and law have evolved and been maintained. This chapter also describes the development of science and the consequent increase in specialisation that is a reflection of the boundaries that separate the expert from the non-expert. That growth in expertise in turn gave rise to the need for legal rules that established the boundaries between fact and opinion, witness and judge. The interpretation of what is considered to be science and the limitations on testimony which may be given by experts, particularly concerning novel scientific evidence, have changed considerably and continue to do so. There has always been a tension between the role of the court in deciding what are the facts at issue and the role of the expert who is called to give evidence on matters that are outside the knowledge of both the jury and, usually, the judge. Rules of evidence have evolved with the development of the common law and the rules relating to expert evidence are described with particular reference to their application to novel scientific evidence. Finally, this chapter details the legal rules that influence decision-making in cases involving expert evidence in the Environment Court.

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<sup>234</sup> The requirement that applicants undertake assessments of effects on the environment under the Fourth Schedule to the Resource Management Act 1991 and that adverse effects on the environment be considered when assessing applications for a resource consent, means that few activities that cannot be supported by mainstream scientific evaluations of likely effects will have much chance of success where adverse physical effects are alleged.

### 3.1.1 *History of expert testimony*

Science was first introduced into the legal arena via the testimony of expert witnesses. Modern environmental litigation routinely includes a variety of expert testimony, including that of a scientific and technical nature. Science is now very much part of the fabric of society and it is expected that all manner of environmental effects can be explained, predicted, avoided and mitigated, by a proper application of the scientific method from a suitably qualified and respected scientist. Society's reliance on scientific and related technological development is relatively recent and has grown rapidly to match the advances in scientific understanding that have been made since the Second World War. Science as a conscious discipline, however, has existed since the time when people first became curious about the world around them.

Prior to the 16th century scientific endeavour was largely a hobby enjoyed by those with the curiosity and private means or patronage needed to pursue it, but once the theories and implications of scientific research were connected with technological developments, there was a movement of science out of the shadows to play a purpose within society. Science was needed for navigation and engineering in order to advance growing trading and military empires. Once it was perceived as both useful and necessary there was rather more interest in scientific research and by the 19th century advances in science were being made at universities, where research was added to the traditional teaching function. Science was needed and advanced by technological developments in a variety of industries. A knowledge of optics became essential for spectacle makers and the cinema industry, magnetism for compass makers, heat theory for refrigeration and steel, sound for the development of radio and telephone, electricity for the electrical industry, and biology for medicine.<sup>235</sup> Despite these many uses the growth in scientific research remained slow and steady. Nineteenth century industrialists were reaping the benefits of their newfound technology and did not readily invest in scientific research that had no guaranteed economic return.<sup>236</sup>

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<sup>235</sup> Bernal, *J Science in History* (Middlesex, England: Penguin Books Ltd, 1969) 1231.

<sup>236</sup> Bernal (1969) 1246.

The 20th century has seen the most rapid development in scientific research and its application. The Second World War caused science to shine. Scientists were perceived as oracles and saviours responsible for the tools that “won” and ended the war. New and more complicated aeroplanes equipped with radar and enormously “successful” weapons of destruction were seen as symbols of a powerful west that promised a prosperous, secure and improved future.<sup>237</sup> Scientists who were enlisted to advise on strategic problems began to apply their scientific training and understanding to operational problems of the State.<sup>238</sup> To those in post war society, science was seen as a useful occupation that was powerful, exciting and expanding.<sup>239</sup>

Since the Second World War, scientific research has grown rapidly, motivated primarily by profit from an ever-increasing array of consumer goods and by military expansion. The needs of science for military development, whether to enhance any future war effort or to prevent the possibility of another war,<sup>240</sup> meant that there was a need for more scientific workers and governments began to support universities and other technical training institutions much more directly.<sup>241</sup> The level of financial support has been the crucial factor in the rate of scientific advance. Cohen argues that the pace of scientific revolutions is intimately related to the level of financial support that is available. Such support is vital to attract and equip sufficient recruits to increase the likelihood of a revolutionary genius being in the right place at the right time.<sup>242</sup>

The modern concept of environmental law has also developed since the Second World War. Major scientific achievements in fields such as space exploration, medical research and electronic communication, have had a huge impact on the

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<sup>237</sup> Braun, E and MacDonald, S *Revolution in Miniature: The history and impact of semiconductor electronics* (Cambridge: Cambridge University Press, 1978).

<sup>238</sup> Braun, E and MacDonald, S (1978) 32.

<sup>239</sup> Braun, E and MacDonald, S (1978) 33.

<sup>240</sup> Both arguments have been used and I suspect that in some cases they have been used in the same speech.

<sup>241</sup> Bernal, J *Science in History* (1969), 1231.

<sup>242</sup> Cohen, I B *Revolution In Science* (Cambridge, Massachusetts, and London: Belknap Press of Harvard University Press, 1985) 21.

organisation of society from local to global levels. We can now see ourselves as components of a larger system that can be profoundly affected by our own activities. The report of the World Commission on Environment and Development (“the Brundtland Report”) comments on the impact of space exploration and satellite pictures of Earth as follows;

Historians may eventually find that this vision had a greater impact on thought than did the Copernican revolution of the 16th century, which upset the human self-image by revealing that the Earth is not the centre of the universe. From space, we see a small and fragile ball dominated not by human activity and edifice but by a pattern of clouds, oceans, greenery, and soils.<sup>243</sup>

Environmental issues such as global warming and the state of the ozone layer have moved to the top of political agendas in much of the developed world and have stimulated scientific debate as to the causes, effects and implications of these phenomena. States have enacted legislation to protect the environment, not only from their citizens, but also from the government, and this environmental legislation relies for its implementation on rules and orders that are rooted in scientific and technical inquiry.<sup>244</sup>

Science is also a feature in environmental litigation. In New Zealand, expert testimony has been common in town planning disputes since the beginnings of the Planning Tribunal in 1953<sup>245</sup> and it is from this background that our present environmental law has developed. There are now numerous experts who are available to litigants for a competitive fee. The commercial community has

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<sup>243</sup> World Commission on Environment and Development, *Our Common Future Our Common Future* (Oxford: Oxford University Press, 1987) 308.

<sup>244</sup> For example see the Resource Management Act 1991 requirements for environmental assessments, contained in the Fourth Schedule, and water quality classes in the Third Schedule, also regulations under the Hazardous Substances and New Organisms Act 1996.

<sup>245</sup> For example see *Mackay v Stratford Borough* (1955) 1 TCPA 4 where expert engineering evidence was proffered concerning the most appropriate access between 2 streets; and *Mullinder v Hawkes Bay County* (1955) 1 TCPA 15 in which evidence from the Department of Scientific and Industrial Research (“DSIR”) was given concerning drainage issues arising from a proposed subdivision.

followed the lead of universities and the military and has invested in its own research and development programs and scientists who now graduate from our universities are likely to find employment in any number of commercial laboratories that may specialise in anything from medical, to agricultural research and analysis. Science is commercially available within the community and the expansion of scientific profile and output has resulted in acceptance and expectation that science can and will solve our environmental problems.

The common law rules of evidence provide that witnesses should not give opinions in their evidence.<sup>246</sup> Rather, their testimony should record their direct recollections or observations of past events. A broad exception to that rule relates to evidence given by expert witnesses who are the only types of witness entitled to give opinions in evidence. The evidential rule requiring that expert witnesses provide opinion evidence in their testimony that is outside the ordinary experience of the jury means that there is likely to be considerable reliance on those opinions.<sup>247</sup> The level of that reliance and the way in which conflicting evidence is preferred will reflect the decision makers' confidence in and understanding of the testimony given and the scientific paradigms underpinning it. The common law has recognised the value of expert involvement in judicial proceedings for over 6 centuries with some of the early experts commonly being summoned to testify in shipping or accounting cases.<sup>248</sup> In his article for the Harvard Law Review of 1901, Judge Learned Hand noted a number of 14th century cases in which expert testimony was called by the court, including a case in 1345, in which surgeons were summoned from London to help ascertain whether a wound was fresh.<sup>249</sup> Prior to the 16th century it was common for jurymen to be selected for their special knowledge of the issue or parties before the court.<sup>250</sup> Jurors determined the issues from their special expertise and there was little distinction

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<sup>246</sup> Cross, R *Cross on Evidence (5<sup>th</sup> ed)* Mathieson, D (ed) (Wellington, NZ: Lexis Nexis, 2005).

<sup>247</sup> Freckelton, I and Selby, H *Expert Evidence* (Sydney: Law Book Co, 1993)1-1822.

<sup>248</sup> Huber, P *Galileo's revenge: junk science in the courtroom* (USA: Basic Books, 1991)13.

<sup>249</sup> Anonymous, Lib. Ass. 28, pl. 5 (28 Ed III) quoted in Hand, L "Historical and Practical Considerations Regarding Expert Testimony" (1901 - 1902) 15 Harv L Rev 40, 48.

<sup>250</sup> Mahon, P "Expert Evidence" [1979] NZLJ 123, 124.

between jurors and witnesses.<sup>251</sup> In some types of dispute there was also a system of assessors where a judge would sit with a number of experts who acted in an advisory role. That system was common in the English admiralty jurisdiction where assessors were commonly sea captains who sat with the judge in the Admiralty Court to give assistance with issues arising from maritime law and practice.<sup>252</sup> Elements of that system can be found in New Zealand's Environment Court where an Environment Judge usually sits with Environment Commissioners, who are required to have "a mix of knowledge and experience in matters coming before the Environment Court"<sup>253</sup> as a condition of their eligibility.

The need to find explanations for the unusual and unexpected events in our environment is also a common theme in our legal history and the courts have summoned and listened to many of those with plausible (or not) theories. A particularly dark period in history concerns the identification of witches as being responsible for various environmental problems, including: famine, flood, pestilence, disease, and birth defects.<sup>254</sup> After researching the evidence concerning those various afflictions, Heinrich Institor and Jakob Sprenger, in 1486, published their medieval explanation for environmental damage in the form of *Malleus Maleficarum* ("The Hammer of the Witches").<sup>255</sup> This persuasive account was adopted by the ecclesiastical courts throughout Europe and witch hunts and witch trials over the next 300 years resulted in the agonising deaths of half a million women.<sup>256</sup> The quality of evidence which was accepted as conclusive of witchcraft was eventually challenged by Inquisitor Alonso Salazar y Frias, in 1610. He found that accusations concerning the existence of witches were false, the principal evidence being confessions obtained after or during the application of torture. Salazar y Frias required those accusing women of witchcraft to bring independent evidence before the court instead of solely relying

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<sup>251</sup> Jones, *C Expert Witnesses: Science, Medicine, and the Practice of Law* (Oxford: Clarendon Press, 1994) 23.

<sup>252</sup> Mahon, P "Expert Evidence" [1979] NZLJ 123, 124.

<sup>253</sup> Resource Management Act 1991 s 253.

<sup>254</sup> Huber, P *Galileo's revenge: junk science in the courtroom* (1991), 9.

<sup>255</sup> Huber (1991) 9.

<sup>256</sup> Huber (1991) 10.

on such confessions. In doing so, Salazar y Frias “introduced rules of evidence which recognised the perverse and essentially meaningless forms which unstructured ‘facts’ could take.”<sup>257</sup> Despite this requirement it was still to be over 100 years until the last legal execution of a witch took place (in Switzerland) in 1782.

During the 16 and 17th centuries there was increasing use of expert testimony in court and this practice was endorsed by the judiciary as evidenced by the following comments of Saunders J.<sup>258</sup>

If matters arise in our law which concern other sciences or faculties, we commonly apply for the aid of that science or faculty which it concerns, which is an honourable and commendable thing in our law. For thereby it appears that we do not dismiss all other sciences but our own, but we approve of them and encourage them as things worthy of commendation.

By the 19th century the system of court appointed or summoned expert witnesses was largely abandoned in favour of an adversarial system in which parties provided, and paid, their own witnesses. There was also a developing trend within the court to separate the roles of witness and jury, confining expert testimony to the witness and thus removing decision making functions from the expert. This separation was largely complete by the early 19th century, when a judicial instruction to the jury that they reach a verdict based on their own knowledge was considered to be grounds for a new trial.<sup>259</sup> Witnesses and the extent of their testimony were thus put more firmly within judicial control and much of the development of legal rules concerning the admissibility of expert testimony has been directed at policing the expert/judicial boundary.<sup>260</sup>

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<sup>257</sup> Huber (1991) 23, quoting from Clark, W *Witches, Floods, and Wonder Drugs: Historical Perspectives on Risk Management* (1981).

<sup>258</sup> *Buckley v Rice Thomas* (1554) 75 ER 182, 183.

<sup>259</sup> Jones, C *Expert Witnesses: Science, Medicine, and the Practice of Law* (1994), 32, gives an example from *R v Sutton* (1816) 105 ER 931.

<sup>260</sup> Jones (1994) 34.

### 3.2 Science in law: rules of expert evidence

#### 3.2.1 Common law rules

There has always been a tension between the role of the court in deciding what are the facts at issue and the role of the expert who is called to give evidence on matters that are outside the knowledge of both the jury and, usually, the judge. Experts have a unique role in the common law judicial arena in that they are permitted to give their opinions on the meaning and implications of the evidence that they, and other witnesses may give to the court. That role is enhanced by the likelihood that opinions of experts are likely to be relied on because they necessarily concern issues that are outside the ordinary knowledge of the court. Because of the special and significant role played by experts, the courts have been careful to ensure that expert testimony is given by people who have special knowledge and training in a recognised field of expertise. The courts have also been careful to identify the role of expert witnesses and to distinguish that role from the decision making function of the court. Five common law rules of evidence have evolved in order to control the content and boundaries of expert testimony.

These rules can be summarised as:

- the “expertise rule” which requires witnesses to have a proven level of knowledge and experience to ensure that they are qualified to help the court in an expert capacity;
- the “area of expertise rule” which requires that the area of expertise from which evidence is being given is an area that has credible theoretical foundations and methodology and is recognised by others capable of evaluating those foundations;
- the “common knowledge” rule which requires that the substance of expert testimony should be outside the common knowledge of the court;
- the “ultimate issue” rule which tends to make inadmissible any expert opinion evidence that effectively supplants the courts’ decision making function; and
- the “basis rule” which restricts expert opinion evidence to those matters which are directly within the expert’s experience and observations.<sup>261</sup>

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<sup>261</sup> Freckelton, I and Selby, H *Expert Evidence* (1993), 1-32.

In a discussion paper concerning expert evidence, the Law Commission notes that there are some practical and theoretical problems that arise from the restrictions incorporated in the various rules relating to expert evidence.<sup>262</sup> Commonly, the situations in which expert evidence is held to be inadmissible involve testimony which goes to the ultimate issue or which is considered to be within the trier of fact's common knowledge. In both situations the reason for inadmissibility focuses on the subject matter of the testimony rather than its reliability or helpfulness. This can mean that unhelpful or unreliable evidence is introduced and other useful evidence is excluded.<sup>263</sup> The requirement that an expert should not give evidence on matters of "common knowledge" to the trier of fact was explained by McMullin J in *R v B (an accused)* that "to allow expert evidence in such a case would be to defeat the purpose for which juries are used."<sup>264</sup> This requirement is also the central theme behind the "ultimate issue rule". The courts have resisted any intrusion of witnesses into the realm of decision making and the development of the lay jury away from the system of expert assessors who advised the court was in large part a process which evolved to limit the power of the jury by limiting their special knowledge.<sup>265</sup> Once the jury had no special knowledge, expert witnesses were required and the admissibility and interpretation of that expert testimony was directed by the judge.

There are also problems with the way that expert evidence is presented to the court. Scientific evidence, in particular, may be very technical and specialised but procedural rules may make it difficult for opposing parties to test evidence for its accuracy and relevance within the time frame allowed and within their own budget.<sup>266</sup>

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<sup>262</sup> Law Commission *Evidence law : expert evidence and opinion evidence a discussion paper* (Wellington : The Law Commission, 1991)1.

<sup>263</sup> Law Commission (1991) 2.

<sup>264</sup> [1987] 1 NZLR 362, 367.

<sup>265</sup> Jones, C *Expert Witnesses: Science, Medicine, and the Practice of Law* (1994), 59.

<sup>266</sup> Law Commission *Evidence law: expert evidence and opinion evidence a discussion paper* (1991), 2.

### 3.2.2 *Opinion evidence*

There seems to be an assumption throughout the case law giving rise to the rules of evidence applying to expert evidence that factual evidence is inherently more reliable than opinion evidence because it is objective and devoid of partisan support for the retaining party. This is an assumption that cannot withstand any degree of close scrutiny. As discussed in chapter 2, scientific evidence relies on a set of assumptions and choices that are influenced by a number of factors including; the individual standpoint of the researcher derived from their values and experiences of life and learning,<sup>267</sup> political and economic pressure from funding agencies and research institutions, the politics which accompanies decisions about selection of and inclusion of articles and research data into reputable journals, the politics and economics which determine which are the reputable journals, and individual researcher's desires for academic and economic advancement.<sup>268</sup>

### 3.2.3 *Teamwork and objectivity*

There is evidence that expert witnesses do feel part of the adversarial team and may in fact be encouraged to feel this way. Such sentiments can be seen in the comments of John Brennan, a retired consultant pathologist and barrister who practised in England and had a wide experience of giving expert medical evidence. In an article that questions the growth and need for new training institutions and qualifications for expert witnesses, Brennan notes;

In the conduct of the case in court, counsel is supreme and he only decides who and who not to call. Many experts have an inflated idea of their importance but it is rare today for a verdict to hang on scientific evidence alone. If his report does not advance the case of the party instructing him

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<sup>267</sup> See for example, Harding, S "Rethinking Standpoint Epistemology: What is 'Strong Objectivity'?" and Longino, H "Subjects, Power, and Knowledge: Description and Prescription in Feminist Philosophies of Science" in Fox Keller, E and Longino, H (eds) *Feminism and Science* (New York: Oxford University Press, 1996).

<sup>268</sup> Law Commission Evidence law : expert evidence and opinion evidence a discussion paper (1991), 3. Mitchell, C "Judging and policing science: the law's need for science consumer protection" (1988) 8 Windsor YB Access Just 3, 8-9. Goldberg, S "The central dogmas of law and science" (1986) 36 J Legal Educ, 371, 379. Smith, R and Wynne, B (eds) *Expert evidence : interpreting science in the law* (London ; New York : Routledge, 1988) 6.

it is clearly a waste of their money and his time, to call him to testify. Only it would be nice occasionally ... to know how the case turned out in the end. Solicitors sometimes let you know and of course it is their job to deal with experts, but I have never in twenty years, had the briefest note of thanks from counsel in the case.<sup>269</sup>

These comments suggest that the writer can feel like a neglected member of the team whose contribution is complete on the delivery of his evidence. Such feelings are understandable but do not lie comfortably with the image of the paid, 'objective' expert who gives testimony impartially and without favour to the employing party.

There has been criticism of the role of the expert witness as being little more than a 'hired gun' with some experts spending as much if not more time giving expert testimony than actively participating in research, development or other activities within their specialist field.<sup>270</sup> Such criticism is supported by the sums that expert witnesses may receive, which may be well over the rate of remuneration for their "regular" occupation.<sup>271</sup> The growth in science as an occupation and growing reliance on science and expert evidence to support claims in litigation, means that there are more individuals available and required to give expert testimony.<sup>272</sup> The development of an "expert industry" is often encouraged by statutory requirements for specialist testing and assessment. Such statutory requirements are particularly noticeable in environmental statutes which require "environmental impact assessments" to be completed and to accompany applications for many environmentally sensitive activities. The Resource Management Act 1991 (RMA) requires that applications for resource consent should contain an assessment of effects on the environment.<sup>273</sup> It is probable that for most

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<sup>269</sup> Brennan, J "The Latest Growth Industry?" [1996] NLJ Exp Witness Supp. 1730, 1732.

<sup>270</sup> Foster, K, Bernstein, D and Huber, P (eds) *Phantom Risk: Scientific Interference and the Law* (Massachusetts: MIT Press, 1993) 436.

<sup>271</sup> Foster, K, Bernstein, D and Huber, P (1993) note that in 1993 the going rate for expert witnesses in the north eastern states was US \$200.00-\$400.00 per hour.

<sup>272</sup> Freckelton, I *The Trial of the Expert: A study of expert evidence and forensic experts* (Melbourne: Oxford University Press, 1987) 3.

<sup>273</sup> Resource Management Act 1991, s 88 and the Fourth Schedule.

applications such an assessment will be completed by a planner or environmental consultant who has expertise in that field, and that person would be called to give evidence in the event of a hearing to decide the application, and almost certainly in the event of an appeal to the Environment Court. In addition, the growth of institutions and providers of qualifications for expert witnesses, indicates the importance of successful expert testimony in the litigation arena. In England there is now an *Academy of Experts*, an *Expert Witnesses Institute* and courses on expert testimony and procedure offered by *Bond Solon*. In addition there is a *Directory of Expert Witnesses* which contains a classified list of experts available for solicitors seeking to engage an expert.<sup>274</sup> In the United States there are also many courses and institutions available for potential witnesses where they may learn how to present their evidence in terms familiar to jurors, how to speak and answer questions, to formulate appropriate analogies and models for presenting technical material and appropriate grooming.<sup>275</sup> There is little doubt that these courses, qualifications and directories would not be available if expert testimony was not a commercially valuable resource.

Within New Zealand, specialist courses for expert witnesses are regularly offered by the New Zealand Law Society and some seminars for environmental experts are offered jointly by the Resource Management Law Association in conjunction with judges from the Environment Court. Although these courses commonly have a charge to cover expenses, they are not primarily designed for commercial gain and instead focus on emphasising the rules relating to expert testimony and publicising the Court's expectations of expert witnesses. Such courses were held throughout New Zealand in the first quarter of 2005, following the release of the Court's latest Practice Note. The Practice Note included further requirements of expert witnesses to reduce duplication of evidence and to emphasise the independent, unbiased role of the expert witness.

The criticism about the perceived independence and reliability of factual evidence is in no way new and the Law Commission's discussion paper quotes Thayer as follows;

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<sup>274</sup> Brennan, J "The Latest Growth Industry?" [1996] NLJ Exp Witness Supp. 1730.

<sup>275</sup> Huber, P *Galileo's revenge: junk science in the courtroom* (1991), 19.

In a sense all testimony to a matter of fact is opinion evidence; ie it is a conclusion formed from phenomena and mental impressions. Yet that is not the way we talk in courts or in common life. Where shall the line be drawn? When does a matter of fact first become a matter of opinion?<sup>276</sup>

The distinction between fact and opinion was also commented on by Wigmore; [N]o such distinction is scientifically possible. We may in ordinary conversation roughly group distinct domains for “opinion” on the one hand and “fact” and “knowledge” on the other; but as soon as we come to analyse and define these terms for the purpose of that accuracy necessary in legal rulings, we find that the distinction vanishes, that a flux ensues, and that nearly everything which we choose to call “fact” either is or may be only “opinion” or inference.<sup>277</sup>

Despite a wealth of literature from both the scientific and legal communities that considers the “myth of objectivity” there is a continuing perception that “good” expert opinion evidence should be and can be objective, and that this is a desirable and necessary component of expert testimony. In a seminar hosted by the New Zealand Planning Institute, each of the presenters stressed the importance of objectivity when giving expert testimony:

- The expert witness’s function is to explain logically and objectively the reasoning for the opinion advanced, in order to assist the court;<sup>278</sup>
- Credibility comes from objectivity and obvious confidence in the comprehensive and careful preparation of the evidence that you present. It follows that the main factors in establishing credibility

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<sup>276</sup> Law Commission Evidence law : expert evidence and opinion evidence. A discussion paper (1991), 3 at n12 quotes Thayer, A preliminary treatise on evidence at the common law (1898), 524.

<sup>277</sup> Wigmore, J Evidence in Trials at Common Law vol 7 (ed) Chadbourn, J (1978) § 1919, 16.

<sup>278</sup> Bollard, R (Judge) “The Role and Performance of Expert Witnesses from the Perspective of the Planning Tribunal” a paper for a seminar of the Auckland Branch of the New Zealand Planning Institute (1997). Presented and supported by Sheppard J.

are to ensure objectivity from the start of the process and to be as thorough as possible in your preparation;<sup>279</sup>

- The weight to be given to your opinion depends upon: ... Your credibility and objectivity as a witness, as shown by the nature of your evidence, your demeanour in the witness box and replies under cross-examination.<sup>280</sup>

These comments serve to reinforce for prospective expert witnesses, that not only can testimony be given objectively it should be given objectively. This is a commendable aim so far as it implores witnesses to give their testimony based on their own experience, understanding and interpretation of the data in question, but to suggest that such evidence can be truly objective is to ignore the influence of individual values on the selections that each individual makes when deciding amongst the various interpretations available. The fact that two equally qualified and respected experts can usually be found to give testimony equally supportive of the opposing parties' cases is evidence that there is scope, even amongst "factual" scientific evidence, for experts to make alternative interpretations of the data, by selecting different criteria and issues for significance. In his discussion of expert evidence, Mahon J quotes from the prominent English jurist, Sir George Jessel, to illustrate this point;

A man may go, and does sometimes, to half a dozen experts. I have known it in cases of valuation within my own experience at the Bar. He takes their honest opinions, he finds three in his favour and three against him; he says to the three in his favour Will you be kind enough to give evidence? and he pays the three against him their fees and leaves them alone; the other side does the same. It may not be three out of six, it may be three out of fifty. I was told in one case where a person wanted a certain thing done that they went to sixty-eight people before they found one. *Thorn v Worthing Skating Rink Co* (1876) LR 6 Ch D 415n.<sup>281</sup>

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<sup>279</sup> Bhana, H "A planner's perspective on appearing before the Environment Court" a paper presented to a seminar of the Auckland Branch of the New Zealand Planning Institute (1997).

<sup>280</sup> Loutit, W "How to be an effective expert witness" a paper presented to a seminar of the Auckland Branch of the New Zealand Planning Institute (1997).

<sup>281</sup> In Mahon, P "Expert Evidence" [1979] NZLJ 123.

### 3.2.4 *Novel scientific evidence*

The two rules of evidence that cause considerable difficulties for parties proffering scientific or technical evidence are those which deal with the expertise of the individual and of the field of research. In particular, difficulties abound when evidence is proffered which involves a new field of scientific endeavour or which involves novel interpretation or methodology applied to established scientific findings. The courts have long recognised that in deciding the admissibility of scientific evidence it is necessary to decide, using some reasonable criteria, that the evidence is both scientific and expert. Different jurisdictions have adopted different approaches to this decision but these approaches have tended to incorporate the theme set by Mansfield LJ in *Folkes v Chadd* as follows;

[I]n matters of science, the reasonings of men of science can only be answered by men of science ... In matters of science no other witnesses can be called.<sup>282</sup>

In *Frye v United States*,<sup>283</sup> the most famous decision to set a test for the admissibility of novel scientific evidence, the United States Federal Court of Appeal determined that the results of an embryonic form of polygraph should not be admissible because the physiological and psychological authorities had yet to accept the technique.<sup>284</sup> The court was anxious about the ability of juries to adequately evaluate scientific evidence and about the validity of the scientific methods at issue. The test in *Frye* established a requirement of general acceptance as follows;

Just when a principle crosses the line between the experimental and the demonstrable stages is difficult to define. Somewhere in this twilight zone, the evidential force of the principle must be recognized, and while the courts will go a long way in admitting expert testimony deduced from a well-recognised scientific principle or discovery, the thing from which

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<sup>282</sup> (1782) 3 Douglas 157.

<sup>283</sup> 293 F 1013.

<sup>284</sup> Freckelton, I and Selby, H *Expert Evidence* (1993), 1-2223.

the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.<sup>285</sup>

The general acceptance, or *Frye*, test became the precedent for the admissibility of *novel* scientific evidence in the majority of federal courts in the United States prior to the introduction in 1975 of the *Federal Rules of Evidence*, however the use of the test was always controversial. The criticisms of the general acceptance test include:

- claims that the requirement that a body of literature and general acceptance of the methods for a new technique, or interpretation results in relevant evidence being excluded from consideration in litigation;
- concern that the standard of general acceptance is “vague, undefinable and not enlightening”<sup>286</sup> in that it leaves the problem of distinguishing scientific evidence from other types of expert evidence and the problem of defining what is the particular field to which the principle belongs and whether that field is an accepted field of scientific research. For example, the forensic study of blood flight characteristics is a specialist field of research, however its findings are primarily drawn from an understanding of mathematics and physics. Another example is the analysis of voice print characteristics which is a specialist field of expertise that does not readily fit into any of the established categories of science;<sup>287</sup>
- concern that the standard of general acceptance does nothing to help determine what constitutes general acceptance;<sup>288</sup>
- doubt about whether the general acceptance test should apply to the underlying theory or to the technique which applies the theory, or both.<sup>289</sup>

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<sup>285</sup> *Frye v United States* (1923) 293 F 1013, 1014.

<sup>286</sup> Giannelli, P “*Frye v United States*” in Thomas, W (ed) “Symposium on Science and the Rules of Evidence” 99 FRD 188, 192.

<sup>287</sup> Giannelli, P 192 - 193.

<sup>288</sup> Strong, D “Questions Affecting the Admissibility of Scientific Evidence” [1970] Univ, Ill, L.Forum, 1,11.

In a particularly cynical discussion of the role of science and expert scientific evidence in tort litigation in the United States, Huber, while supporting the general aims of the *Frye* test, alleges that the test was easily bent by charlatans who established their own national societies, attended national conventions and formed their own relevant scientific community.<sup>290</sup> During the 1970s there was a growth in pessimism towards new technologies and their impact on traditional society and people looked to science to explain and assign blame for the miseries of society which remained as yet unexplained but increasingly more reported thanks to improvements in communications technology.<sup>291</sup> Communities perceived that there were new and rampant epidemics of cancer, child birth defects and crop and cattle losses and they looked to the legal community to determine and assign blame and thus compensation. The legal community, in turn, looked to science for these explanations, so that the scientific community became at once the culprit and the means of assigning liability. Courts had to determine a path between the claims of the traditional scientific community (the alleged culprits behind a multitude of chemical and engineering developments) and those seeking to give testimony from the fringe of recognised scientific endeavour. It was not long before many courts seemed to equate the meaning of “new” and “innovative” scientific research findings and techniques with “improved” and when combined with an understandable desire to support the weak and afflicted there was widespread admission and acceptance of fringe scientific testimony which shifted liability onto those best able to compensate.<sup>292</sup> This “let it all in” trend saw successful claims for:

- lung cancer triggered by impact with a car’s steering wheel; and
- breast cancer triggered from;
  - a fall from a streetcar,
  - a slip in a store,
  - an exploding hot water cylinder,

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<sup>289</sup> Giannelli, P “*Frye v United States*” in Thomas, W (ed) “Symposium on Science and the Rules of Evidence” 99 FRD 188, 193.

<sup>290</sup> Huber, P *Galileo’s revenge: junk science in the courtroom* (1991), 14.

<sup>291</sup> Huber (1991) 15.

<sup>292</sup> Huber (1991) 216.

- a blow from an umbrella handle, and
- a bump from a can of juice

to note but a few of the more controversial.<sup>293</sup>

In a reaction against the weak evidential basis for many of these claims and in response to the serious inconsistencies between cases brought on very similar issues, the *United States Federal Rules of Evidence* were codified in 1975 to refocus the consideration of scientific evidence to issues of relevance and reliability. Rule 702 provides:

If scientific, technical, or other specialized knowledge *will assist the trier of fact to understand the evidence or determine a fact in issue*, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.  
[Emphasis added]

This rule places emphasis on the helpfulness of the evidence in assisting the fact finder and moves away from a requirement of general acceptance of the evidence from within the recognised scientific community. The helpfulness rule has been described as a practical approach that allows the courts more discretion in deciding the admissibility of scientific evidence.<sup>294</sup>

### 3.2.5 *The decision in Daubert*

Adoption of the Federal Rules of Evidence was not the immediate end to the influence of the *Frye* test. Because the Federal Rules were not intended as a comprehensive codification of the rules of evidence and because they were silent as to their legal effect on *Frye*, the general acceptance test continued to be applied in many federal courts and applied inconsistently within the state courts.<sup>295</sup> It was not until the United States Supreme Court decision in *Daubert v Merrell Dow Pharmaceuticals Inc*<sup>296</sup> that the test in *Frye* was determined as being formally

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<sup>293</sup> Huber (1991) 1.

<sup>294</sup> Law Commission Evidence law: expert evidence and opinion evidence. A discussion paper (1991), 23.

<sup>295</sup> Giannelli, P “*Frye v United States*” in Thomas, W (ed) “Symposium on Science and the Rules of Evidence” 99 FRD 188, 197.

<sup>296</sup> (1993) 125 L Ed 2d 469. (1993) 113 S Ct 2786.

superseded by the Federal Rules. In *Daubert* the two plaintiffs alleged that the serious birth defects suffered by their children were the result anti-nausea medication, Bendectin, which was taken during pregnancy and which was manufactured by the defendant. The plaintiffs wished to introduce expert evidence which challenged the accepted analyses of epidemiological studies of Bendectin and evidence from animal studies which linked Bendectin with malformations. This evidence was ruled inadmissible in the lower courts because of the effect of the general acceptance test in *Frye*.<sup>297</sup> The Supreme Court vacated the decision which excluded the plaintiffs' scientific evidence and remanded the case for rehearing on the basis of the criteria in Rule 702.<sup>298</sup> The Supreme Court considered that the admissibility test in the Federal Rules is more liberal than the previous general acceptance test in *Frye* which was described as:

... at odds with the liberal thrust of the Federal Rules and their general approach of relaxing the traditional barriers to opinion testimony.<sup>299</sup>

The Court emphasised that for scientific knowledge to be admissible in evidence it need not provide certainty as to the science in question, rather, it must achieve a standard of reliability that is linked to its methods and which will assist the court to understand or determine the fact in issue.<sup>300</sup> This approach differs markedly from that of some courts which required that scientific findings should be proven "beyond reasonable doubt."<sup>301</sup> The decision in *Daubert* identified four factors that should assist courts in assessing admissibility of scientific evidence.<sup>302</sup> These factors were:

- (1) The degree of testing to which the theory or technique has undergone;

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<sup>297</sup> Robertson, B and Vignaux, G *Interpreting evidence : evaluating forensic science in the courtroom*. (Chichester, England : John Wiley & Sons, 1995), 204.

<sup>298</sup> Cranor, C, Fischer, J and Eastmond, D "Judicial Boundary Drawing and the Need for Context-Sensitive Science in Toxic Torts After *Daubert v Merrell Dow Pharmaceuticals Inc*" (1996) 16 Va Env'tl L J 1, 7.

<sup>299</sup> *Daubert v Merrell Dow Pharmaceuticals Inc*. (1993) 125 L Ed 2d 469, 480.

<sup>300</sup> *Daubert*, 481.

<sup>301</sup> Magnusson, E and Selinger, B "Jury Comprehension of Complex Scientific Evidence: The Inference Chart Concept" (1990) 14 Crim LJ 389.

<sup>302</sup> *Daubert v Merrell Dow Pharmaceuticals Inc*. (1993) 125 L Ed 2d 469, 483.

- (2) The extent of peer review and the publication of the theory or technique;
- (3) The known or potential margin of error for a particular technique together with its methodological reliability;
- (4) The level of general acceptance within the relevant scientific community.

The overall effect of the decision in *Daubert* was to focus issues about admissibility of scientific evidence on basic principles of relevance and probative value and the decision offers assistance on the determination of probative value. It is noteworthy that this decision not only superseded the rule in *Frye* but also extended the approach to encompass all aspects of scientific evidence.

The gate-keeping role assigned to the Court in *Daubert* was welcomed by some commentators as a mechanism to address increasing tension between jurists and the science community, however, others cautioned that judges without formal science training would have difficulty in applying the *Daubert* tests when determining the merits of expert scientific testimony.<sup>303</sup> Questions regarding the extent that judges could weigh competing scientific theories and the scope for judicial research into complex scientific matters were again considered in the Supreme Court decision in *General Electric Co v Joiner*.<sup>304</sup> In *Joiner* the plaintiffs, Robert Joiner and his wife, alleged that General Electric was negligent in failing to protect Joiner from carcinogens such as polychlorinated biphenyls (PCBs), furans and dioxins. The Plaintiffs wanted to lead testimony from 2 experts who considered that these poisons caused his lung cancer. The lower Courts had differed in their interpretation of the extent to which the rule in *Daubert* allowed the Court to consider conclusions drawn by the expert witnesses. The Supreme Court held that it is within the Court's gatekeeping role to decide whether there is sufficient connection between the data presented and the conclusions drawn from that data.<sup>305</sup> That gate-keeping role was further expanded

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<sup>303</sup> Siegel, A "Setting Limits on Judicial, Scientific, Technical, and Other Specialized Fact-Finding in the New Millenium" (2000) 86 Cornell Law Review 167, 179.

<sup>304</sup> *General Electric Co v Joiner* 522 US 136 (1997).

<sup>305</sup> *General Electric Co* 147 –150.

by the Supreme Court in *Kumho Tire Co v Carmichael*.<sup>306</sup> In that decision the Court extended the *Daubert* criteria to include all expert testimony where it had previously only applied to scientific evidence. The Supreme Court agreed with the District Court's decision to exclude technical evidence of the plaintiff's tyre expert on the basis that his methodology failed the *Daubert* reliability requirement.

### 3.3 The New Zealand position

In New Zealand there is no equivalent to the Federal Rules of Evidence and the traditional approach of the courts to the admissibility of novel scientific evidence has been to apply criteria that reflect the comments of Lord Mansfield in *Folkes v Chadd* and the general thrust of the rule in *Frye* requiring that the subject matter of expert scientific testimony be generally accepted within the scientific community. This can be best illustrated by the comments of McMullin J in *R v B (an accused)*,<sup>307</sup> a case that considered the admissibility of expert evidence from a child psychologist, as follows:

As a precondition of admissibility the subject-matter to which the expert opinion relates must be a sufficiently recognised branch of science at the time the evidence is given. For this reason the fields on which expert evidence will be allowed may be expected to be enlarged as research establishes the accuracy of knowledge in that field.

The Law Commission suggests that the approach in *R v B* is open to the same criticisms as the test in *Frye* in that evidence may be excluded by a criterion that attaches to the subject matter generally rather than to its helpfulness and reliability.<sup>308</sup> The test in *R v B* was rejected by Tipping J in *R v Calder*<sup>309</sup> as being unhelpful due to the different subject matter of the evidence. An approach was adopted in *R v Calder* that provided that:<sup>310</sup>

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<sup>306</sup> 526 US 137 (1999).

<sup>307</sup> [1987] 1 NZLR 362, 367.

<sup>308</sup> Law Commission Evidence law : expert evidence and opinion evidence. A discussion paper (1991), 22.

<sup>309</sup> Unreported, High Court, Christchurch, 12 April 1995, (T 154/94). Tipping J.

<sup>310</sup> *R v Calder* unreported, High Court, Christchurch, 12 April 1995, (T 154/94). Tipping J, 7.

Before expert evidence, such as that in issue in this case, can be put before the jury by a suitably qualified person it must be shown to be both relevant and helpful. To be relevant the evidence must logically tend to show that a fact in issue is more or less likely. To be helpful the evidence must pass a threshold test which can conveniently be called the minimum threshold of reliability. This means the proponent of the evidence must show that it has a sufficient claim to reliability to be admitted.

The decision in *Calder* is consistent with the approach in *Daubert* in requiring the testimony to be both helpful and relevant. General acceptance of the subject matter of the evidence may be a factor in assessing its reliability, and thus helpfulness, but general acceptance need not be in itself be determinative of admissibility as under the test in *Frye*.

### 3.3.1 *Scientific evidence in the Environment Court*

The preceding discussion on the admissibility of scientific evidence provides the background to the approach of the Environment Court in New Zealand. Under s 276(2) the Environment Court is not bound by the rules of evidence however the Court does use the criteria for admissibility of scientific evidence as a type of evidentiary sieve. The Court applies the common law “expertise rule” to determine whether a particular witness does qualify as an expert and the decision of Judge Treadwell in *Marlborough District Council v New Zealand Rail (“Fast Ferries”)* illustrates this well where he comments on the qualifications of the expert witnesses as follows:

I have considered all evidence but have restricted my comments to those witnesses with greater expertise and experience in any particular discipline. .... The NIWA study was commissioned by the district council and presented to the Tribunal by .... Neither the presenter of that report nor those concerned with its compilation had the academic qualifications of the other witnesses referred to at the commencement of this part of this decision.<sup>311</sup>

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<sup>311</sup> [1995] NZRMA 357, 374-376.

In his commentary on the topic of expert witnesses Principal Environment Judge Sheppard adds the “area of expertise rule” as a requirement for defining an expert when he writes:

An expert is one who has made a study of and gained experience in a particular field of learning and knowledge. It must be a field recognised as one about which knowledge can only be acquired by special training and experience.<sup>312</sup>

Prior to the decision in *Daubert* the Environment Court seems to have generally followed the model in *Frye* and which was consistent with the approach in *Folkes v Chadd*. In *Trans Power New Zealand v Rodney District Council*<sup>313</sup> Judge Sheppard comments that:

We acknowledge our own personal limitations in making findings on technical scientific questions. The appropriate course for us is to be guided by the scientific community and by conclusions reached by application of scientific method ... As a judicial body it would not be appropriate for us to weigh suspicion, even when expressed by one who is qualified as an expert witness, against the opinions of even better qualified experts which are consistent with the consensus of the international scientific community.<sup>314</sup>

The Environment Court addressed the issue of novel scientific evidence in its decision in *McIntyre v Christchurch City Council and Bell South*,<sup>315</sup> a decision delivered after *Daubert v Merrell Dow*. The action in *McIntyre* was brought by a resident in the vicinity of a proposed site for a telecommunications facility (a ‘cell site’) to be erected by Bell South (New Zealand) (‘Bell South’) in suburban Christchurch. Christchurch City Council had granted the application for land use consent subject to conditions including the review of power flux density limits. The appellant, Ms McIntyre appealed the decision on the grounds that exposure to

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<sup>312</sup> Sheppard, D “The Expert Witness” in Data Services Limited *Resource Management Handbook* (Takapuna: Data Services Limited, 1996).

<sup>313</sup> Unreported, Planning Tribunal, 14 November 1994 (A 85/94) Sheppard J.

<sup>314</sup> *Trans Power New Zealand v Rodney District Council* at 21 - 22.

<sup>315</sup> [1996] NZRMA 289.

the levels of radiation which would be emitted by the transmitter would be potentially dangerous for human health and that:

...it would be an error of law to decide on the present state of scientific knowledge, on the balance of probabilities, whether there are harmful health effects from low-level radio frequency exposure from these facilities.<sup>316</sup>

It was submitted by counsel for the appellant that there is some scientific evidence that suggests a link between low levels of electromagnetic radiation, such as those to be emitted from the proposed cell site, with disease in humans, including various forms of cancer. Although the scientific evidence was controversial and not generally accepted within the scientific community, the hypothesis that such a link exists is the subject of continuing study. Under such conditions of uncertainty, it was the appellant's case that the Tribunal should take a precautionary approach and refuse the consent until the relationship between electromagnetic radiation of this intensity and human health is better understood.

In reaching a conclusion on the appropriate basis for decision making involving uncertainty in scientific evidence, the Tribunal in *McIntyre* adopted the approach taken in *Daubert*. The Tribunal did not accept that the existence of a serious scientific hypothesis is sufficient in itself to establish a potential effect even in the terms of s 3(f). The Tribunal held that:

... like any other evidence tending to establish a contested fact, the grounds for the hypothesis have to be exposed to testing (as discussed in *Daubert's* case (Supreme Court)) to assist the Tribunal to weigh the evidence and make a finding one way or the other.<sup>317</sup>

The issue of uncertainty and risk was again addressed at length in the Environment Court decision in *Shirley Primary School v Christchurch City Council*.<sup>318</sup> This case also concerned an application to establish a cell site, this time adjacent to a primary school. In *Shirley Primary School* the Court

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<sup>316</sup> *McIntyre v Christchurch City Council* [1996] NZRMA 289.

<sup>317</sup> *McIntyre* 307.

<sup>318</sup> [1999] NZRMA 66.

considered the following matters: the assessment of risk in the context of the RMA; burden and standard of proof issues; and admissibility and reliability of evidence.

### 3.3.2 *Assessment of Risk*

The Court noted that the RMA is a statute that deals with the management of risk. It is not a “no risk” statute, and the Court is not required to ensure that the cell site could operate with absolute safety.<sup>319</sup> The definition of effect in s 3 includes reference to future effects,<sup>320</sup> potential effects of high probability,<sup>321</sup> and potential effects of low probability but with high potential effect.<sup>322</sup> In addition, s 5(2)(c) refers to avoiding, remedying, or mitigating adverse effects on activities on the environment. That statutory language anticipates that the world involves risk and that the role of decision makers under the RMA is to ensure that those risks are acceptably managed because decisions almost always relate to future events.

The Court noted that the usual requirement to prove an assertion on the balance of probabilities is not a helpful concept when applied to the evaluation of future risk.<sup>323</sup> That is because there is no certainty about the future and also because the degree of risk may involve extremely small probabilities in which preference for one extremely unlikely outcome over another almost as unlikely outcome may be of no practical difference.<sup>324</sup>

In following the approach of the Court of Appeal in *Commissioner of Police v Ombudsman*<sup>325</sup> the Environment Court held that “whether a risk exists is a matter of judgment”.<sup>326</sup>

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<sup>319</sup> [1999] NZRMA 66, 97, paragraph 106. On the subject of risk generally, see Somerville, R “A Public Law Response To Environmental Risk” (2002) 10 Otago LR 143.

<sup>320</sup> Section 3(c)

<sup>321</sup> Section 3(e)

<sup>322</sup> Section 3(f)

<sup>323</sup> [1999] NZRMA 66, 105 paragraph 135.

<sup>324</sup> *Shirley Primary School v Christchurch City Council* [1999] NZRMA 66, 104, paragraphs 129 – 131.

<sup>325</sup> [1988] 1 NZLR 385.

<sup>326</sup> [1999] NZRMA 66, 101, paragraph 120.

### 3.3.3 *Burden and Standard of Proof*

The Court in *Shirley* also considered the onus of proving assertions, whether supported by expert evidence or not, and the appropriate legal test such assertions must meet in order to be accepted.

There is always a persuasive burden on the applicant for a resource consent to show that the purpose of the Act will be achieved. The Court has held that the ultimate issue when deciding an application for a resource consent, is whether or not the application will meet the single purpose of sustainable management.<sup>327</sup> Even if there is no opposing evidence the Court is still entitled to decline an application if there is insufficient evidence to show that the legislative purpose is achieved.<sup>328</sup>

The RMA also imposes an evidentiary burden on applicants wishing to pursue a non-complying activity. Section 104C<sup>329</sup> prohibits the grant of consent to a non-complying activity unless the decision maker is satisfied that one of 2 tests can be met. That requirement for satisfaction imposes an evidentiary burden on the applicant. Likewise there is an evidentiary burden on any party wishing to persuade the Court to a particular view. In other words the Court must have some evidence to evaluate when deciding a matter.

The Court in *Shirley Primary School* disagreed with the approach taken in *McIntyre* regarding the application of standard of proof requirements when assessing evidence about risk. In *McIntyre*, the Tribunal followed the decision in *Trans Power New Zealand v Rodney District Council*<sup>330</sup> finding that:

We are confined to evidence probative of the fact, that meets a basic threshold of reliability, and is persuasive to us on the balance of probabilities having regard to the gravity of the question.<sup>331</sup>

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<sup>327</sup> *Caltex NZ Ltd v Auckland City Council* (1997) 3 ELRNZ 297, 304.

<sup>328</sup> *Baker Boys Ltd v Christchurch City Council* [1998] NZRMA 433, 442.

<sup>329</sup> Previously s 105 (2)(b) and s 105 (2B) in earlier versions of the RMA.

<sup>330</sup> Unreported, Planning Tribunal, 14 November 1994 (A 85/94). Noted in (1994) 4 NZPTD 35.

<sup>331</sup> *McIntyre v Christchurch City Council* [1996] NZRMA 289, 314.

The Court in *Shirley Primary School* held that while the standard of proof requiring matters to be proven on the balance of probabilities is a requirement when determining factual evidence, such an invariable test is inappropriate when assessing the uncertainty associated with very small risks. The Court summarised the position regarding onus and burden of proof under the RMA as follows:

- (1) In all applications for a resource consent there is necessarily a legal persuasive burden of proof on the applicant. The weight of the burden depends on what aspects of Part II of the Act apply.
- (2) There is a swinging evidential burden on each issue that needs to be determined by the Court as a matter of evaluation.
- (3) There is no one standard of proof, if that phrase is of any use under the Act. The Court must simply evaluate all the matters to be taken into account under s 104 on the evidence before it in a rational way, based on the evidence and its experience; and giving its reasons for exercising its judgment the way it does.
- (4) The ultimate issue under s 105(1) is a question of evaluation to which the concept of a standard of proof does not apply.<sup>332</sup>

This approach to the application of burden and standard of proof matters has been subsequently followed in other decisions<sup>333</sup> and the decision in *McIntyre* was later distinguished as relating to factual matters about the communications structure. In *Clifford Bay Marine Farms v Marlborough District Council*<sup>334</sup> the Court referred to a decision of the High Court, on appeal in *Ngati Maru Iwi Authority v Auckland City Council*.<sup>335</sup> Referring to the decision in *Shirley Primary School*, Doogue J confirmed:

...the appropriate standard of proof upon someone asserting a fact, [is] the balance of probabilities. I do not read *Shirley Primary School* as in

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<sup>332</sup> *Shirley Primary School v Christchurch City Council* [1999] NZRMA 66, 106, paragraph 136.

<sup>333</sup> For example *Rangitata South Irrigation Ltd v New Zealand and Central South Island Fish and Game Council* C109/2004, 5 August 2004, and *Clifford Bay Marine Farms Ltd v Marlborough District Council* C131/2003, 22 September 2003.

<sup>334</sup> *Clifford Bay Marine Farms Ltd v Marlborough District Council* C131/2003, 22 September 2003.

<sup>335</sup> *Ngati Maru Iwi Authority v Auckland City Council* (High Court, Auckland) A18/02 Doogue J.

conflict with what is common to so many decisions of the Environment Court.<sup>336</sup>

Commenting that the High Court in *Ngati Maru* was not referring to the standard of proof relevant to possible future events and their effects, the decision in *Clifford Bay* then notes that the line of authorities that followed the *McIntyre* approach to standard of proof<sup>337</sup> can be distinguished because *McIntyre* refers to factual propositions about the fixture itself and because it has the qualification that the “gravity of the question” must be considered. Before concluding “it is not logical automatically to apply the balance of probabilities to the judgements necessary under the RMA”<sup>338</sup> the Court addressed the *McIntyre* approach as follows:

- (1) Can all propositions about a possible future event be described as a ‘fact’? (Some can: a very high statistical probability may be described as a “fact”. But a particular event perhaps not: it may be the exception.)
- (2) Is it suggested that a statement about the risk of a catastrophic event (say the failure of a dam) should always be decided on a 50-50 basis?
- (3) The answer to (2) is obviously ‘No’ because of the gravity of the question. So when is an issue sufficiently grave to demand a different standard of proof? And to what standard?<sup>339</sup>

This approach in *Clifford Bay* is therefore where the law rests on the issue of standard and burden of proof in respect of potential future events.

#### 3.3.4 *Admissibility and Reliability of Evidence*

In *Shirley Primary School* the Court held that there is no rigorous reliability threshold under the RMA.<sup>340</sup> Referring to the US Supreme Court decisions in *Daubert* and *Joiner*, the Court noted that the admissibility debate is of limited

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<sup>336</sup> Quoted in *Clifford Bay Marine Farms Ltd v Marlborough District Council*, 23, paragraph 58.

<sup>337</sup> For example *Contact Energy Ltd v Waikato Regional Council* [2000] NZRMA 12 and *Kiwi Property Management Ltd v Hamilton City Council* A045/2003, 29 March 2003.

<sup>338</sup> *Clifford Bay Marine Farms Ltd v Marlborough District Council*, 28 – 29, paragraph 66.

<sup>339</sup> *Clifford Bay Marine Farms Ltd*, 24, paragraph 59.

<sup>340</sup> *Shirley Primary School v Christchurch City Council* [1999] NZRMA 66, 107, paragraph 141.

relevance to the Environment Court because the thresholds for hearing expert evidence are very low. Experts must qualify themselves as such, provide relevant evidence and present evidence in a way that is not too lengthy or “witless” as to be vexatious.

Section 276 RMA provides:

- (1) The Environment Court may—
  - (a) Receive anything in evidence that it considers appropriate to receive; and
  - (b) Call for anything to be provided in evidence which it considers will assist it to make a decision or recommendation; and
  - (c) Call before it a person to give evidence who, in its opinion, will assist it in making a decision or recommendation.
- (2) The Environment Court is not bound by the rules of law about evidence that apply to judicial proceedings.
- (3) The Environment Court may receive evidence written or spoken in Maori and the Maori Language Act 1987 shall apply accordingly.

While the Court has discretion in s 276(1)(a) to allow, or refuse to hear any evidence it considers appropriate, the Court in *Shirley Primary School* noted that the discretion to refuse expert evidence is exercised with extreme caution. Relevant evidence, whether or not it is unreliable, is usually heard provided it relates to more than a “low impact” effect.<sup>341</sup> Under the RMA, the issue around reliability relates to the weight to be given to the evidence, rather than to its admissibility. The Court noted that whether the assessment of reliability goes to its admissibility or to its weight, may have little practical or theoretical difference in the Environment Court. That is because there is no judge/jury separation and because the tests may be the same or very similar, especially for effects of potentially high impact. Where there is reference to a high impact risk, “a scintilla or evidence may be all that needs to be established in the Court’s mind to justify the need for rebuttal evidence.”<sup>342</sup> The Court held that the factors to be taken into account when assessing expert evidence are:

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<sup>341</sup> *Shirley Primary School* paragraph 141.

<sup>342</sup> *Shirley Primary School* [1999] NZRMA 66, 108 paragraph 142.

- (1) the strength of the qualifications and the duration and quality of the experience of each witness;
- (2) the reasons for each witness's opinions (and their consistency, coherence and presentation);
- (3) the objectivity and independence of each witness and the comprehensiveness of their evidence – for example whether they have identified and taken into account matters which do not favour their opinion;
- (4) there is an identification of and general acceptance of the science of methodology involved; and
- (5) Especially for “hard” science – the research or papers referred to by the witnesses in reaching their opinions, with respect to whether: [Loosely these are the *Daubert* criteria]
  - (a) the techniques used are reliable
  - (b) the error rates are known and published (and the research is shown to be statistically significant)
  - (c) the research or papers have been published
  - (d) the research or papers have been subjects to peer review
  - (e) the research is repeatable (and has been replicated).<sup>343</sup>

The Court noted further, that while not all of the above criteria need to be met in every instance, they are criteria for measuring weight to be given to evidence.

The Court also provided further examples of its perception of “hard” and “soft” science. Factors (1) to (3) may be the only factors relevant to measuring weight of expert opinions “which are only “science” in the softest sense eg town planning and resource management.”<sup>344</sup> Factor (4) was described as relevant for the “social science, physicians, epidemiologists and ecologists” and all of factors (1) to (5) were deemed necessary for evaluating some ecological evidence and all hard science. Clearly, the Court had a view of expert evidence having a range between soft and hard science, but the degree of overlap between the quoted examples makes the boundaries between those terms uncertain.

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<sup>343</sup> *Shirley Primary School* [1999] NZRMA 66, 108 – 109 paragraph 144.

<sup>344</sup> *Shirley Primary School* [1999] NZRMA 66, 109 paragraph 145.

### 3.3.5 *Precautionary Approach*

The RMA provides scope to take a precautionary approach to decision making in Part II, in the matters to be considered when deciding an application for resource consent (s 104) and in the definition of effects (s 3). All consideration of applications for resource consent is subject to the provisions of Part II of the Act that contains the purpose and principles. Section 5 provides that the purpose of the Act is to promote sustainable management of natural and physical resources and sustainable management means managing resources while;

Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;<sup>345</sup>

A need for a reasonably healthy environment would be a consideration if a proposal was likely to result in a health risk. When deciding an application for a resource consent the decision maker must also consider; “[a]ny actual and potential effects on the environment of allowing the activity.”<sup>346</sup>

Effects are further defined in s 3 to include “[a]ny potential effect of low probability which has a high potential impact.”<sup>347</sup>

Concerning the weight to be given to the precautionary principle, the Tribunal in *McIntyre* followed the reasoning in the English case, *R v Secretary of State for Trade and Industry, ex parte Duddridge*<sup>348</sup> and in *Greenpeace Australia v Redbank Power Company*.<sup>349</sup>

*Duddridge* was an appeal to the English High Court for review of a decision by the Secretary of State, who had refused to issue regulations that would require an electricity distributor to restrict the level of electromagnetic fields from proposed

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<sup>345</sup> Section 5(2)(a).

<sup>346</sup> Section 104(1)(a).

<sup>347</sup> Section 3(f).

<sup>348</sup> *R v Secretary of State for Trade and Industry, ex parte Duddridge* The Independent, 4 Oct 1994.

<sup>349</sup> *Greenpeace Australia v Redbank Power Company* (1994) 86 LGERA 143.

underground electricity cables. It was claimed that the proposed levels of radiation would expose children to the risk of developing leukaemia. Expert witnesses did not claim any causal link had been established between exposure to electromagnetic fields and the development of cancer, but there was some evidence to suggest a possibility of such a link with childhood cancer, and a need for studies based on objective measurements of exposure. The Court found that the Secretary of State was under no obligation to take account of the precautionary principle and the application failed.

In *Greenpeace Australia v Redbank Power Co*<sup>350</sup> the Land and Environment Court of New South Wales considered an appeal against consent for a new power station where the appellants alleged that the emission of carbon dioxide would contribute to the greenhouse effect. Pearlman J noted that where scientific uncertainty existed, the precautionary principle dictated a cautious approach to the evaluation of relevant matters, however this fell short of a requirement that the issue of scientific uncertainty (the greenhouse effect) should outweigh all other issues.<sup>351</sup>

In *McIntyre* Tribunal noted that a consent authority has discretion whether to allow consideration of the precautionary principle to influence their discretion to grant or refuse consent, "consistent with the statutory purpose of promoting the sustainable management of natural and physical resources".<sup>352</sup>

In *Golden Bay Marine Farmers v Tasman District Council*<sup>353</sup> the Court considered the applicability of the precautionary principle and or precautionary approach as part of aquaculture references to the Tasman District Council's Proposed Resource Management Plan. The Court noted the decision in *Ngati Kahu Ki Whangaroa Co-operative Society Ltd v Northland Regional Council*<sup>354</sup> where the precautionary approach was held to be applicable in situations of

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<sup>350</sup> *Greenpeace Australia*, 143.

<sup>351</sup> *Greenpeace Australia*, 154.

<sup>352</sup> *Greenpeace Australia*, 154.

<sup>353</sup> Environment Court, Wellington, 27 April 2001, (W43/2001).

<sup>354</sup> *Ngati Kahu Ki Whangaroa Co-operative Society Ltd v Northland Regional Council* [2001] NZRMA 299.

scientific uncertainty where the exercise of the consent could cause serious or irreversible environmental damage. In *Ngati Kahu*, the Court held that “a precautionary approach is already implicit in the Act”<sup>355</sup> and that taking further precaution as part of discretionary judgments (for example regarding the threshold tests under s 105 and under s 104) may be acceptable where there is uncertainty about the likely effects of a proposal. The Court in *Golden Bay* accepted argument that the precautionary principle is applicable when considering certain policies and principles in the New Zealand Coastal Policy Statement (“NZCPS”). Principle 12 is a restatement of the precautionary approach and Policy 3.3.1 also refers to that approach.<sup>356</sup> However, the Court followed the decision in *Shirley Primary School* that doubted the usefulness of a wider precautionary principle under the RMA. The Court held that a precautionary approach is relevant to consideration of reference proceedings on a plan or proposed plan change through:

- a) analysis of the factual evidence relevant to assessment of effects, particularly s 3(f) regarding potential effects of low probability but high potential impact;
- b) consideration of evidential findings in light of relevant plan provisions;
- c) the plan’s classification of an activity as prohibited, discretionary or controlled etc;
- d) supporting documents such as management plans;
- e) the use of review conditions under s 128 and opportunities for enforcement orders under s 319(2) which give the Court the discretion to make orders against a person despite acting in

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<sup>355</sup> *Ngati Kahu Ki Whangaroa Co-operative Society Ltd*, paragraph 223.

<sup>356</sup> NZCPS Principle 12 reads: “The ability to manage activities in the coastal environment sustainably is hindered by the lack of understanding about coastal processes and the effects of activities. Therefore, an approach which is precautionary but responsive to increased knowledge is required for coastal management.”

NZCPS Policy 3.3.1 reads “Because there is a relative lack of understanding about coastal processes and the effects of activities on coastal processes, a precautionary approach should be adopted towards proposed activities, particularly those whose effects are as yet unknown or little understood. The provisions of the Act which authorise the classification of activities into those that are permitted, controlled, discretionary, noncomplying or prohibited allow for that approach.”

accordance with a resource consent or plan, where there has been a change in circumstances leading to unanticipated adverse effects.

The precautionary principle/approach was also addressed by the Court in *Clifford Bay*. Following the decision in *Shirley Primary School*, the Court held that there is no single approach to the assessment of risk under the RMA.

In our view the approach the Act requires is that under section 104(1)(a) and (i) of the Act *each* potential effect raised in the evidence should be assessed qualitatively, or preferably quantitatively, in the light of the principles of the RMA, and the objectives and policies of the relevant instruments as to:

- (a) probability of occurrence; and
- (b) force of impact.

Whilst the facts must be proved on the balance of probabilities, there is no single standard of proof for most of the judgements involved in those two steps, nor does the same standard have to be used for each risk. The standard varies according to the weighing of the potential impact of the effect.

We do not overlook that the NZCPS and the NZBS<sup>357</sup> include admonitions to be extra cautious in certain situations.<sup>358</sup>

Thus the Court has determined that there are numerous opportunities within the Act for decision makers to exercise caution when deciding proposals involving risk and uncertainty so that any further application of the precautionary principle would lead to double counting of the need for caution.

### 3.3.6 *Environment Court Practice Note*

In March 2005, the Court issued a Practice Note that includes directions for presenting expert evidence. The Practice Note contains a Code of Conduct with

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<sup>357</sup> New Zealand Biodiversity Strategy.

<sup>358</sup> *Clifford Bay Marine Farms Ltd v Marlborough District Council* C131/2003, 29 – 30, paragraphs 68 - 70.

which all expert witnesses must comply. The Code of Conduct emphasises the expert's overriding duty to assist the Court independently without advocating for the instructing party. The Code also contains directions to ensure that the reliability thresholds outlined in *Shirley Primary School* together with the common law rules requiring that expertise is established, are met as follows:

**Duty to the Court**

1. An expert witness has an overriding duty to assist the Court impartially on relevant matters within the expert's area of expertise.
2. An expert witness is not an advocate for the party who engages the witness.

**Evidence of expert witness**

3. In any evidence given by an expert witness, that person must, in the body of the witness's statement or affidavit (if the evidence is in writing) or orally (if the evidence is being given orally):
  - (a) acknowledge that the expert witness has read this Code of Conduct and agrees to comply with it;
  - (b) state the expert witness's qualifications as an expert;
  - (c) describe the ambit of the evidence given and state either that the evidence is within the expert's area of expertise or that the witness is relying on some other (identified) evidence;
  - (d) identify the data, information, facts, and assumptions considered in forming the witness's opinions;
  - (e) state the reasons for the opinions expressed;
  - (f) state that the expert witness has not omitted to consider material facts known to the witness that might alter or detract from the opinions expressed;
  - (g) specify any literature or other material used or relied upon in support of the opinions expressed;
  - (h) describe any examinations, tests, or other investigations on which the expert witness has relied, and identify, and give details of, the qualifications of any person who carried them out;
  - (i) if quoting from statutory instruments (including policy statements and plans), do so sparingly. (A schedule of relevant

quotations may be attached to the statement of evidence or a folder produced containing relevant excerpts).

4. If any expert witness believes that his or her evidence, or any part of it, may be incomplete or inaccurate without some qualification, that qualification must be stated in the evidence.
5. If an expert witness believes that his or her opinions are not firm or concluded because of insufficient research or data, or for any other reason, that must be stated in the evidence.
6. If after the exchange of a brief of evidence has occurred, an expert witness changes any of his or her opinions, that must be communicated without delay to the party or parties wishing to call the witness.<sup>359</sup>

Paragraphs 1 – 2, 3(a), (b), (f), 4 and 6 all emphasise the objectivity and independence requirements set out in *Shirley Primary School*. Paragraph 3(c) articulates the common law expertise rule. Paragraphs 3(d), (e) and 4 make explicit the requirement to give reasons for expert opinions and paragraph 5 incorporates the basis rule, restricting expert observations to the witness's own observations and expertise. Paragraphs (g) and (h) articulate minimum methodology requirements relevant to assessing weight of expert evidence in general. The decision in *Shirley Primary School* has further requirements for the methodology applicable to evidence of "hard science". Paragraph 3(i) relates to the written presentation of evidence and is aimed at limiting the volume and replication of statutory references in briefs of evidence.

In addition, the Practice Note provides for directions from the Court that may require experts from the parties to confer on matters common to their respective fields and to provide joint statements identifying agreed issues and issues in conflict together with reasons. The provisions for experts to confer further emphasise the expectation that witnesses will be both objective and independent experts with an overriding duty to assist the Court.

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<sup>359</sup> Environment Court Practice Note on Alternative Dispute Resolution, Expert Witnesses, and Amendment to Practice Note on Case Management (Effective 31 March 2001).

### 3.4 Conclusion

Technical rules of evidence have evolved as a means to prevent rumour and hearsay from influencing juries and those rules still operate to counter the effects of superstition within our modern courts. In the past, rumour and superstition (shared by judges, juries, witnesses and even the accused), resulted in very sad events in our legal history, the witch trials of the 14th to 16th centuries being but an example. The admissibility of evidence is now the focus of a lot of legal argument for the purpose of screening out the untested, and 'unscientific'. Decision makers have moved from a situation where precaution against alleged harm and fear of the unknown resulted in the persecution of women and children to a situation where a precautionary approach to the scientifically uncertain is at their discretion, unless required by statute. The courts, including New Zealand's Environment Court, are requiring that new theories have some basis of credibility within the scientific community, as this is the most efficient mechanism for screening out wild and superstitious claims. This is not a universally accepted approach however, and those who fear the high potential impact of scientifically untested or unverified hypotheses for the environment and for human health urge decision makers to take a precautionary approach. As discussed previously<sup>360</sup> adversarial litigation is not a mechanism designed to find absolute truth and even given its wider powers of evidential discovery the Environment Court is unlikely to make such a claim in relation to its hearings. The role of the Court is to decide matters that come before it having considered all of the evidence in light of the common law and statutory framework. Those decisions concerning future activities or events require an assessment of risks identified in evidence and that risk assessment is guided by legal rules for allocating weight to testimony together with the exercise of discretion in light of the circumstances of the case.

This chapter has identified the development and application of rules that guide legal decision makers when deciding issues requiring expert opinion. Those rules apply to that legal process over and above any individually held models of science of the type described in chapter 2. The following chapter articulates the research questions arising from the literature review in chapters 2 and 3 and describes how the research aim is given effect in order to answer those questions.

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<sup>360</sup> See chapter 3.2.5 and following.

## CHAPTER 4

### RESEARCH QUESTIONS AND METHODOLOGY

The aim of this research is to investigate the models of science held by decision makers comprising the New Zealand Environment Court. This chapter sets out the research questions underpinning that aim followed by the methodology adopted to answer those questions.

#### 4.1 Research Questions

The aim of this research, as set out in Chapter One, informs the literature review undertaken in Chapters Two and Three. Those chapters identify a number of different approaches to describing, understanding and evaluating science and scientific evidence and give rise to the following research questions:

1. How do members of the Environment Court:
  - a. Describe the meaning of science?
  - b. Define the boundary that separates science from non-science?
  - c. Differentiate between scientific and non-scientific evidence?
  - d. Determine what makes a witness an expert scientific witness?
  
2. Do individual members of the Court describe models of science that are consistent with each other?

Within that question are the following sub-questions:

- Do judges hold the same views as each other about science, scientific evidence and scientific witnesses?
  - Do commissioners hold the same views as each other about science, scientific evidence and scientific witnesses?
  - Do commissioners and judges hold the same views as each other about science, scientific evidence and scientific witnesses?
3. Do members of the Court give different weight to scientific evidence than to other types of evidence?

4. Do the members of the Court describe a model of science consistent with views within the science community?
5. Do members of the Court describe a model of science consistent with views within the legal community?

#### 4.2 Research methodology

Research methodology is the theory of knowledge that guides a particular research project. Three broad paradigms of methodology used in social research are: scientific and positivistic methodologies; naturalistic and interpretive methodologies; and methodologies from critical theory.<sup>361</sup> These methodologies, or paradigms, differ from research methods in that they address different theories of learning rather the tools to achieve that learning. This research adopts an interpretivist approach that focuses on understanding the detail of contextual interactions and responses within a particular social environment that includes the researcher. Unlike positivist research, which aims to predict future behaviours or events, and critical theory which addresses social justice and social change issues, interpretivism sets out to interpret the meaning of subject responses through the researcher's own lens. Having said that, qualitative research can and does give rise to theories grounded on data generated by the research. Cohen et al describe how social theories evolve from interpretive research as follows:

Investigators work directly with experience and understanding to build their theory on them. The data thus yielded will be glossed with the meanings and purposes of those people who are their source. Further, the theory so generated must make sense to those to whom it applies. The aim of scientific investigation for the interpretive researcher is to understand how this glossing of reality goes on at one time and in one place and compare it with what goes on in different times and places. Thus theory becomes sets of meanings which yield insight and understanding of people's behaviour. These theories are likely to be as diverse as the sets of human meanings and understandings that they are to explain.<sup>362</sup>

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<sup>361</sup> Cohen, L Manion, L and Morrison, K *Research Methods in Education (5<sup>th</sup> ed)* (London and NY: RoutledgeFalmer, 2000) 3.

<sup>362</sup> Cohen, L Manion, L and Morrison, K (2000) 23.

Rather than an aim for a universal theory that characterises a normative approach, interpretive research gives rise to multiple theories of human behaviour that are as varied and complex as the contexts supporting them.

#### 4.3 Qualitative Research

Qualitative research is an interpretive study of an issue or problem in which the researcher is relevant to the sense that is made.<sup>363</sup> Qualitative research attempts to capture the sense and significance of the research problem by studying actions and experiences in their natural state. While there are a number of different qualitative research methods, their key feature involves awareness of the gap between the research object and the way that object is represented through the researcher's interpretation.

Qualitative methods enable the researcher to study selected issues in depth, without the constraint of having predetermined categories of analysis that necessarily applies to quantitative research.<sup>364</sup> Quantitative research, on the other hand, is based on empiricism and aims to eliminate any element of interpretation by using mathematical analysis to establish general laws and principles.<sup>365</sup> Quantitative methods require standardised approaches and analysis that are limited to predetermined categories so that the empirical tools will operate. Where quantitative research methods can enable a large number of responses to be measured and statistically compared against a fixed set of data criteria, qualitative methods tend to produce a wealth of detailed data about a smaller group of subjects and issues.<sup>366</sup>

The questions pursued in this research ask about the Environment Court members' individual understanding of science and scientific evidence. They

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<sup>363</sup> Banister, P, Burman, E, Parker, I, Taylor, M and Tindall, C *Qualitative Methods in Psychology* (Philadelphia: Open University Press, 1994) 2.

<sup>364</sup> Patton, M *Qualitative Evaluation and Research Methods* (California: Sage Publications, 1990) 165.

<sup>365</sup> Jones, A "Methodology and Methods" in Jones (ed) *Qualitative Research in Science Education* (Hamilton, NZ: University of Waikato, 2005) 4.

<sup>366</sup> Patton, M *Qualitative Evaluation and Research Methods* (California: Sage Publications, 1990) 165.

require contextual descriptions that reflect the subject's interpretation of both the question and their understanding of science. The nature of the research aim and the research questions that articulate that aim require a qualitative research approach.

#### 4.4 Research Validity

Validity is an essential requirement of both qualitative and quantitative research. Traditionally, the mechanisms for judging the validity of research has been by reference to 4 criteria: internal validity; external validity; reliability; and objectivity.<sup>367</sup> Slightly different criteria have been proposed for judging interpretive qualitative research because the nature of that research involves the researcher as participant. The criteria used by Guba and Lincoln<sup>368</sup> to assess the trustworthiness of research are:

- credibility* – to replace internal validity;
- dependability* – to replace reliability;
- confirmability* – to replace objectivity; and
- transferability* – to replace external validity.

Research credibility can be enhanced by a number of factors, including prolonged engagement, persistent observation (in order to establish the relevance of the characteristics for the focus), member checks (to enable participants to correct factual errors and to offer the opportunity to add further information) and peer debriefing (to a disinterested peer in order to test honesty, working hypotheses and to identify the next steps in research).

Dependability relates to the stability of data over time. It requires that changes to interpretive constructions are identified and described so that alternative interpretations can be considered or even preferred. However the researcher's own interpretation can be identified and traced to the supporting data.

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<sup>367</sup> Jones, A "Methodology and Methods" in Jones (ed) *Qualitative Research in Science Education* (Hamilton, NZ: University of Waikato, 2005) 6.

<sup>368</sup> Guba, E and Lincoln, Y *Fourth Generation Evaluation* (Newbury Park, CA: Sage Publications, 1989).

The confirmability criterion seeks to ensure that research results are not due to influence by the researcher. The raw data and the process for analysis are both available to scrutiny by the reader. This criterion typically results in relatively large extracts from transcripts or raw data being published in the body of the research text.

Transferability relates to the extent that findings can be applied to other situations. The research context, methods and interpretation should all be described in detail so that the reader can determine whether the findings can be relevant in a different situation. Extensive portions of verbatim transcript can also aid a reader when making transferability judgements.

Triangulation is a further tool for enhancing validity of qualitative research. Triangulation involves the gathering of information from a number of sources to cross-check data from different accounts. Triangulation is particularly important when the validity of the data being provided is significant for the research. Triangulation appears to be less important when the research focus is on different contextual interpretations by subjects rather than on the substance of their behaviour or responses.

#### 4.5 **Research Method: Interviews**

An interview is a research method that enables the researcher to find out and understand an individual's views about a particular issue or field of interest. There are various interview methods best suited to different aims of inquiry but the features common to interview techniques are: the use of open-ended questions to reveal data significant to the subject; the relationship between interviewer and subject; and the generation of a rich and diverse set of data.

The interview methods commonly used for qualitative research are:<sup>369</sup>

- The informal conversational interview. This style is relaxed with questions spontaneously arising from the natural flow of conversation. The interviewer has a lot of flexibility but the diverse range of issues and responses arising means that analysis of data can be difficult.

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<sup>369</sup> Patton, M *Qualitative Evaluation and Research Methods* (California: Sage Publications, 1990).

- The standardised open-ended interview. This style is reasonably structured and involves participants being led through a predetermined sequence of questions using the same wording. The emphasis of this style is to reduce researcher influence and the data is typically easier to manage and analyse. This interview technique is also most appropriate where a number of different interviewers are involved in data collection. A disadvantage is that the data loses some of the depth and breadth of response elicited by a more informal approach.
- The semi-structured or general interview. This style is more structured than an informal interview but still has considerable flexibility of both sequence and format. The issues to be discussed will be set out for participants before the interview and the researcher will have an interview guide to ensure that all topics are covered during the course of the interview. The use of the interview guide, which could be in the form of sample questions, makes data gathering more systematic and data analysis easier.

I adopted the interview as the most appropriate method for obtaining data to answer the research questions. My interview structure was typical of semi-structured, open question techniques, with introductory questions to develop a conversational atmosphere and to provide necessary background information, followed by questions to elicit themes arising from the research questions. Associated with the thematic questions were a series of generic prompts designed to expand answers and to enable the interviewees to clarify for themselves as well as for me, what they understood by the terms science and scientific.<sup>370</sup>

#### Interview questions

Prior to compiling the interview framework, I attempted to describe my own understanding of science. That was partly to identify what issues were relevant to my model of science and the thought processes needed to articulate the model. I also wanted to clarify my own model of science so that I could identify and distinguish my own expectations as distinct from the responses of interviewees. I

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<sup>370</sup> Tolich, Martin and Davidson, Carl. *Starting Fieldwork*. (Melbourne: Oxford University Press, 1998) 108.

found that it was not a straightforward process. In fact, my model of science incorporates a number of different ideas and is not readily condensed into a couple of sentences. It required consideration of a number of different concepts and the relative significance of those concepts.

I prepared a draft framework based on the types of research topics to be covered in the interview. Those topics were:

- Individual background including qualifications
- The Environment Court as a specialist court
- Expert witnesses and
- The nature of science

I then prepared some semi-structured questions that sought information about the interviewees' experience in identifying and deciding expert scientific evidence and how they separated science from non-science.

The practice interviews were helpful in showing that my initial framework was initially too broad. The questions did not help the interviewees to consider the types of evidence that would be scientific and why. The first two interviewees had difficulty trying to identify a context for their answers and in articulating their model of science. Their feedback suggested that more contextual questions would help to identify what was significant in their model of science.

It was also apparent that a direct question asking what is science was too difficult for people without considerable forethought and preparation. Rather, indirect questions related to what is not science or scientific together with an opportunity to explain why, helped interviewees to build a picture of their model. Questions about their view of good and poor scientific expert witnesses provided a context to demonstrate what themes were significant in that model. The interview framework used in the research used the 4 broad headings above comprising 15 semi-structured questions. Each of the questions encouraged interviewees to expand and explain their responses. The interviews began with questions about background, qualifications, and experience including school history and educational experience of science. That was familiar ground and the questions

were not intellectually challenging. The questions about school experience of science provided a context for interviewees to consider the influences on their perception of science and to relax and speak freely about non-threatening matters. The questions about the specialist nature of the court and expert witnesses enabled interviewees to describe their own role in decision-making and to articulate what issues are important when deciding questions involving science. The final group of questions aimed to discover where and why judges and commissioners put the boundary between scientific evidence and non-scientific evidence and the boundary between science and non-science.

#### 4.6 Planning the research

While there are some excellent references that deal with the practicalities of interviewing,<sup>371</sup> I found that talking with others who had undertaken qualitative research, naturally including my supervisors, was enormously helpful. Obvious hints, such as, “practice your interview technique and skills with the recording equipment” enabled me to discover and overcome some unexpected difficulties. For example, a faulty transcribing machine stretched the tape from my first ‘guinea pig’ practice interview, so that parts of the tape recording became unintelligible. To overcome this possibility I made two copies of each tape, giving the original to the transcriber and keeping the others in separate locations. My first inclination was to keep the original tape, but I was advised that the quality of the recording decreases with each copy and this may make transcribing more difficult and also more costly. The nature and scope of the research was informed by my discussions with colleagues and supervisors as well as with legal practitioners and the Principal Environment Court Judge. Academic colleagues who had carried out research into the views of science held by learners described the various options for obtaining the data needed to answer my research questions. Their research comprised a combination of interview and survey techniques relevant to the type of data being sought. Interviewing is tool for eliciting subjective meanings associated with individual models of science. Interviews can also

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<sup>371</sup> For example Tolich, Martin and Davidson, Carl, *Starting Fieldwork*. (Melbourne: Oxford University Press, 1998) and Banister, P, Burman, E, Parker, I, Taylor, M and Tindall, C *Qualitative Methods in Psychology* (Philadelphia: Open University Press, 1994).75

provide data about complex ideas that are not easily articulated in a survey format. My research questions consider complex issues related to how and why people draw boundaries between science and non-science. Those issues cannot be readily articulated in structured questions that are applicable to a range of research participants. The semi-structured interview is a flexible tool that can identify different perspectives, including those not anticipated by the researcher.<sup>372</sup> The direction of a semi-structured interview, the variety of responses and subsequent analysis also requires the researcher to be aware of their own involvement in the research, including expectations of responses and thematic significance. Colleagues and supervisors who had carried out research into individual views about science also recommended a series of preliminary practice interviews to help develop an interview framework that would elicit the type of information needed to answer my research questions.

My discussions with Principal Environment Court Judge Sheppard confirmed that the type of research I proposed had not previously been done with the Environment Court. Judge Sheppard also indicated support for the research and an interest in the potential outcomes and their implications for decision making within the Court. Judge Sheppard offered to discuss the general nature of my research with other members of the Court at a forthcoming conference, at which the subject of expert evidence would be discussed.

My preliminary discussions with members of the legal profession also helped to clarify the appropriate protocol for contacting and working with members of the judiciary. Two legal practitioners working predominantly in the field of environmental law and one legal academic also researching and teaching environmental law agreed to act as practice interviewees. That experience and their feedback were extremely valuable for planning the interview framework and for managing the practicalities of the interviews.

In addition, one of the judges provided comments concerning the structure of the interview following my introductory letter. Those comments were helpful in identifying a misunderstanding about the purpose of the research. The comments

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<sup>372</sup> Banister, P, Burman, E, Parker, I, Taylor, M and Tindall, C (1994) 51.

focussed on matters relevant to analysis of legal decisions involving expert scientific evidence under the RMA and to matters relating to conflicting scientific evidence. They indicated a misunderstanding that my research was to discover the way in which the Court decided specific cases involving expert evidence. That misconception may have related to the explanation in my introductory letter to participants. A subsequent letter containing interview details was drafted to more clearly articulate the research aims.

Following my initial approach to the Court by letter, one of the Court's research counsel sent copies of notes and extracts from the Court's recent conference concerning expert witness guidelines. That information helpfully indicated the issues of concern and interest to the Court and also the range of material relevant to expert evidence that was familiar to individual Court members.

#### Ethical considerations

The research was carried out with approval from the University of Waikato Human Research Ethics Committee and complies with the University's Human Research Ethics Regulations and the Research Ethics Handbook. The following ethical principles are particularly relevant to this research:

- Informed consent. All interviewees participated voluntarily following a written explanation of the research aims and interview framework.
- Confidentiality. All information has been kept confidential by the use of code descriptors.

I decided that the interviews should be on a confidential basis so that interviewees would be more prepared to answer freely and frankly. Also, the research sought to identify individual models of science in order to discover consistency within the court and with other models of science. An individual's view of science is not relevant per se and there is thus no need to identify individual comments or even individual participants. My introductory letter also told interviewees that their comments would be treated confidentially with reference only to their position as judge or commissioner. The letter of introduction sent to prospective participants described the purpose of the interview and explained that responses would be kept

confidential. Every letter had a detachable approval form that was signed by all participants before the interview commenced.

The decision to maintain confidentiality of the participants means that I have not referred to individual backgrounds, qualifications or experience. While that information addresses links between individual models of science and educational and practical background, it also readily identifies members of the Court irrespective of the code descriptors.

Participants were not offered any inducement to take part. They gave their time freely and interviews were arranged around their work schedule. All participants were sent a letter of thanks following the interview and were offered an opportunity to review the transcript before research data was collated. None of the participants requested a copy of the interview transcript, although a couple of individuals expressed interest in reading the completed research findings.

#### Recruiting interviewees

I chose to interview the Environment Court for 5 main reasons. Firstly, the Court is a New Zealand judicial body that regularly hears expert evidence, including novel scientific evidence about environmental effects as part of its jurisdiction under the RMA. Secondly, the Court reflects the diverse nature of decision-makers that hear similar evidence concerning environmental issues. The commissioners have varied backgrounds as prescribed under the RMA and their backgrounds, qualifications and experience are typical of the decision-makers involved in environmental policy-making at local, regional and central government levels. Thirdly, the Court is a discrete group organised around a central administration. There were a total of 8 Environment Judges, including the Principal Environment Judge and alternate judges. There were 16 Environment Commissioners including deputy commissioners. That number of individuals was great enough to provide a diversity of experience informing responses and small enough to manage the collection and analysis of interview data. Fourthly, the research had the general support of the Principal Environment Court Judge. Fifthly, the Environment Court has jurisdiction for a range of matters under the RMA generally dealing with sustainable management and environmental

planning. That is an area of the law of particular interest to me as a researcher as well being within my area of legal expertise.

I initially approached all interviewees by way of a standard letter individually addressed and sent to the Environment Court Registry in Wellington. The letter provided an outline of the research aims and explained that participation would be both voluntary and confidential. Interviewees would be identified only as Judge or Commissioner. The introductory letter contained my contact details, including email and indicated that I would contact Court members individually to confirm whether or not they would participate and organise interview times. The proposed timeframe for interviews was between late 1999 and early 2000.

One judge replied in writing and 2 judges and 2 commissioners responded by email. All agreed to participate. I phoned the Environment Court registrar and explained my research as a preface to obtaining telephone contact details for each Court member. I was able to organise interview dates and venues with each of the judges either by phone directly or via their support staff. The commissioners did not have offices at the local hearings centres located at Auckland, Wellington and Christchurch and, rather surprisingly, Court staff gave me their home telephone numbers. I was able to arrange interviews with the commissioners following calls to their homes.

Only one commissioner declined to participate in the research. One other commissioner was unavailable, being overseas at the time.

Following our telephone conversation I sent a further letter confirming the time and venue for our interview and enclosing the ethics approval form to be signed by each participant. That letter also outlined the 4 interview subject headings, noting that my emphasis would be on the role of expert witnesses and the evidence of scientific experts. I spoke to all 8 judges in their chambers, although one of those interviews was originally scheduled to be at the judge's home. I interviewed 14 commissioners in total, 7 in their homes and 7 at the Court.

I did not conduct interviews with scientists or experts concerning their views about science. Although such data would undoubtedly be very revealing, my purpose is not primarily to present a disunity between the understanding of the Court and that of those appearing before it, although that may indeed become evident. Rather, my aim is to discover what are the views of the Court and to find whether these views coincide with philosophical scientific discourse.

### The interviews

Following introductions, I briefly explained my academic and professional background and the aims of my research. I also collected the signed ethics approval forms. The interviews were all tape recorded. The interviews with one judge and one commissioner required an additional tape and lasted nearly two and a half hours.

The microphone was usually placed on a desk or table between the interviewee and myself. One recording was unable to be transcribed. The interview was held in a lounge area rather than a meeting room or office. The microphone was placed on a coffee table and did not pick up the interviewee's responses clearly, particularly against a background of traffic noise. I did not attempt to re-interview that commissioner. Although the research is qualitative and does not need to be compared against other responses obtained without prior notice of the questions, the time involved was significant and I considered it would be unreasonable to ask someone to give up further time to repeat the interview.

#### 4.6.1 *Managing the data*

The data was all copied and then transcribed from the original tape. I randomly assigned each judge a number from 1 to 8 and each commissioner a number from 1 to 14. The original transcriptions were under the participant's name, but all references in the results analysis is by code. For example, Commissioner 5, Judge 3 etc. The percentage of women was small within both groups of interviewees although there were more women commissioners. In my presentation of results and discussion I have referred to all judges as "he" and all commissioners as "she". That gender assignment also allows the discussion of responses to read more easily without constant reference to the interviewee's code.

The first group of interview questions related to the participant's educational and work background and to their exposure to formal science education. Those questions set the tone for a less formal conversation and enabled both the interviewee and the interviewer to relax. The responses to those questions were not included in the results, however, as the individual experiences would enable clear identification of individuals in many cases.

All research papers and seminars prepared and presented from these research results have used the participant codes, with reference only to the individual's role as Judge or Commissioner and occasionally to the relevant proportions of those groups expressing a particular view.

### Analysis of Interviews

Once the interviews were transcribed and assigned code identifiers, I studied each transcript for themes in the participant's description of science, scientific evidence and scientific witnesses. That process involved a degree of reflexivity in that I started by listing the themes relevant to my own model of science as well as other themes that I expected to observe in participants. Bannister et al describe reflexivity as "...perhaps *the* most distinctive feature of qualitative research."<sup>373</sup> Reflexivity involves acknowledging the central position of the researcher in the construction and reconstruction of knowledge. I have interpreted the interview transcripts by identifying themes that appear significant to each individual and themes that recur in a number of transcripts. That process involved listing all of the themes that I identified as being relevant to an individual's model of science and tabulating those results across all individuals. I interpreted the significance of those themes by the number of times a theme occurred within an interview and across all interviews as well as by the emphasis given to a particular theme. Sometimes that emphasis could be deduced from the emphatic words used, or by the depth or length of analogy used in explanation by the interviewee.

I expected to find that interviewees either defined science to include technology or separated technology from their model of science. Thus I also tabulated the occurrence of individual themes within these two broader macro-groupings and

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<sup>373</sup> Banister, P, Burman, E, Parker, I, Taylor, M and Tindall, C (1994) 150.

also a third, unexpected group that described a much wider framework for science.

I did not aim to identify universal models of science or even to identify every theme relevant to an individual's perception of science. Rather I aimed to identify difference and consistency both within the Court and between the Court and those articulating views about science and scientific evidence from within the science and legal communities. Thus a reflexive interpretation is appropriate because it identifies those differences and commonalities from my own perspective as the researcher and interviewer.

The results of that thematic analysis are presented in the following chapter and tables showing the distribution and frequency of themes are attached at Appendix 2. Those tables are not included to provide any quantitative basis for the research. Rather, they demonstrate the themes considered to be significant in forming boundaries between science and non-science for the purposes of my data analysis.

#### **4.7 Issues Relating to Validity and Reliability**

Credibility/internal validity was enhanced by the circumstances of the research interview. Each interview was based on the same question framework that had previously been tested with research colleagues. Interviewees nominated the date, time and location of interviews. There was no coercion or incentive to participate and 6 Commissioners were interviewed in their own homes, at their preference. One of the judges also arranged for an interview at home, however a chance lunchtime meeting at the Court following another interview resulted in a change in schedule to complete that interview the same afternoon. The interviews all took more than an hour, with the longest being nearly two and a half hours. Most interviews were nearly one and a half hours long. Questions were open with opportunities for the interviewee to expand and explain their answers. There were several similar questions for each topic to enable answers to be checked for consistency of interpretation. The opening questions dealt with the interviewee's educational and professional background in order to establish a non-threatening research environment where interviewees felt at ease. Each interviewee was offered the opportunity to review and comment on transcripts although none took up that offer. The interviewees were also promised complete confidentiality and

research data was transcribed and coded to remove identifying references. The expectation of confidentiality also encouraged openness in answering.

Dependability/reliability is promoted by using a reflexive approach to the interpretation of data. My own expectations form the starting point for analysis of the data and different themes, emphases and categories are identified. The analysis of data includes large extracts from the transcripts that allow the reader to review my analysis from the reader's own perspective. A reflexive approach acknowledges that there can be alternative interpretations but provides valid reasons for the interpretation adopted by the researcher.

Confirmability/objectivity is also enhanced by the use of large extracts from the transcript and the opportunity for interviewees to review the raw data. A reflexive approach also enhances confirmability because the reader is aware of my own standpoint in relation to the research questions.

The sample size and nature of the Environment Court contribute to the transferability of the research findings. All of the Court was invited to participate and all but one member in New Zealand at the time consent to be interviewed. The analysis thus reflects my interpretation of the Court's views on science and scientific evidence. The judges all have the same legal qualifications and all have worked within the New Zealand legal profession. They have the same qualifications as other judges within New Zealand's judicial system and have similar professional experience to others appointed to the bench. They have high exposure to expert evidence and that may mean that they have definite views about their expectations of expert evidence and can more easily articulate their views of science. The Commissioners have educational and professional backgrounds typical of the independent hearings commissioners employed by local authorities. Many of the Commissioners have past experience as hearings commissioners or as members of local authority hearings committees. That professional experience contributes to the potential for my research findings to be transferable.

#### 4.8 Summary

This chapter sets out the questions to be answered by this research. Those questions address complex issues involving individual perceptions and understandings of science that cannot be answered by survey or experiment.

The broad approaches of research methodology are described. This research adopts an interpretative approach involving reflexive interpretation of complex, contextual responses. The research is qualitative in that analysis involves the identification and interpretation of themes for significance rather than quantification of numerical data.

The criteria for research validity are outlined, being: credibility; dependability; confirmability; and transferability. Those criteria were met through the choice of research method, research planning and preparation, and through data management and analysis.

Qualitative research can involve a variety of interview types. In this study data was obtained using a semi-structured interview technique that combines the scope for flexibility and complexity while focussing on specific themes relevant to the research questions. The interviews and data analysis were designed to include the features that indicate research validity and reliability and those features are described with reference to the actual data collection and analysis. The research was also carried out in accordance with recognised ethical standards for research involving human subjects.

The following chapter sets out my analysis of the interviews in light of the research questions. The data analysis identifies themes that are significant for establishing individual boundaries between science and non-science. The following chapter also analyses the interview data to assess how individuals value, or weigh scientific evidence compared with other types of expert evidence.

## CHAPTER 5

### RESULTS: PERCEPTION OF SCIENCE

#### 5.1 Introduction

This chapter sets out the analysis of interviews designed to investigate models of science held by decision makers comprising the New Zealand Environment Court. The results identify and describe three macro themes that differentiate interviewees according to their categorisation of science, technology and expertise. Within those broader macro themes are a number of micro themes that are common to various individuals from all macro groupings depending on the criteria essential to establish boundaries of their own model of science. The micro themes are identified with reference to interview extracts that illustrate the interviewees' views about science. This chapter also sets out the analysis of questions designed to discover whether interviewees have different expectations of expert scientific witnesses and their evidence. That analysis also considers whether there is any difference in the weighting given to expert scientific evidence.

The interview questions were designed to give interviewees a range of opportunities to describe how they categorise scientific evidence and scientific witnesses. Interviewees were asked to identify the essential features of evidence that determined whether or not it was "science". Some of those questions were direct, for example, "What is it that makes scientific evidence scientific?" and, "What do you perceive to be the purpose of science?" Other questions were less direct and asked interviewees to describe what types of evidence they would classify under a general 'umbrella' term of science and whether or not certain types of evidence, for example engineering or sociology, would be described as scientific. The explanations to those questions provided data that helped to illustrate an individual's own views of science and to identify the key 'micro themes' crucial to that view.

Questions that sought the characteristics of good expert witnesses, as opposed to poor ones, and whether expert scientific expert witnesses showed any different characteristics also indirectly provided information about key themes and helped

to identify the 'macro themes' discussed below. Another question that also indirectly discovered an interviewee's views on science asked how the Court assessed evidence which was described as 'novel' or 'fringe'. Where interviewees described the type of evidence that could fall into such a category and the way in which such evidence could be differently weighted for decision making, there were good insights into perceptions of science and its role in society.

## 5.2 Analysis

In order to assess the significance of a theme for each individual's model of science I coded all of the question subject areas with a given letter and numbered each different idea identified in answer to those questions. The list of codes for the subject areas is attached as Appendix 1. Whether or not I assessed a response as being significant to an individual's model of science depended on a number of factors including: the number of times the interviewee referred to that idea; the intensity of that reference; and the context of the reference. For example although Judge 7 referred to the importance of the scientific community twice during the interview, the context of those references was in response to a question about how he would determine when new scientific theories had become accepted as mainstream science. I did not classify those references as being significant to his model of science. On the other hand, he referred to knowledge on 6 occasions and to fact or proof once, but in a manner that indicated its importance to his understanding of science as follows:

We're talking about expert witnesses giving opinions, based on their scientific knowledge and experience, which they've acquired by the scientific method of, um, you know, of um systematically formulating their knowledge and testing it. Yea, that's what makes it scientific. ... The whole of Part II um, gives, provides the possibility to adopt such an approach where the results of, where the scientific knowledge is not, um, sufficient to be able to formulate ah judgements about what is likely to happen and in [case name] we said the scientific knowledge was sufficient to enable us to do that.

It depends on whether we're talking about scientific fact or opinion here, because (pause) there, it's one thing to, the pursuit of certainty of knowledge is, is a difficult thing,...(J7)

Where Judge 7 refers to fact he does so in the context of there being a certain body of scientific knowledge and the two ideas are significant to his explanation of the nature of science.

The following extracts from Commissioner 7's interview also demonstrate the difference in assessment between ideas significant to her view of science and ideas not significant:

There was a time when the "scientific method" became defined as honest unbiased studies of cause and effect and people stated what they found and formed a theory of it, if they could, and if they couldn't then they shut up about it.

I suppose it is studies that will form the basis of an increase of human knowledge, something which was not known before. ... The word "science" just means knowledge, doesn't it? (C7)

While Commissioner 7 refers to scientific method in the first extract above, the reference is as much a reference to objectivity and theorising. The reference does not suggest a close link with her understanding of the nature of science. As such the reference is recorded as being not significant. However, there are four different references to knowledge and the extract above shows the close connection between that idea and her view of science.

Having identified the various ideas that were associated with each interviewee's responses to questions about the nature of science, I grouped these within themes that recurred across the interview results. Those themes are recorded in tables I – V of Appendix 2. Table I shows the number of references to each theme for each individual without distinguishing whether or not those references were assessed as being significant to the interviewee's model of science. Table I was compiled following a close initial analysis of each of the interview transcripts. Some of the further analysis of interview abstracts and their context in the following sections may not be reflected by a reference on table I. Tables II - IV show both the

significant and non-significant micro themes and distinguishes between judges and commissioners. These tables also divide the interviewees according to the relevant macro theme as described below. The different tables were prepared to try and identify any patterns that could give rise to generalised conclusions. However, the tables confirmed that the responses are individualised with no clear patterns apart from the divisions between macro themes which represent my organisation of individuals based on their understanding of scientific evidence within the context of expert evidence generally.

### 5.3 Key Themes

As discussed above I have organised the key themes emerging from my analysis of the data into two broad groups; macro themes and micro themes.

#### 5.3.1 *Macro themes*

The macro themes are 3 broad categories that can be drawn according to whether the interviewees distinguish scientific evidence from other types of expert evidence and whether they differentiate science from technology. Within each of these categories, there are a number of reasons, or criteria, that distinguish that type of evidence as being science, for each interviewee. These secondary criteria, I shall refer to as micro themes.

Within the science and science education communities there is a separation between concepts of science and concepts of technology.<sup>374</sup> I used the categorisation of evidence as scientific or not as an indicator of difference between the various understandings of science. The key terms to indicate overlap between an interviewee's perception of science and my perception of technology were those that described the 'application' of science or 'applied science' as being part of, or crucial to science. Other indicators of overlap were the categorisation of engineering and/or medicine as science. I expected to find a difference between interviewees that included all technical evidence in their classification of scientific evidence and those that separated science from technology. For example:

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<sup>374</sup> Refer to the discussion in section 2.3.2.

Ah, engineering is almost a science. There's, I've always thought of the engineers almost as scientists....Because they can give precise measurements and then predict on those measurements what may or may not happen, which is very akin to science. They can be more precise often than the scientists, as can be the lawyers' experts.... I think there's a distinction. I think there is scientific research which underpins medicine and medical matters. Um, but I don't see medicine as a science in itself, because again one training, one's discipline, one's discretion, one's judgement come into all of that, but I see the scientists as being much more precise. (J4)

Judge 4 articulates a difference for him between science on the one hand and engineering or medicine on the other. That difference is partly to do with the level of precision that technologists (such as engineers or doctors) can attach to their evidence and precision through measurement is a significant micro theme for his model of science.

Judge 7 does not differentiate technologists such as engineers or doctors from his category of scientists although he does identify that some expert evidence will not be scientific. When asked whether there were differences in his expectations of scientific experts Judge 7 responded:

Well, I suppose that depends on what you mean by "scientific experts" doesn't it really. Ah, yea, I guess there is, because they're scientists and their approach to things will therefore be a bit different won't it? (J7)

If we talk about science as being an umbrella term, what would you be happy to see under that umbrella? There's the hard sciences that you've described, what about medicine or engineering? (Interviewer)

(pause) Yep. I think they're sciences in my book. (J7)

The analysis of how interviewees categorised evidence also uncovered another broad and unexpected difference in the way science is perceived. That difference involves the distinction, or lack of one, between expert evidence and expert scientific evidence. When I developed the interview questions on the basis of considerable research of various models of science, I did not anticipate that some

members of the Court would categorise all expert evidence as necessarily scientific. The following extract from the interview of Judge 3 illustrates this macro theme:

Do you perceive a difference between evidence and scientific evidence?

(Interviewer)

I don't quite - It's all evidence, but I think probably what you're getting at is whether it might be relevant in a certain situation. (J3)

The members of the Court that I included within this macro theme articulated a definition of 'expert' that was either coextensive with their definition of science or their definition of 'expert' actually defined science. A close analysis suggests there may be a fine distinction between the two approaches to this 'science = expert' view and it is a view that is very clearly distinct from the 'science includes technology' and the 'science is different from technology' approaches.

My analysis of interviewees' own classification of evidence as scientific or not indicated that there was considerable overlap between evidence that I would place fairly inside the category of science and with other evidence that would more easily fit into my personal description of technology. This overlap was a source of uncertainty for several interviewees and many described their concept of science in terms of a continuum with 'the arts' at one end and 'science' or 'the sciences' at the other. The three macro themes reflecting the different content matter of each individual's model of science are described as follows:

- Science is different from technology

This group comprised:

Judges 5 and 4, and

Commissioners 3, 4, 6, 7, 11, 13

- Science includes technology

This group comprised:

Judges 1, 2, 7, and 8 and

Commissioners 1, 2, 5, 8 and 9

- Science = expert

This group comprised:

Judges 3 and 6 and

Commissioners 10 and 12

I have not separately dealt with macro themes in this chapter because it is the micro themes that are critical to individuals' boundaries around their models of science. Those micro themes appear in responses from individuals across all of the macro themes and reflect the factors significant to their model of science, whether or not that model includes all expertise or includes only expertise that directly relates to the academic disciplines of chemistry, physics or biology.

In the following analysis of micro themes, I identify the relevant macro themes where these are apparent from the interview extracts. The identification of macro themes for interviewees that include technology in their model of science was generally apparent from their classification of evidence and this is summarised in the tables in Appendix 2.

### 5.3.2 *Micro themes*

The micro themes combine to describe the model of science held by each member of the Court. These micro themes do not correspond with any particular macro theme, but do form some patterns according to each individual's model of science. For example, the existence of empirical data may be crucial to the identification of evidence as scientific for individuals within each of the 3 broad classification bands. For others the existence of professional or academic qualifications may be an essential element. Thus my analysis of the data shows that members of the Court use a variety of key themes to describe their own models of science and that these themes are not necessarily those which would be crucial for models of science described by the scientific community. In addition, individuals can be further divided according to the types of evidence that they would describe as being scientific. These broad divisions encompass similar mechanisms for the determination of what is science, however, the micro themes described within each macro theme are applied differently so as to define science with quite different boundaries. The key micro themes identified are:

- Continuum models
- Fact/proof/certainty
- Empirical measurement/data
- Process including; scientific method, research/experiment
- Objectivity
- Science as knowledge
- Qualifications and traditional linkages
- Scientific community
- Purpose of science

The micro themes are the reasons why an individual categorises evidence as scientific. They reflect criteria that are apparent in models of science described within the scientific community. For example, Popperian criteria of testability, replication and falsification that are essential elements of the scientific method. Other themes include rationalist concepts of a 'body of knowledge' and empiricist requirements for observation, measurement and collection of data. Central to these two models and to the uniting approach of logical-positivism is the requirement for objectivity, or neutrality of the observer, and this theme is also identified. Another theme arises from Ziman's requirement that the goal of consensuality is a defining feature of science and this requires the scientific community to be prominent.

These themes were not necessarily anticipated when the interview questions were prepared but they became apparent as the interviews proceeded and then later when the transcripts were analysed. In some cases relevance was apparent from the direct or intense way a particular criterion was described by the interviewee. For example one judge described science in terms of its purpose to improve human life as follows:

To me science, is, is an enquiry into the reality of the physical world. In other words it's all to do with the, and of course you use all different scientific disciplines to do that – physics, chemistry and maths and all those sorts of things to empirically look at the thing and to, and to make, make inferences and deductions from those empirical investigations and

*then you use that to try and improve um, um man's lot in life, I suppose, don't you? (emphasis added). (J8)*

A commissioner described specific qualifications as being the key to whether an expert witness was a scientific expert:

Um, I would say a person with a discipline with, um, yes I would say with a discipline, with academic skills and training, qualifications, yeh, it would be, it is a discipline and, um, of a scientific background. I would suppose that is a bit Irish, but ah, they have got to have a scientific training, academically, and, um, practised in that field. (C5)

The intensity of the qualifications theme can be assessed in the above quotation by the use of the imperative '*they have got to have*' in relation to the need for scientific training. The importance of qualifications to determine classification of an expert as a scientific expert was evident amongst the majority of commissioners, and this theme was further analysed to identify what made qualifications significant.

In other cases, the importance of a particular criterion could be inferred by the frequency it occurred in a particular interviewee's description of their view of science. For example, four commissioners, on at least four separate occasions during the interview, referred either to the importance of qualifications or to backgrounds in traditionally recognised fields of science as being significant indicators of science. Frequencies of responses are recorded in table 1 of Appendix 2.

In some cases, themes are described by a number of different key words or concepts. The reason for this grouping is related to the common intent which can be inferred from the comments and also from the association of these concepts with one another by the interviewees. For example the distinction of science from non-science for many interviewees was associated with the difference between fact and opinion evidence. In drawing on language to describe this distinction, interviewees variously used the concepts of fact, proof, exactitude, certainty, precision and accuracy. Sometimes those concepts were used concurrently to

indicate a generalisation of intent, and in other instances the different words were used to explain the opinion/fact distinction. When asked what he meant by “pure scientific evidence” one judge responded as follows:

Well, there is no opinion. It’s a test of fact. If you, ah, like hydro dams, the dam is built to have a certain flood capacity, because the weakest point of a dam is about half way down, where the full water pressure is getting at the dam, and, ah, so an engineer can tell you with precision that, ah, if you fill that dam to 2 feet above its designed flood level, it could collapse.  
(J3)

This comment links the concept of fact with precision to describe the absence of opinion from scientific evidence. In the following example, a commissioner links the ideas of proof, fact and accuracy with science:

Certainly I think there are ways of using science to prove a fact that you can’t do in some of the other airy fairy ways of so called proving but again you have got to be accurate and honest. (C8)

In this chapter I shall illustrate how the macro and micro themes are relevant to each individual’s model of science. The tables recording the distribution and frequencies of responses are attached in Appendix 2.

#### 5.4 Continuum Model

The classification of expert evidence as scientific or not, and the description of scientific expert as opposed to other types of expert evidence required interviewees to articulate where they would place the boundary in their own model of science. This process of articulation resulted in four judges and six commissioners describing their model of science as some form of progression or continuum. The individual would classify certain evidence as scientific or not depending on the extent to which that evidence reflected the key theme or themes crucial to their own model of science.

##### 5.4.1 *Fact v Opinion*

For two judges science was identified on a continuum between fact and opinion. For example, if ‘fact’ was identified as key to a view of science, and ‘opinion’

was the antithesis of science, then opinion evidence that relied on the interpretation of data would fit closer to the individual's view of science as if that view formed a continuum between 'pure' science and 'pure opinion'. This approach is clearly demonstrated by the following extract from Judge 3:

Yes, well, science covers all sorts of things, human sciences and all sorts of things these days. ... Certainly in ?[unrecognisable case name] you had scientific evidence on that. That's pure scientific. They test the underground aquifer and if they find certain traces in it, they can then tell you definitely that comes from a rubbish tip situation. (J3)

What do you mean by pure scientific evidence? (Interviewer)

Well, there is no opinion. It's a test of fact. If you, ah, like hydro dams, the dam is built to have a certain flood capacity, because the weakest point of a dam is about half way down, where the full water pressure is getting at the dam, and, ah, so an engineer can tell you with precision that, ah, if you fill that dam to 2 feet above its designed flood level, it could collapse. And that, there is opinion in that, but it is basically based on on factual design elements and, ah, factual tests they have done on these things. Um, ah, (pause) put it like this, there is not too many situations where you deal with environmental law where the pure science is important as the application of that science to then a matter of opinion. (J3)

This passage indicates a view in which science is associated with a range of topics, however the crucial indicator is the reliance on fact. "Pure scientific evidence" involves no element of opinion, however this stance is then modified to accept that such evidence would be rare in the Environment Court. More often scientific evidence involves the giving of opinions based on factual data. The judge implies that the giving of opinions is acceptable where those opinions are based on facts and in the final sentence links the concept of fact with science when he associates the application of science with the giving of opinions. Another judge articulated his view of science as follows:

You know there are people like landscape, but in the way I suppose that it is a science, to some extent, although that's greater opinion, but I

suppose looking at my um my continuum we don't have science here and art here. I suppose I see science as something of an art in itself when it gets to the point of view of their opinions. So I don't see that that, that black and white definition between science and, and the other sort of callings. (J5)

As I've said before, I see science and art, we can put it on a continuum and that um, if we, we go back to 'scientia' in the terms of knowledge, one must say that that's accumulated and empirical fact. Now, I believe we wouldn't if we limited science to that definition we wouldn't, most of the experts would be in the art category. So it is a continuum and so I suppose I would have to say I would see engineering as generally being science related. (J5)

Both judges describe their view of scientific evidence in terms of a dichotomy between opinion and fact, however, the way in which they actually classify evidence is quite different. Judge 3 includes a very wide range of evidence under his classification of science. In a passage of the interview which precedes the quotation above, he describes a range of environmental and engineering evidence concerning water and atmospheric discharges as being "purely scientific" with a strong association between pure science and fact or data. However, when asked if he perceived a difference between scientific as opposed to other evidence he responded as follows:

I don't quite - It's all evidence, but I think probably what you're getting at is whether it might be relevant in a certain situation.

I don't really see any difference. Science is so much a part of the world, today and is contributing to our knowledge of it, that I don't really feel there is much difference between any evidence if it comes to that? Well, do you? (J3)

Judge 3 was able to illustrate what was crucial to his category of science using the following analogy:

If you have, um, in Jerusalem the belief that Jesus was born in a certain place, that is handed down from history, there is no proof, that is word of

mouth. ...That is not scientific evidence, but it is vehemently held by many many people.

...I thought probably you could take Egypt. They've just found these new graves under the sands which no one knew were there, but if you had, ah, word of mouth handed down that such and such High Priest was buried round about such and such a place and nobody had ever been able to identify his tomb and all of a sudden you fell into it, like they did here and found him, well there you've got hand down material backed by a scientific find. (J3)

In essence, for Judge 3 any evidence that is relevant and can be linked with some factual or empirical data is sufficient to separate that evidence from pure opinion, which is non-science. Judge 3's model of science also fits within the macro theme of 'science = expert'.

On the other hand Judge 5 places his boundary for science at quite a different position in the continuum between the fact/opinion dichotomy. When asked whether he would include sociology evidence under his classification of science, he answered:

Yes, well this and psychological evidence. You know the good old "Nimby Principle" and all of this. And I, I, to me that is opinion. The question of - is then, what's the basis? Its like the architectural, what's the basis for it? *Now you might call that science and if you're going to call it science then all the expert witnesses have to be science*, but um (pause) you know at the end of the day it's an opinion. What's the factual basis for it? On what are the assumptions based and what are the conclusions reached? I don't have a problem with people doing that, but they have to qualify themselves, that's all. (J5) (emphasis added)

Judge 5 articulates quite clearly that he does not consider that all expert evidence is necessarily scientific. For him the factual basis for opinion is still a crucial element in the differentiation of science from non-science, however the requirements for a factual basis are rather broader and include an indication of the methodology to identify the assumptions and conclusions inherent in the

substance of the expert opinion. Judge 5 puts repeated emphasis on the notion of a scientific method in his organisation of science along the fact/opinion continuum, and I shall return to a discussion of ‘scientific method’ as a key theme arising from the data.

#### 5.4.2 *Hard v Soft continuum*

The continuum analogy was also modified by some interviewees to describe ‘hard’ versus ‘soft’ science, where ‘hard’ science displayed a greater proportion of the themes key to the individual’s definition of science than did ‘soft’ science. Judge 1 has a strong continuum description where he places ‘hard’ scientific evidence at one end with rational evidence at the other. Judge 1 adopts the continuum, or spectrum analogy at five different points during the interview and his analogy is clearly articulated in the following extract:

Oh, well I wouldn’t want there to be a hard and fast line in my thinking about that. I mean, ah, I think of scientific evidence as being part of a spectrum, say from rational evidence and hope that all evidence is going to be rational, ? it doesn’t in fact occur. So there’s a continuum from just the merely rational evidence, if you like, through to scientific evidence of the hard sort. You’re going through, um, resource management and town planning evidence at the soft end, through social sciences. Although I sometimes wonder if they’re much better in scientific terms than resource management evidence generally. Ah, through to epidemiological type evidence to of a causative evidence. Yes. So it’s a continuum. There’s no cut off point where you can say, “This is scientific evidence and this is not”. (J1) (Question mark indicates unidentifiable word on the audio tape.)

For Judge 1 the continuum analogy allowed flexibility in the classification of evidence as scientific or not. Judge 1 resisted my attempts to identify at what point the “merely rational” would become ‘hard science’ preferring to rely on the continuum analogy but he did identify several key themes as being indicative of science, for example methodology including experimentation and the measurement of data.

Judge 7 uses a 'hard/soft' analogy to distinguish the physical sciences from the social sciences. For him, the degree to which a body of 'scientific' knowledge can be tested is the key distinction between the 'hard' sciences and the social sciences.

Judge 4 refers to 'hard' science in order to distinguish social science from his own model of science and associates hard science with hard data. He does not otherwise articulate any reference to a continuum definition of science although when he explains why he perceives the hard sciences to be different to the social sciences, he comments: "because they're dealing with more socio-economic matters, than, there's a separation there somewhere."

Judge 6 did not directly apply a continuum analogy as such, but referred to science as "such a fluid word" and described sociology and psychology as being "on the cusp" of science. Judge 6 does use a 'hard/soft' science analogy, however, for him the analogy distinguishes the type of knowledge concepts which can be easily understood by non-scientists ('soft') from those which are intellectually harder for non-scientists to understand. For example:

Well, um, I suppose the um the "soft" group, so to speak, are, are more, dealing more with um every day, not every day, but more readily understood um concepts, um. A traffic engineer telling us about how he went out and did such and such a survey, or the sociologist that talks about giving, putting questionnaires in people's boxes and getting so many answers and giving us the percentages and we can readily understand that sort of evidence... More straight forwardly if you like, but ah the "hard" group I suppose I'm tending to call that to some extent, because they are harder to assimilate, they're in a more esoteric ah, ah level, if you like, their science is ah is highly specialist. (J6)

This example illustrates very clearly the use of a particular analogy to describe subsets in the interviewee's category of scientific evidence. The analogy is almost identical in language to the one used by Judges 1, 4 and 7, but the application of that analogy is entirely different. Judges 1, 4 and 7 apply the analogy to distinguish categories of evidence by the degree that those categories

reflect the themes key to each individual's model of science. Judge 6 applies the analogy to distinguish intellectually familiar, from intellectually unfamiliar evidence.

#### 5.4.3 *Other types of continuum*

Six of the commissioners expressed some difficulty with defining the boundaries for categories of scientific evidence and implied some elements of a continuum or spectrum analogy when describing how they would categorise different types of evidence. Commissioner 13 described a continuum without actually verbalising that analogy. She describes her own uncertainty about the boundaries of science and implies a continuum model in the following extracts:

... what I struggled with and probably made clear in the beginning, where in your mind does science finish and science begin? Because I may have, put it, quite a number of categories into science.

But, for me there's a little grey area in the middle. You know, where do you put? I'd probably like to ask you, where do you put the ah noise people? (C13)

Commissioner 13 does clearly differentiate science from technology:

(pause) I should have thought about all of this before. Air, soil, water. All the biologies, that whole botanical range. Um, (pause) those are the four that really um and then you move into the technical stuff, which is like the surveying, the road designs and you'll get componentry, they will tell you how certain things are made now and again, but that's usually not. Um, (pause). (C13)

This reference to "technical stuff" was later repeated to distinguish engineering and the effects aspects of medicine from science. Thus Commissioner 13 has a model of science that reflects the 'science is different from technology' macro theme.

Commissioner 12 describes a linear analogy to differentiate cultural evidence from science.

Well, (pause) I guess I should have got a line of demarcation between cultural and science. Cultural and science. I mean there's obviously going to be overlaps I suppose. I can't think of them, but I sort of have a clear idea in my head and I mean I, I, I can't tell you the line, but I can tell you good examples where I'd put it I guess. It seems to me it's never something that I've had to um think about. (C12)

Although Commissioner 12 describes a continuum between her cultural/scientific evidence dichotomy, she expresses confidence in being able to draw a boundary around the categories of evidence that she would include as scientific. During her interview Commissioner 12 indicates the concepts of a body of scientific knowledge and of the existence of a supervisory scientific community as being relevant to her model of science and thus her classification of evidence as scientific, rather than cultural.

Commissioner 11 also has a linear analogy for categorising scientific evidence, articulating her view in terms of a wedge with a "thick" and a "thin" end:

So ah I think that science, the expert evidence, expert witnesses whether they're scientists or other experts, in terms of noise and noise is, you know, drifting towards the thinner end of the sciences too, in my opinion. (C11)

This description is also one indication of the 'science is different from technology' macro theme, when she distinguishes sound experts from scientific experts.

For three other commissioners, the classification of scientific evidence was described as having an element of change or flexibility. The following extracts illustrate these approaches:

Ah, when I first kicked off, we didn't have traffic engineers or landscape architects. All these things have developed and then you have got to say, are they scientists or are they what? ... It's really an evolving thing.

...So the word “scientist” is being used, like consultants, very, the picture is changing. (C5)

No I think the pendulum moves over as I say, there is a modicum of a degree of science in all of them, but it is progressively diminished. Architecture has some scientific limits, but architectural appreciation is a non-scientific thing. Landscaping is to a degree in the eyes of the beholder and planning is almost a play on words. (C2)

I have my astrology charts done for my own personal life, but that is a science, I guess. ... It depends on how broad the definition of science is, I guess. (C10)

Each of these three commissioners perceives the definition or boundaries of science to be changing or developing but each would draw a different boundary and for different reasons. Commissioner 2 had an intense association between the requirement for measurement or data and also a defined body of knowledge and the appearance of science. Each of those key themes was identified at four different places in the interview, for example:

Yes where a knowledge of demographic trends and things are based on background statistics and calculated projections and things like that. It is scientific...Again, where you have the study of case history and have a body of knowledge, you have to accept that that is scientific. (C2)

For Commissioner 5 the key themes which differentiate science from non-science are the traditional subject areas and qualifications as an earlier quotation illustrates.

Commissioner 10 also strongly identified science with evidence of qualifications, however her category of qualifications was considerably wider as is implied in her reference to astrology, above, and by the following comment:

Sociology. Analysis of community needs. That whole process is a science. Anything that requires a professional person to be in front of me, stating their qualifications and putting their reputation on the line on paper has a science to it for me. (C10)

These extracts illustrate that the macro theme, science = expert dominates Commissioner 10's model of science.

### 5.5 **Fact/Proof/Certainty**

Under this theme, I have collected references to fact, proof, certainty, accuracy, precision and exactness. Interviewees have used these terms variously and in combination to link science with something that is known to be a fact, or is not disputable. In each case, the more that evidence can be defined as factual and proven, then the greater its connection with science. It is tempting to describe this connection as an analogy with truth, but interestingly none of the interviewees articulated the idea of fact or certainty with the concept of truth. I have separated this theme from empirical measurement and data, as some responses indicate that there can be certainty or fact associated with evidence without any direct empirical research by the expert witness.

Some interviewees describe scientific fact as an element in a fact/opinion dichotomy as illustrated by the following:

... you have this body of scientific information and then we get to this point and what is science fact, science opinion what's the line between fact and opinion and at what point in time will draw opinion from facts. (J5)

Judge 5 uses a fact/opinion dichotomy not to differentiate science from opinion, but rather to differentiate factual from opinion scientific expert evidence. For Judge 5 the concept of fact is a key element in his view of science, but he recognises that facts and opinions are closely linked. In the following passage he tries to illustrate how he differentiates factual from opinion science drawing on theoretical physics and engineering as examples:

...I would say to the physicist, you're not dealing in facts only you're dealing with assumptions and opinions you've based on those assumptions and therefore you're dealing with opinion. Therefore it is an art or some of us call it a less black art in, in the sense that much of science comes down to opinions when you scratch beneath the surface and much of art actually has a foundation in fact as well,... And on the other end you're going to have areas that are very high in science like engineering, for

example, which is about how much water falls and how much is the pond and how much is the run off, but then again there are elements of opinion in all of those things too. So um I would see it as a continuum. (J5)

Here he analogises ‘art’ with the giving of opinions and concludes that the types of evidence most closely relying on fact or data, in this case engineering evidence, display more elements of science than does physics which involves the formation of opinions based on assumptions. Although the concepts of fact and measurement are recurring themes in Judge 5’s description of science and scientific evidence, they are not his sole requirements as indicators of science and this is evident in his description of a continuum between opinion and fact within his own model of science.

Judge 7 also differentiates between scientific fact and opinion. It is unclear whether he is actually distinguishing between scientific fact and *scientific* opinion or with opinion generally but he comments that there can be no certainty of knowledge in such a way that his distinction appears to be the former.

It depends on whether we’re talking about scientific fact or opinion here, because (pause) there, it’s one thing to, the pursuit of certainty of knowledge is, is a difficult thing, ... There is no certainty, but I didn’t give you an example. (J7)

He then proceeds to give an example concerning land alongside a lagoon which is sheltered from the sea by a beach barrier. In an application for development of that land expert evidence was given as to the likely long-term effects of littoral drift on that piece of coastline and the corresponding effects on the beach barrier. The expert’s evidence was not contradicted in the hearing and was accepted by the Court, but Judge 7 implies that there will be no certainty about the evidence until the 35 year timeframe is concluded and the physical changes to the land can be observed. Judge 7 links the concept of hard science with accuracy. He has a model of science that emphasises the accumulation of knowledge and then distinguishes hard from soft science according to the accuracy and specificity of the evidence. His use of the words ‘accurate’ and ‘specific’ imply that evidence, or knowledge, based on measurement will be classified as hard science.

Judge 3 relies on the concept of fact to distinguish scientific from non-scientific evidence. As illustrated by the Egyptian analogy quoted in the previous section, Judge 3 has a very broad definition of science that includes practically any relevant evidence that can be supported by fact. His meaning of ‘fact’ seems to equate with physical evidence. For example the discovery of bones in the Egyptian tomb or as the following example illustrates, physical evidence of contamination of water.

I don't think sciences, science has just got to be sorting out what the orbit of Mars is, or something like that. Its, ah, the applied sciences, I find are much more useful than the straight sciences, but the, ah the straight sciences are normally used as a springboard for the next opinion. With a planner who says, well, I'm relying on the evidence (a) that there will no unacceptable contamination to this lake. Therefore accepting that there will be no amenity detraction caused by the discharge. My views are - But then the only useful question to ask that witness is, ah, that I understand that the person called by the opposition is going to disagree with this particular expert on his evidence on which you base your theories. If the Court accepts the opposing evidence, would your views change? And you would normally find that they would....So, that's probably a good example. If you've got the, ah, the factual situation of will the water be contaminated or won't it? (J3)

The above quotation demonstrates Judge 3's very broad understanding of science. His examples include reference to the predictive power of science where he alludes to astronomy and he also describes the applied sciences as more useful. The ‘straight’ sciences are those like astronomy which he does not categorise as ‘applied’. Like Judge 5 he seems to identify the theoretical components of ‘straight’ science that are used to ‘spring’ to a scientific opinion. In this context it appears that he categorises planning evidence as relating to the ‘straight’ sciences in that it is evidence based on “the factual situation”. Where the “factual situation” is found by the Court to be consistent with evidence to the contrary, then the planner's opinion as to the amenity detraction will most likely change accordingly. That is, a new opinion, or prediction, will be formed based on the

changed 'factual situation'. This quotation also illustrates that for Judge 3 the 'factual situation' is that which is accepted by the Court. It is not an immovable physical truth, but rather an assessment of the physical evidence that is found by the Court to be most credible.

Judge 8 was reluctant to differentiate scientific evidence from other types of evidence although he directly contemplates expert evidence in fields other than science. He defines expert evidence as follows:

...rather than look upon it as scientific evidence, I look upon it as expert evidence and expert evidence, in my view, is evidence which is given by a person who has, has an accepted or a proven expertise in a particular field and can therefore give evidence, not just the facts, but also his or her opinion and so I prefer to look upon whether a person is an expert witness or not an expert witness. They can have expert witnesses in fields other than science. (J8)

Although Judge 8 refers to facts separately from opinions his entire interview shows that measurement and data are very strong themes in his model of science. This extract also illustrates that Judge 8's model of science is not consistent with the science = expert macro theme. His examples of types of evidence that would be included in his classification of science include engineering and other technologies and is most consistent with the second macro theme, 'science includes technology'.

Commissioner 11 alluded to 'proof' when asked to differentiate between scientific and other types of expert witness as follows:

Well, I think (pause) I think the science is science and there is a proof of arguments, proof of research which has gone on to enable that person to come that opinion. (C11)

This association of 'proof' with the Court's acceptance of a scientific opinion was a strong theme for Commissioner 11. When asked to identify what makes evidence scientific she makes the point that opinion evidence from a scientific expert is not enough in itself.

I think we come back to the standing and the qualifications. Um, and the proof, the proof that the experiments or the process which is established is to be fact withstands the jurisdiction of the Court and withstands the process of evaluation by the Court. (C11)

For Commissioner 11 evidence must be supported by ‘proof’ as to the process that provided the evidence of fact. Here, ‘fact’ must be supported by proof and is only ‘fact’ to the extent that it is accepted by the Court.

By contrast Commissioner 1 differentiates scientific evidence from other types of evidence, including sociological and psychological evidence on the basis of ‘exactness’ and describes the social sciences as “not exact sciences”. Commissioner 1 closely links scientific fact with certainty as illustrated in the following extract where she responds to a question about the Court’s confidence to rely on uncontested scientific evidence:

You’d have to accept the evidence. It doesn’t mean to say that the evidence would necessarily form um an important part of the decision, but you can’t deny incontrovertible scientific fact. You’ve got to accept it and we do, but we use it as we feel appropriate... (C1)

She describes the features of ‘pure science’ as those relating certainty and proof, as well as other concepts associated with scientific method, for example replication of results.

Incontrovertible proof and by incontrovertible, the only proof that’s incontrovertible is proof that can be repeated and repeated and repeated and you come up with the same answer. Reproducibility of result. That’s pure science. One and one are never going to be three, so it’s got to go on like that. (C1)

Allusions to ‘fact’ or a ‘factual basis’ or ‘foundation’ are also key themes in Commissioner 10’s model of science. She describes the “scientific model” in contrast to her own life experience as follows:

Well in a scientific way. In that everything has to have a factual basis to it. Personally my world is not like that. (C10)

And:

My concern is, I guess, in a bigger picture, would be where in the industrialisation and scientific models that we tend to lean towards, because they have some foundation, we are actually missing the point about what life is really about, in a general sense. (C10)

Unlike Commissioner 1, who is definite in her acceptance of “incontrovertible scientific fact”, Commissioner 10 expresses a reluctance to embrace what is her own model of science. In the first extract, above, she distinguishes her own world from her perception of the scientific model and in the second extract she expresses concern with what she perceives to be the role of those scientific models.

For Commissioner 8 the fact/proof/certainty theme was the most frequent of several micro themes used to describe her model of science with 5 different references to fact, accuracy, precision or proof. When asked about the type of disagreement that arises between the evidence given by ‘opposing’ scientific experts she comments:

I don’t know if I can answer that. You would think that fact is a fact, but often they assess a thing from a slightly different angle... (C8)

Commissioner 8 does not express reluctance to rely on scientific evidence, but emphasises the need for accuracy:

But they are paid to give evidence that should be accurate and should be based on fact and should be well, well, well researched. ...

I mean one could be facetious and say when one calls himself a scientist you have to accept that their evidence is scientifically based, but again it must be accurate with information that they know must be relevant. (C8)

## 5.6 Empirical Measurement/Data

Measurement and data were significant in the models of 7 of the 8 judges and 4 of the 13 commissioners. In addition, at least one of the 4 commissioners who expressed views encompassing the concept of fact or proof, also implied a close relationship of that concept with measurement or data. Following her reference to

“incontrovertible scientific fact” Commissioner 1 illustrated her statement by giving the following example:

... but you can't deny incontrovertible scientific fact. You've got to accept it and we do, but we use it as we feel appropriate and you could, you could take a fact that an extremely loud noise of say 95 dBA is coming from a bar. Now we have to accept that 95 dBA coming from a bar, recorded on a sound machine, on a sound recording, is an unacceptable noise for any time of the day or night and it is often coming in the evenings in sounds from ... (C1)

In this example she links the idea of a ‘fact’ with the evidence of sound measurements recorded mechanically. Her example implies that so long as the accuracy of the device itself is not challenged, the very existence of measured, perhaps especially mechanically measured, data is sufficient to make that data an “incontrovertible scientific fact”.

Of the other 3 commissioners with fact or proof as a key theme in their model of science none can be specifically linked to a requirement for data or measurement. Commissioners 8, and 11 indicated a link between ‘fact’ and research or experiment but no direct link with data or measurement. On the face of it there seems to be quite a difference between the approach of the judges and that of the commissioners given the very high proportion of judges for whom data or measurement was significant.

#### 5.6.1 *Empiricism*

Judge 8 very closely associated the theme of ‘empiricism’ with his model of science, using the adjective ‘empirical’ (or as the adverb ‘empirically’) 16 times during the interview. Judge 8 never directly defines his understanding of the word ‘empirical’ but he uses it in conjunction with the word ‘analysis’ six times and in conjunction with ‘research’ and ‘investigation’ once each.

...um I suppose there's two types of new theory. There's a new theory based on empirical you know analysis if you like, applying certain methodologies which is very logical and there's others which are, are based purely on, on the unknown and they're two different things. You

can have, you can have fringe, fringe, not fringe, but new ideas coming forward which are, which are quite methodically and logically and empirically based, but, but you can also have new ideas that are come forward that are more conjecture and there's a difference. ...Most new theories are based on empirical research. Conjecture theories are not based on empirical research. That's the difference....I mean a lot of scientific evidence um is not so much empirical, but I suppose it's got an empirical base, but so often um the results come from various models which are, which are and most of them and many of them are mathematical models which are, which are um, are um created I suppose, I suppose created is not the word, but formulated, um so you couldn't say the evidence in that situation is necessarily empirical. So I wouldn't necessarily say that empirical evidence is saying evidence which comes from empirical investigation is scientific, now, now that would be too strong. (J8)

This rather long quotation usefully encapsulates the significance of the concept of empiricism in Judge 8's model of science. The frequency of his references to empirical analysis illustrate the importance of this theme to his model of science, however, it is not conclusive of scientific evidence. His comparison of empirical scientific evidence with mathematically derived evidence provides an example that is not completely empirically derived, (although it does have "an empirical base") but which he would still classify as scientific. His last sentence in the above quotation also contemplates that empirical evidence in itself does not necessarily determine its scientific character, and the earlier reference to logic and methodology indicate that these themes may also need to be apparent. The significance of empirical research to his model of science is consistent with his classification of scientific evidence, which reflect the macro theme, 'science includes technology'.

For Judge 5 the concept of empirical data is a recurring theme, with six references in the interview. His direct linkage of the word 'empirical' with the word 'data' suggests his understanding of the term, and he gives many examples in explanation that refer to data or measurement. When asked what made scientific

evidence scientific, he responded: “I think it’s getting some empirical data to support - and another example I just thought of was...” Judge 5 closely links empiricism with the idea of a ‘scientific method’ and the following extract is a very clear explanation of his understanding of ‘scientific method’:

I personally am of the view that scientific method is to collect data, assemble and extrapolate that data, form an opinion based upon that data, then test the hypothesis. And I believe it’s that initial step which has led to many of the errors that have been made in scientific, scientific assessment really. They are working from an assumption back to, and one, and we’ve seen, sure I mean, sure you’ve found more than me, where scientific method has been sacrificed to get the right results. One has ignored them, on occasions, I remember in some of - I remember in physics a lot of the results were treated as random results, when in fact um if they had taken them into account, they would have got a much different answer to the hypothesis they were working on. (J5)

Thus the availability of empirical data can improve the scientific method and provide different conclusions. He then continues to give an example concerning global warming where an expert who gave evidence had collected “hard data” on a weekly basis of wave action on a beach and comments:

So that’s actually the only hard data anyone’s got and unfortunately it doesn’t fit with the assumptions everyone has made, so it’s then it’s been discounted on the basis that it’s empirical data and not on a long enough period, which is how you always discount empirical data, but the point in my view is that if people actually worked on assembling the data first, they might come to a very different conclusion. (J5)

In this extract Judge 5 notes that empirical data is often discounted by others, or is easily avoided by attacking the method behind it - in this case, by attacking the sample size for the weekly measurements. Judge 5’s interview reflects the macro theme, ‘science different from technology’ when he identifies engineering as being “generally science related” rather than being science of itself. He identifies concepts such as sound, electrical and electromagnetic waves as being the scientific elements of engineering.

The adjective ‘empirical’ also recurred in three different parts of Judge 1’s interview. He used the term, empirical research, to differentiate soft from hard sciences and suggests that the soft sciences, for example sociology, do not often produce empirical results that are replicable. Judge 1 also notes that his category of *good* scientists would include both empiricists and theoreticians:

I mean, all the really good scientists and there’s not just, um, empirical ones, ah, but the theoreticians too, Newton or Galileo or people like that.  
(J1)

The phrases “there’s not just” and “but the” suggest that empiricist scientists would be his first and natural choice for the category of good scientists and the theoreticians should not be forgotten, as if they are an afterthought. Thus he appears to give considerable weight to the role of empiricists within *good* science. It is also interesting to note that both Newton and Galileo relied heavily on observations and data in order to formulate and test their theories and could justifiably be described as empiricists in the classical sense. The use of these 2 scientists as a contrasting example of theoretician suggests that either Judge 1 has a different understanding of the word empirical, or that his understanding or memory of the history of science was awry at that moment.

### 5.6.2 *Data and Measurement*

Judge 4 directly linked the notion of quantification and data to his understanding of science. When asked to explain what makes scientific evidence scientific, he said:

(long pause) To be able to be built up from research to data bases, um, and quantified in a way that is peculiar to the discipline. Um, and is very, I mean, if it’s done properly is actually very easy for a non-scientist to follow, um, although I must admit some of the mathematical formulas I have difficulty with. Um, and I guess a good witness is one who can make that intelligible for the lay person and for the Court. Have I answered your question? (J4)

His reference to quantification and to his difficulty with mathematical formulas, indicates that data and measurement are integral to his understanding, and expectation of scientific evidence. Judge 4 also linked the analogy of hard science with hard data suggesting again that data is what separates the hard sciences from those “dealing with more socio-economic matters”. His reference to precise measurement was also central to the identification of ‘science is different from technology’ as the macro theme consistent with his model of science. Judge 4 commented that; “I’ve always thought of engineers as almost scientists.” When asked to explain what it is about engineering evidence that is close to science he responded:

Because they can give precise measurements and then predict on those measurements what may or may not happen, which is very akin to science. They can be more precise often than the scientists, as can be the lawyers’ experts. (J4)

By these comments Judge 4 clearly contemplates that precision and measurement is important in both science and engineering but that there is a difference between the two.

For Judge 3 data and measurement are relevant to his view of science, but in a much broader sense. Judge 3 equates scientific evidence with relevant evidence and thus includes any documentation or expert opinion which supports that evidence. For example, Judge 3 described an ideal expert with reference to evidence given in a hearing concerning a power project.

...they would produce maybe 30 or 40 pages of documents written in just straight English, in terms that anybody could understand. Saying what was going on and what in their opinion was, ah, was ah, acceptable, say noise or something like and what conditions they would suggest, etc, etc, and hooked on to that evidence would be a lot of documents, about that thick, which would contain all the scientific data, the research they’ve done, the calculations as to water flows and temperatures. (J3)

As I have noted previously Judge 3 does not differentiate scientific evidence from other types of expert evidence, nor from relevant evidence as such and his reference to scientific data is a reference to the file of documentation that supports expert opinions.

Judges 2 and 6 only directly referred to data or measurement once in their interviews but both did so when describing their understanding of the scientific nature of evidence.

Well, I think it's to do with the application of reasoning to the problem, which leads to careful collection of data to thoughtful application of tests and to the application of reasoning to the results in leading to an interpretation or opinion. (J2)

[With reference to an identifiable psychologist] those people still have to be scientific, in as much as they compile data and ah and demonstrate that their opinions are sound in the light of what they've compiled, so we would go into their methodologies and so, and again traffic engineers fall into a similar class where they go out and take surveys and have their staff out counting numbers and peak periods and all this sort of thing, and um, so on. (J6)

For Judge 2 the collection of data is part of his description of the process of science and for Judge 6 the compilation of data is a common feature in both of his examples and is the basis on which scientific opinions are built. Judge 6's reference to an inquiry into methodology is also with reference to the data collection underlying expert opinions.

Of the commissioners, only four had empirical measurement or data as key themes independent of proof or of a more general concept of method. Of these four, three directly linked this theme to their understanding of the essence of science. Commissioner 2 described science in terms of a body of knowledge that is based on measurement and data. She illustrated her approach to social science as follows:

That is a bit of a play on words. Yes where a knowledge of demographic trends and things are based on background statistics and calculated

projections and things like that. It is scientific... Again, where you have the study of case history and have a body of knowledge, you have to accept that that is scientific. (C2)

She also distinguished science from social science by the ability of the latter “to be established in the absolute”. When asked to explain what factor enabled her to recognise that scientific evidence was established in the absolute, she responded:

I think measurement is probably the answer to that. You stick a thermometer in water and it reads such and such. That is evidence hard evidence as distinct from ‘the water felt warm’ or whatever. I think measurement where evidence can be adduced from physical measurement I think that has a stronger standing than evidence based on an assessment basis. (C2)

For Commissioner 2 the scientific essence of evidence is the knowledge base referred to above, but she describes the capacity for measurement as desirable.

The case [is] to be knowledge based, desirably capable of measurement, capable of repetitive confirmation, um and I would think they are some of the characteristics. Possibly having a demonstrated outcome that can be, if not repeated, alluded to or shown to be the case in other circumstances. (C2)

Commissioner 2 seems to be saying that science is certainly knowledge based but that a mechanism for differentiating science from non-science is the extent to which knowledge has a foundation in measurement. In addition the ability to replicate measurable results “confirms” the evidence.

Commissioner 5 identifies data and measurement as key to the degree of weight attributed to particular evidence. She also differentiates social sciences, which she terms “human sciences” from the “hard sciences” by their lack of measurement:

I suppose to put it bluntly, it is a bit of a moving target. [Social science] Ah, whereas, I’ve said you can measure water quality, you can measure traffic, but people’s values and perceptions change and I can ..., (C5)

Commissioner 5 sees measurement as a constant on which she can rely whereas evidence based on values and perceptions, that she analogises with social science, is changeable and impliedly unreliable.

Commissioner 9 had a very strong theme involving replication of data as her essential characteristic of scientific evidence. Explaining the importance of the replication of data she said:

That's the surest foundation of scientific evidence. If it can be demonstrated ah the data, that different persons can produce comparable data and that different persons using that data can, ah, replicate conclusions. Um, that's the core about a good scientist, and one can move from there and say, well sometimes the evidence will be well the data is inconclusive, but the conclusions I draw from it are these and some others would say. Yes we agree the data is inconclusive, but, um, my conclusions are in conflict with yours. (C9)

She clearly anticipates that scientists may differ in their conclusions based on the data but that a "good scientist" will produce data that can be replicated by themselves and others. She does not refer to the method of data compilation or publication of that method, suggesting that the data itself is the crucial characteristic. It is unclear from her statement just how the data itself could be inconclusive, and she seems to suggest that the data may have a clarity or otherwise that is distinct from the expert's assessment or conclusions based on that data. Commissioner 9 again directly links the measurement and replication of data with the essence of science when she says:

The essence of, um, the core under the heading of science is, ah, measurement and replication and the conclusions arriving from evidence of data measurement. The replication of that. Well by definition one can't do that in social science, or so called social studies. One can't experiment with human beings and replicate the [unrecognisable word] situations. (C9)

She is hostile to the term 'social science' and suggests an alternative of "social studies" to describe those academic disciplines that involve interpretation and evaluation of non-measurable matters; approving of Auckland University's department called political studies rather than political science.

Commissioner 6 uses the concept of data and measurement to differentiate scientific experts from other types of expert. She does not strongly link this concept to her explanation of science but infers its importance when she describes "the proper scientific and integral way" in which scientific experts approach their work.

Well, I think as I said before, somebody that, um, sort of sets out what the basic facts, the basic data he's got, as they apply to the, ah, specific case in hand and then uses that data to reach a conclusion and explain, explains clearly how, how and why he's reached the conclusions he has ... (C6)

Commissioner 6 also commented that disagreement, or rather refusal to agree, over slight differences in measurements, for example ambient noise measurement, is a common source of difference between scientific experts. From these references I infer that Commissioner 6 considers that measurement and data are important features of scientific endeavour, but she articulates that the common factor which differentiates science is a connection to the disciplines which have been historically associated with science.

### 5.7 Process

The identification of science with a particular method, or process was a theme in the models of seven out of eight judges and seven out of 13 commissioners. While a particular process was identified as being integral to their model of science, this group of interviewees had differing descriptions of what constituted that process. In addition the context of that process also differed. For some, the process was what provided proof or certainty and for others the process provided the body of knowledge that is science. Four of this group explicitly referred to a "scientific method" and two interviewees described science solely in terms of a specific process. Another six interviewees referred to the requirement and ability

to reproduce scientific results and of these two identified the ability to replicate results as the essence of their model of science.

### 5.7.1 *Science is the process*

Judge 5 strongly identifies science with the collection and analysis of empirical data and facts. He has a clear personal view of the method of science as illustrated in the following 2 comments:

I personally am of the view that scientific method is to collect data, assemble and extrapolate that data, form an opinion based upon that data, then test the hypothesis. And I believe it's that initial step which has led to many of the errors that have been made in scientific, scientific assessment really.

I suppose I would, we see science as a person who, who is interested firstly in collecting facts, yea, and doing all of those things and then assembling that, extrapolating that, forming an opinion, testing the hypothesis. I suppose that's to me what a scientist would be. (J5)

Judge 5 is very clear that scientific method is the process by which data is collected and then analysed to form opinions. The second extract suggests that scientists will have done "things" with the data although he is not specific as to what those things would be. The common factors in his method are the collection, assembly and extrapolation of data.

Commissioner 4 also describes science as a process and refers to the process of science at three points in her interview. Her explanation of what makes evidence scientific refers to the following method:

Ah, well I guess it's probably somebody who has a research project, or something and they go through a you know they have a particular hypothesis and they go through and test it and do whatever they need to do. Set up some sort of experiment or do some sort of research.

If you've got somebody who is putting forward an idea or a hypothesis and they have just gone about testing it somehow and researching it come up with a result and give their opinion on analysing that result. (C4)

When asked whether the explanation above would also summarise her view of what science is, she responded:

Probably I would say and whether that's just from my background. Yea. I'm not sure. You know, the old experiment. Method. Aim. (C4)

Thus the key theme in her model of science is of a particular process or method which begins with a hypothesis and produces results. She does not separate any knowledge component from the process by which that knowledge is obtained. Commissioner 4's examples of scientific evidence also indicate that her model of science is most consistent with the 'science is different from technology' macro theme.

#### 5.7.2 *Science involves a process*

Commissioner 8 describes science in terms of providing proven facts, however, she distinguishes social science from science by the process of experimentation that gives rise to 'proof'. When asked about the purpose of science she responded:

Well I guess it is something that can be hypothesised and then proved. I don't think you can do that with things like sociology, for example, to the same extent, but proved by experimentation, trial and error, etc. (C8)

She referred to traffic engineering evidence, and when asked whether she would describe such evidence as scientific, responded:

So long as it was based on research and trial and error I guess.(C8)

From the interview with Commissioner 8 and particularly the extracts above, it appears that her model of science is one that involves a process of experimentation that gives rise to provable facts. Although she is not explicit about the process, it involves experimentation from a hypothesis. Her repeated reference to "trial and error" suggests that her view emphasises the process of data collection rather than reasoning and theorising.

Judge 1 also refers to the methodology of science and as a means of distinguishing science from social science. He describes that methodology in terms of reasoning, empirical results and reproducibility of those results. His explanation of what makes scientific evidence scientific describes the following method:

Um, (pause) first of all it has to be reasoned, it has to set out what assumptions have been made and why they come to the conclusions they do, and of course in that it doesn't differ from any other rational behaviour. I suppose what science also does, it depends on, um, empirical research, um, and work that has all the other indicia of scientific work...(J1) [ Judge 1 continues to illustrate with reference to a particular decision.]

The "other indicia" referred to include: reliability and error in research techniques; publication and peer review of research findings; and replication of results. Of these indicia, he identifies the process of replicating empirical results as distinguishing hard science from soft science. When asked whether the extract above would summarise his model of science, Judge 1 answered:

Um, well no, because that's closer to hard science. Although, of course it's interesting, it's an interesting sociological phenomenon I suppose, that soft science tries to do the same thing, but without very often, um, empirical results that are repeatedly or replicable and I suppose that simply shows the mana that hard science has that people are mimicking that in form, if not in substance. (J1)

Judge 2 refers to scientific method in terms of investigation and research, but his model of science emphasises the importance of the scientific community and the ability of that community to replicate scientific results:

By the regular application of the scientific method to investigations and research and by following the customs in the scientific community of publication and peer review. The Court is as interested in those methods as ah as the scientific community is. (J2)

Judge 2 further defines what makes evidence scientific as follows:

Well, I think it's to do with the application of reasoning to the problem, which leads to careful collection of data to thoughtful application of tests and to the application of reasoning to the results in leading to an interpretation or opinion.(J2)

Although this passage describes a methodology involving reasoning, data collection and testing, his description of science and scientific evidence strongly asserts that the purpose of that methodology is to allow for the scientific community to accept or reject findings which are peer reviewed and published.

Judge 8 refers to 'methodologies' in science but does so as part of his emphasis on an empirical basis as the essence of science. Judge 6 makes similar references to methodologies, but in the context of how expert witnesses collect and interpret data. Judge 6 does not differentiate scientific evidence from other types of expert evidence and his comments focus on his expectations of expert witnesses and evaluation of their evidence.

Judge 3 also refers to a methodology as being "the scientific part of social sciences" but this reference is tied to his explanation of the way that scientists can apply scientific 'facts' in order to predict future events or explain the world. For Judge 3, evidence of physical or measurable data, is key to his model of science.

Commissioner 11 describes science in terms of "a process which is founded in...the principles of science". She does not clarify what are those principles, but does emphasise the importance of facts and proof:

I think we come back to the standing and the qualifications. Um, and the proof, the proof that the experiments or the process which is established is to be fact withstands the jurisdiction of the Court and withstands the process of evaluation by the Court. (C11)

Commissioner 11 refers to scientific process as the way in which the Court may scrutinise evidence to verify facts or certainty. She does not emphasise process as being the essence of what makes scientific evidence scientific.

### 5.7.3 *Replication*

Two interviewees emphasise the importance of the ability to replicate scientific results as the significant feature in their model of science. The importance of replication is clearly illustrated by Commissioner 9 as follows:

That's the surest foundation of scientific evidence. If it can be demonstrated ah the data, that different persons can produce comparable data and that different persons using that data can, ah, replicate conclusions.

The essence of, um, the core under the heading of science is, ah, measurement and replication and the conclusions arriving from evidence of data measurement. The replication of that. Well by definition one can't do that in social science, or so called social studies. (C9)

Although Commissioner 9 identifies the production of data as a key indicator of scientific evidence, she does not describe any particular method for scientific endeavour. Instead she emphasises that the essence of science, that distinguishes it from social science or "social studies" is the ability to replicate those results.

Commissioner 1 has a model of science in which the concept of proof is a key theme. She equates proof with the ability to replicate results and describes the characteristics of science as:

Incontrovertible proof and by incontrovertible, the only proof that's incontrovertible is proof that can be repeated and repeated and repeated and you come up with the same answer. Reproducibility of result. That's pure science. (C1)

Commissioner 1 refers to scientific endeavour as involving acceptance of hypotheses and the logical application of scientific knowledge, however, the key factor which differentiates science ("pure science") from social science (which she does not consider to be science and describes as "garbage") is the ability to reproduce results. When explaining why she does not include sociology and psychology in her definition of science she comments:

They – inexactness. Their inexactness. They are not exact sciences.(C1)

So what makes something exact? (Interviewer)

Its reproducibility. If you can't reproduce the evidence of a psychologist.(sic) (C1)

She returns to this theme of replication at several points in the interview including the following where she equates the work of good scientists with reproduction of results:

These people are not biased, they are very good scientists, they accept that reproducibility and a basis of theory, hypothesis and proof, concept the scientific reason (sic) and they work on those principles and they come up with answers that say it doesn't, or it does, or doesn't or whatever. (C1)

#### 5.7.4 *Process linked to knowledge*

Judge 7 has a model of science in which the accumulation of a body of knowledge is a very significant theme. He refers to scientific method as the method by which scientists go about "systematically formulating their knowledge and testing it." However, despite several references to systematic formulation of knowledge, Judge 7 does not elaborate on his expectation or understanding of the system.

Commissioner 2 also refers to the requirement for replication of results and this is her only reference to any process associated with science. The significant theme in her model of science is the formulation of a body of knowledge and evidence of replication of results is what gives that knowledge credibility.

Commissioner 7 has knowledge as a key theme in her model of science, and her references to research and "scientific method" are in the context of describing how the body of scientific knowledge is formed.

There was a time when the "scientific method" became defined as honest unbiased studies of cause and effect and people stated what they found and formed a theory of it, if they could, and if they couldn't then they shut up about it. (C7)

She also refers to experimentation as what distinguishes scientific knowledge from statements lacking scientific credibility:

The word “science” just means knowledge, doesn’t it? I suppose, well, as science developed from Newton on, or even perhaps before that, the idea of testing theories, as distinct from statements.

Yes. Of course there was a time when philosophers made statements without ever bothering to find out the facts of the matter. Even how fast a thing would drop. The action of gravity they made wild statements, but until somebody got up there and dropped something and took into account the air friction and a few other things. (C7)

She does not articulate what constitutes scientific method or studies of cause and effect as, in her model of science, the process by which knowledge is obtained is clearly subordinate to the knowledge itself.

#### 5.7.5 *Research, testing or experimentation*

Three other interviewees referred to some sort of process in science, either by example of experimentation, or with a general reference to research.

Judge 4 has a model of science in which data and measurement are important. When describing what makes scientific evidence scientific, he responds:

To be able to be built up from research to data bases, um, and quantified in a way that is peculiar to the discipline. (J4)

He continues to note that the issues may vary among scientific disciplines but the way that scientific knowledge is “constructed and produced” does not greatly differ. This implies an underlying perception of a common process in science.

Commissioner 3 refers to experimentation obliquely when she explains why she would separate social science from her definition of science:

Well (laugh) when you get into determining how people are going to behave or should behave under certain circumstances. It’s that “should behave” that, that separates it, I think. Um, you know, now if I apply a scalpel to you, you’re going to bleed, um but if I do something, if you should do something then you may not, you know...(C3)

Commissioner 10 also refers to research in the context of the factual basis of her view of scientific evidence. She does not articulate any particular process to this research, which is consistent with her understanding of all expert evidence as being scientific.

### 5.8 Objectivity

Only 2 of the interviewees referred to objectivity, either directly or indirectly, when articulating their understanding of the nature of science. Another 8 interviewees referred to the need for objectivity when describing the characteristics of experts in a more general sense.

The interviewees which held a model of science incorporating a concept of objectivity were Commissioners 7 and 8. When describing her understanding of the purpose of science, Commissioner 7 commented:

I suppose understanding the causes of change, seeking the link between cause and effect, evaluating available data without previous bias, presenting data which don't fit as well as that which does fit. (C7)

Commissioner 7 describes her meaning of "without previous bias" with reference to critical evaluation of both supporting and negating data. She alludes to the idea of bias to distinguish between theorising with no basis of experimental data and scientific theories arising out of the application of scientific method, "defined as honest unbiased studies of cause and effect" where "people stated what they found and formed a theory of it, if they could, and if they couldn't then they shut up about it." Commissioner 7 has a model of science that has the concept of scientific knowledge as a key theme and she describes that model with reference to how scientific theories can be confidently relied on as contributing to a body of knowledge. She also has a view of science as something different from technology, and has a professional background in a technical field. Her explanation of science is of a process that develops a body of knowledge that explains the present, past or future world and the 'objective' component of that process is to enhance confidence and reliability in that knowledge.

Commissioner 8 also refers to objectivity in the course of describing her model of science, however, she seems to hold a more classical meaning of the term in which she contrasts objectivity with subjectivity, linking the former with data and the latter with values. For example:

Perhaps on the precision thing for real science, a scientist is possibly more precise, or should, or could be, or should be I think. I mean things like, for example, landscape architecture is much more subjective, whereas a scientist's evidence is usually more objective. (C8)

The first sentence of this passage suggests that Commissioner 8 links precision (and by implication, data) with objectivity whereas subjectivity is linked with personal perception and values, as indicated by the use of landscape architecture as the example. She implies that "real" science involves precision and that this is achievable because subjectivity and the personal value judgements associated with subjectivity are not involved. Commissioner 8 refers to the key theme of accuracy, precision and fact more than to any of the other themes, however, she never directly refers to measurement or data. I infer from her comments, in the context of the entire interview, that a notion of a scientific method in which subjectivity is minimised or eliminated is what produces her confidence in the precision and factual accuracy of science.

The other interviewees who referred to a concept of objectivity did so in relation to discussion of the merits of expert witnesses in a more general sense. Judges 7 and 1 both used the term in a sense that corresponds to scientific objectivity as described by philosophers or historians of science. Judge 7 described the role of an expert witness to include giving:

their own objective analysis of the case that they are supporting, ah, at least they're presenting an opinion that supports their particular expertise. And, ah, um, that they will um answer questions in cross-examination fully and frankly, ah, regardless if that damages their client's case or not. (J7)

This passage suggests that criticism and questioning of expert opinions and the support of those opinions with reference to the witness's own expertise is central

to the meaning of objective analysis. Judge 7 also refers to the importance of establishing that a witness has expertise within a given field and that that expertise is recognised by the relevant community of peers. Judge 1 expresses an understanding of objectivity that is more consistent with that of Commissioner 8. Judge 1 does not understand objectivity to be equivalent to neutrality in the Baconian sense, but related to the process of reasoning. He also distinguishes objectivity in the scientific sense, with reference to scientific as opposed to other types of expert, as being less values-laden:

I think the important qualities of a good expert are objectivity, which I appreciate is not an absolute quality, but does nevertheless exist... Well the mere fact that they are applying, um, (pause) scientific method, ah, to the case, well at least scientific results in a reasoned way the facts of a case, um, means that if, um, that evidence is crucial that it gets significantly more weight. As there are less value judgements and less cultural evaluations involved.(J1)

Conversely, Judge 1 describes the characteristics of poor witnesses to include a lack of objectivity. He seems to have a view of scientific objectivity in which the integrity of the scientific process is enhanced by the reduction of value judgements.

The remaining group of interviewees that refer to objectivity of expert witnesses as a quality of good experts, all use the term to differentiate the giving of an opinion based on the witness's own expertise from the advocacy of a view in favour of the client or employer. The members of this group are Judges 6, 2 and 4 and Commissioners 1, 3 and 4. This use of the term is illustrated in the following passage from Judge 2 where he describes the role of an expert witness.

Well, to bring to the Court an understanding of the (pause) of the true nature of, of that particular um issue, which is one that the Court won't necessarily have a full understanding of themselves, but to do it in a way that's objective, rather than partisan or campaigning. When people claim under ah the guise of giving expert evidence to be assisting the Court, but are really conducting a political campaign or a partisan case, the court

really doesn't have um faith in anything that they say, they tend to become discredited in the minds of the Court. (J2)

Judge 2 articulates his understanding of objectivity to mean impartiality as to the implications of an expert's evidence. The objective witness is one who does not advocate views in relation to a proposal. This interpretation does not necessarily require the avoidance of value-laden judgments or recognition of one's own opinions within one's community of peers. Rather it requires that the witness not advocate those views on behalf of the parties to the case before the Court. Two of this group also commented that evidence from a witness lacking objectivity, that is, displaying a partisan or advocacy role, would attract less weight.

The weight of his evidence was lost to us completely, because he lost his objectivity as a, ah, subjectivity I guess, as a witness when he decided to become an advocate for one side or the other. Now that's the one thing we don't want in an expert witness. (C1)

This passage also suggests that Commissioner 1 had some diffidence in her own mind as to whether an indication of advocacy by an expert meant a reduction in objectivity or subjectivity on the part of that expert. Clearly, evidence of advocacy in itself was the principal failure.

## 5.9 Knowledge

The identification of science with an accumulation of knowledge is a very strong theme in the interviews with two judges and three commissioners. These interviewees explain their understanding of science in terms of the production of knowledge or of a "build up" of information that can be accessed by others. Another two interviewees also refer to the production of knowledge as a function of science, but do not express this production as a defining feature of science.

On three occasions, Judge 7 describes science as the “systematic formulation of knowledge”. He uses that phrase twice and also describes his understanding of scientific method in the same terms as follows:

We’re talking about expert witnesses giving opinions, based on their scientific knowledge and experience, which they’ve acquired by the scientific method of, um, you know, of um systematically formulating their knowledge and testing it. Yea, that’s what makes it scientific. (J7)

In addition he describes scientific knowledge and pursuit of certainty of that knowledge, on a further three occasions in the interview. Overall, the concept of science as a process for obtaining knowledge is the strongest theme in Judge 7’s model of science. He describes science not just as a basket of knowledge but also as the process by which that knowledge is obtained. Thus, in his view science is both the knowledge and the process by which that knowledge is constructed. Building from a concept of constructed knowledge, he refers to the ability of others within that scientific community to access and share that knowledge and the need to verify that knowledge by testing.

Judge 5 also describes science in terms of a constructed body of knowledge, and he then superimposes his continuum model onto that body of knowledge according to the opinion/fact dichotomy.

...you have this body of scientific information and then we get to this point and what is science fact, science opinion what’s the line between fact and opinion and at what point in time will draw opinion from facts. (J5)

Judge 5 describes “science opinion” and “science fact” and links his definition of science back to the Latin derivation of the word:

As I’ve said before, I see science and art, we can put it on a continuum and that um, if we, we go back to ‘scientia’ in the terms of knowledge, one must say that that’s accumulated and empirical fact. Now, I believe we wouldn’t if we limited science to that definition we wouldn’t, most of the experts would be in the art category. (J5)

Judge 5 seems to describe a model in which knowledge is constructed and comprises both fact and opinion. That knowledge which has the greater empirical element will fit more squarely into his model of science, while knowledge which is more opinion based is linked to the arts.

Commissioner 6 describes science predominantly in terms of traditional categories of research, however, she indicates that the substance of these research categories is constructed into libraries of knowledge. When explaining the nature of social science, she commented:

Probably with this, um, getting to be a bigger build up of information and, and stuff stored away in libraries that other people can draw on.

...You know, I think they're becoming more a, um, (pause) a science in that case, in that sort of sense, rather than I think a few years ago they used to just be all a matter of opinion. (pause) Somebody said that's my opinion and that was it, but now you've got to back up your opinion with some (pause) reference to something somebody has written or put in a book somewhere or someone has written in a thesis. (C6)

Commissioner 6 uses a construction metaphor to describe how scientific knowledge increases. She also describes the essence of what makes contemporary social science research more scientific than previously, as the cross referencing of a researcher's opinion against other documented research.

Commissioner 7 also expresses a very strong emphasis on accumulation of knowledge in her model of science. She links science with the production of new knowledge and with the value of that knowledge for explanation of observed effects. Commissioner 7 also links her definition of science back to the Latin derivation, and includes reference to theories. Although she refers to the importance of experiments to test theories, Commissioner 7's model clearly differentiates between science and applied science.

If you take biology, or take limnology, the study of fish. I mean they are collecting data really. It is hard to say it is original cutting edge research. They are collecting data and studying effects of certain things. I mean they might be studying the effect of pesticides on fish life and that sort of

thing. I suppose it [science] is studies that will form the basis of an increase of human knowledge, something which was not known before. I suppose that sums it up really. (C7)

For Commissioner 7, it is the discovery of new knowledge that is significant. Unlike Judges 7 and 5, she doesn't describe scientific knowledge in terms of its production, or construction, but rather as a discovery from a process of research and theorising. For example, in the following extract, Commissioner 7 describes her view of science versus applied science in the field of social science:

They [sociologists] are in a class of their own, aren't they? They again, many of them are parroting other people's views, like many others of course. Others are researching, perhaps searching for links between behaviour and external conditions, which are not clear. ...So I suppose those that are seeking to find out something new and those that are applying what has been found out. (C7)

Her use of the verbs searching, seeking and finding, implies a view of scientific knowledge that is rather Cartesian in nature. That is, that knowledge is out there to be found and sufficient attention to research and theory will uncover that knowledge. Commissioner 7 expresses a model of science that is very consistent with the 'science is different from technology' macro theme. She expressly excludes engineering from her classification of science. Interestingly, Commissioner 7 personally, as well as her professional background, is given as an explicit example of science by several of the interviewees.

Commissioner 2 also expresses a strong link between science and a body of knowledge. For her, science is a combination of a body of knowledge and the empirical data that supports that body of knowledge. When asked about the scientific status of the social sciences, and in particular sociology or psychology, she commented:

Yes where a knowledge of demographic trends and things are based on background statistics and calculated projections and things like that. It is scientific.... Again, where you have the study of case history and have a body of knowledge, you have to accept that that is scientific. Yes, but

there is a lot of body [sic] work in that area which is probably non-scientific. (C2)

Later in the interview, when asked to explain what is the essence of scientific evidence, she comments:

The case [is] to be knowledge based, desirably capable of measurement, capable of repetitive confirmation, um and I would think they are some of the characteristics. Possibly having a demonstrated outcome that can be, if not repeated, alluded to or shown to be the case in other circumstances. (C2)

In this description, the first and most definite criterion that distinguishes scientific, from other types of evidence, is the knowledge theme. She implies that the other criteria concerning measurement and replication are discretionary, by her use of the words “desirably”, and “possibly”. Commissioner 2 indicates neither a constructivist nor a Cartesian model of scientific knowledge.

Two other interviewees describe science with reference to a body, or an accumulation of knowledge. Commissioner 12 describes scientific data being built up on a particular topic, and acceptance of evidence as being scientific when: “it’s an acceptance in the literature, in the scientific literature by the scientific community.” She also describes science in terms of its explanatory power:

Well, I think it’s an understanding of, of (pause) of the environment and our universe. It’s an explanation, it’s, it’s a process of explanations for me. So without the understanding of it you can’t make predictions of what might happen under a given set of circumstances. (C12)

Her use of the words “build up” and “process of explanations” suggest a constructivist view of knowledge and her allusion to explanation supports an inference that the body of knowledge is central to her model of science.

Judge 4 also describes knowledge using a construction metaphor, and he identifies science as comprising process and knowledge components:

I don't see science as being different from the way it's constructed and produced. Um, I think the issues are different as between the different scientific disciplines. Um, but at the end of the day they're not all too different in the ways they're built up from the grundnorms particular to that particular issue. (J4)

Measurement and data appear to be the strongest themes in his model of science, but he does refer to a "build up" of research into data bases which further supports an inference of a constructivist view of scientific knowledge.

#### 5.10 **Traditional association**

Under this heading I include those interviewees that have a model of science that is closely linked to an association of science with traditionally recognised subject fields or disciplines. As a key theme this traditional association differs from a focus on qualifications in that it is the subject matter or subject recognition that creates an identification with science. Within this group are two judges and five commissioners. All of the commissioners who identify the subject matter or traditional association with science as key to their model of science also stress the importance of academic qualifications as an indicator of science, leaving only three commissioners for whom the qualifications in themselves was sufficient.

Judge 1 relied on the traditional scientific categories of chemistry, physics and biology in order to explain his meaning of hard science as follows:

So hard science is basically causative science, really – physics, chemistry. These days biology, mmm. Of course, we don't get a lot of that, because most of those issues are so clear you don't really need the Environment Court to decide them. (J1)

For Judge 1 the idea of a continuum of definition was very strong with the hard sciences, which involve those traditionally recognised disciplines, being at the "scientific" end of that continuum. In addition, evidence of empiricism was a key indicator of science for him.

Judge 8 also indicates a view of science with reference to the traditionally recognised disciplines when he describes what makes evidence scientific. In the following statement he implies the integration of the concept of science with its description under known categories or fields:

Well, as I said I prefer to look on evidence as being either expert evidence or non-expert evidence in my simple mind and um ah if it, ah becomes scientific if it's expert evidence given in a field of science. (J8)

Judge 8 then explains his understanding of science more fully, with reference to the inquisitorial nature of scientific endeavour and the significance of empirical research.

To me science, is, is an enquiry into the reality of the physical world. In other words it's all to do with the, and of course you use all different scientific disciplines to do that – physics, chemistry and maths and all those sorts of things to empirically look at the thing and to, and to make, make inferences and deductions from those empirical investigations and then you use that to try and improve um, um man's lot in life, I suppose, don't you? (J8)

The theme most significant to his view of science is clearly that of measurement and data, to which he has four different references, however, the ability to associate expert evidence with a traditionally recognised scientific field supports his categorisation of that evidence as scientific or not.

Of the commissioners who describe their view of science with reference to the traditional fields, Commissioners 5 and 6 indicate that this theme is integral to their understanding of science. Commissioner 5 describes her understanding of science strongly in terms qualifications in traditional fields of science with reference to only two other themes; the significance of measurement or data, and the explanatory role of science. Her association of science with particular qualifications and background is most clearly illustrated by the following, when she describes her perception that the definition of scientists is changing:

It's really an evolving thing. If you go back to my school days, ah, science was science, you had bunsen burners and that sort of thing, but

you are talking about social scientists now. So the word “scientist” is being used, like consultants, very, the picture is changing. Um, I would say that a scientist to me is a person of very great discipline and learning. Mainly in the chemistry, physics, engineering, geology, those sorts of fields, really. (C5)

Even though she describes science to include the subject matter of social scientists her examples which illustrate the subject matter of scientists are those traditionally linked with science or applied science. Her reference to engineering indicates a view consistent with the ‘science includes technology’ macro theme.

For Commissioner 6 the association of science with the traditional subject is even more pronounced. When asked what makes expert evidence scientific she replied:

I suppose it is something that involves the basic sciences. I’m not sure whether that’s a clear answer. (C6)

In terms of what exactly? (Interviewer)

In terms of it involves say biology, [unrecognisable word] or electricity, magnetism. (C6)

Okay, yes. (Interviewer)

The things that were called science when I went to school (laugh). (C6)

She then expressed some diffidence about categorising engineering and implies that this diffidence arises from her view of science as one of a group of traditional subject groups.

Well, usually you get a witness that’s um, you’re specialising in a particular subject and it’s the subject which, to me, is either scientific or it isn’t. But, there is still a bit of a blurry line there with engineering. You know, if somebody comes along to give evidence on water quality, or electricity, or you know, radioactivity that to me is scientific. I’m not sure whether I would call basic engineering actually (pause) science as such. I

don't think I would, but engineering, branches of engineering can go under science. (C6)

She indicates that this theme is key to her view of science at three different places in the interview and signifies only three other themes as important, including qualifications. Both of the remaining themes, of measurement and of particular knowledge, are mentioned in relation to the traditional categories of science. Her model of science reflects the 'science is different from technology' macro theme.

Commissioner 11 strongly identifies science with scientific qualifications. Although she contemplates that other experts may be able to give valid evidence, she explains that an initial category of science would include all those subjects encompassed by a Bachelor's degree in science.

Commissioner 1 implied an association of science with the traditional subject areas when she gave examples of scientific evidence. She also describes science in terms of process with an emphasis on replication of results and incremental development from other "proven" facets of science. Although she articulates her understanding of science with reference to the traditional subject areas, the key themes in her view of science are the measurement of data, replication of results and the qualifications held by scientists.

Commissioner 3 also implied an association of science with the traditional subject areas when she commented that "most science must have an element" of physics and chemistry. Although that comment does indicate a traditional association as part of her understanding of science, analysis of her interview shows that the role of peers within a community of science is clearly the key theme in that understanding. Commissioner 3 describes an "instinctive" mechanism to distinguish science from technology. When asked whether she would classify engineering as science she responds:

Parts of it, yes, but, but not the not the practical aspects of it. When you get down into the soil mechanics, ah, and the, and the chemistry underlying the soils and so on, and what's taking part under pressure and

these sorts of things, ah then you're getting into the scientific realm and most engineers will step away from it and in favour of the scientists. (C3)

And what for you separates the practical aspects from that? What is the thing that makes..?.. (Interviewer)

(pause) It's a hard one that. It's an instinctive sort of thing. (C3)

I know what you mean. (Interviewer)

I think anybody with long practice can know that. Ah, or, or can, can analyse that and so on, but it, it's when it goes beyond that, when they can't explain why necessarily, or they don't know why they, there must be something there, um, um, then you are into science, aren't you, at that sort of level. (C3)

She separates the practical aspects of engineering from her definition of science, but is not entirely clear why. These comments reflect the 'science is different from technology' macro theme.

### 5.11 Academic qualifications

Evidence of academic qualifications was key to acceptance of an individual as a scientific expert for eight of the 13 commissioners. For five of this group the existence of academic qualifications was a very significant theme in their description of science and was the most widely identified of all themes within the group of commissioners. In contrast, evidence of qualifications only featured as a theme in the model of science for one judge. Judge 6 has a model of science that is consistent with the 'science = expert' macro theme. Thus, his references to specialist backgrounds and qualifications are references to the backgrounds of experts generally. The following extract illustrates this global approach to science when he describes what makes scientific evidence scientific:

Well, (pause) I suppose um the fact that it needs um analysis in an area that um the (pause) lay person wouldn't be capable of um undertaking, so that the Court um as the um independent body, albeit a specialist

jurisdiction, relies on um that ah person's um ah expertise and um advice in order to be informed and deal adequately with that area of the case where that expert's advice is relevant. Um, now I don't think that's a very precise answer, but I, I, I think that scientific in my book is basically um evidence coming from ah somebody who has got a specialist background ah qualifying him or her to um a specialist whether through experience, academic qualification or a combination, um, qualifying him or her to advise the Court as to um some area that ah ah the Court ah would be assisted in um by in coming to its decision. (J6)

Commissioner 10 articulated the importance of qualifications to her model of science in a very direct way as follows:

Anything that requires a professional person to be in front of me, stating their qualifications and putting their reputation on the line on paper has a science to it for me. (C10)

Commissioners 6, 1 and 5 also described their understanding of science with very clear reference to academic qualifications. Commissioner 6 explained her view of science with reference to university degrees:

I probably tend to put things in three boxes just like you used to go to university to get a B.A. or a B.Sc or B.E. You know, that's about it. But as I said now I can see blurring between the engineering and the science, and there's probably blurring edges between the arts too. But to me they're pretty basic. (C6)

Commissioner 1 was equally direct when asked to explain what she meant by a "real science background" in her description of the backgrounds of the various members of the Environment Court:

Well they have a masters degree in a science subject, or they have a doctorate or whatever, or they have, they're qualified, they have a university qualification in a science subject. (C1)

When asked what, in her opinion made evidence scientific, Commissioner 5 replied:

Um, I would say a person with a discipline with, um, yes I would say with a discipline, with academic skills and training, qualifications, yeh, it would be, it is a discipline and, um, of a scientific background. I would suppose that is a bit Irish, but ah, they have got to have a scientific training, academically, and, um, practised in that field. (C5)

The theme of background and qualifications was broadened by Commissioner 5 to encompass an idea of a scientific “discipline and training” which produced people able to present evidence “in a scientific and logical way”.

For Commissioner 11 the type of academic qualification held by an expert was clearly significant when she was asked to differentiate scientific from other types of evidence: “I think we come back to the standing and the qualifications.” However, when describing how she determines whether a person is a scientific witness or not she did not consider the qualification to be determinative. When she described the types of evidence which she would categorise as falling under the umbrella she said:

Ah well obviously everything which takes a science degree. Ah, that would be the first issue. Um (long pause) um, I suppose there are a lot of people who have scientific background but it is not vested in a scientific ah degree. ... So I think the issue, it isn't just about the bread and butter of um, he see it, they see it, I see it. It's about having a process of which is founded in um the principles of science or how you got there, rather than just the experience and of course most importantly I suppose is the principles of being able to think around and through and why, so many people know that is a fact, but can't tell you how. (C11)

Commissioner 11 has a high regard for the role of science and scientists and links this regard to academic institutions. She claimed to have a “healthy suspicion” of all witnesses in relation to resource management issues with the exception of scientists, whom she likened to a touchstone:

So I start off with a passion for getting the RMA right and a deep and healthy suspicion of everybody I suppose (laugh). Scientists are not always included, because I think - what have you got? You've got a

touchstone somewhere. I think that's why the science faculties are so critically important, aren't they? Because parliamentarians, local government, business all rely on getting the science right. The law will come second. All of the other faculties come second, don't they? (C11)

The other three commissioners which I have identified under this theme imply a strong connection between the existence of academic qualifications and their model of science. Commissioner 13 differentiated science from non-science by her identification of scientific witnesses. This she did by reference to their expertise that is established by way of qualifications and credentials:

I can't (pause) well, (pause) the fact that it's a scientist. That person would have been called in specifically to present. Scientists, they will be identified as an expert witness in the first place and that would send the first signal....And probably if you look at most of our evidence, most of our witnesses, they're experts in some field aren't they. They're either experts or - They are there because they have the qualifications to present that evidence. (C13)

Commissioner 7 also referred to university qualifications, in terms of the perceived status of that qualification, as a mechanism to measure "pertinent experience" when differentiating between opposing expert witnesses.

You can only measure it terms of time and perhaps the university they went to. I mean if they spent time at Harvard, Oxford or Cambridge, or something like that and gained distinction in those particular areas and the other person was of a lower order in that particular respect. That generally is reflected in how they are regarded. (C7)

Commissioner 7 implied the importance of qualifications when she described how some scientific evidence can be more convincing:

For example, if you are talking about types of radiation, then if highly qualified neurologists and atomic scientists and bio atomic people, or whatever they call themselves, can explain how radiation can affect neurons or the operation of neurons, or whatever it might be and axons

and synopsis and all that sort of thing, if they can explain how that could take place, that becomes more convincing. (C7)

Commissioner 3 also implied an important role for academic qualifications when she commented on the rapid growth of scientific endeavour:

(laugh) It's developing so fast, isn't it. I mean um not new sciences, but new branches of science seem to be rolling out of the woodwork all the time. Universities are producing them specialise in this, specialise in that, shave that piece off and ah we've seen it go right through all the practical things, you know, we, there was just one generalist at one stage. We, we had about 20 people who came up to tell us about what the landform is and what's growing on it and what's eating it and what's growing on it and so on and so on. (C3)

When she refers to the role of universities in producing new specialists Commissioner 3 seems to imply that the specialist qualifications are, at least in part, how she determines what is a subset of science.

Although none of the interviews with judges indicated that academic qualifications were key to their model of science, at least one of the commissioners perceived that this was an important to her usual judicial colleague when weighing expert evidence from different witnesses.

What happens is that at the end of the day you line up the experts' qualifications and so you might get three or four noise experts, for example. What we try and do now or what [the judge] tries to do now is to put them in a room together, find out their commonality of agreement and where they disagree, highlight that and then at the end of the day, if that is part of whether we say yes or no, then you will line up the qualifications of the respective experts and that is what we will go with. So if one has got the extra degree from Oxford, or something else from Cambridge, or whatever. It is interesting, it is fascinating in this country about how many of, I mean it is one of the things that excite me about how many of our experts have international experience and this is my view, this is what I see go down, the Judge may not agree, but at the end of the day if

we are looking at should it be 55 dBA or 70 dBA, then and if we want the 55 because of how the case is shaking down, then hopefully the 55 dBA guy is better qualified than the 70 dBA guy. (C10)

Clearly Commissioner 10 has observed the decision making process where conflicting expert evidence is crucial to the case, and has inferred from that process that the judge uses qualifications as a mechanism to rank the evidence and to support decisions of the Court.

### 5.12 Scientific Community

Often the references to the scientific community arose out of questions about novel or ‘fringe’ science. I posed those questions because the High Court, and other courts bound by the common law rules of evidence, have rules about admissibility of expert evidence. The admissibility of novel scientific evidence is specifically covered in case law and incorporates the criteria from the United States Supreme Court decision *Daubert v Merrell Dow*.<sup>375</sup> This case has been cited in Environment Court decisions including *McIntyre v Christchurch City Council*<sup>376</sup> and *Shirley Primary School v Christchurch City Council*<sup>377</sup>. The *Shirley Primary School* decision was specifically mentioned as illustrating significant issues for the consideration of scientific evidence by three judges and four commissioners and one other judge and two other commissioners referred to their experience in hearing cases involving electromagnetic radiation from cell phone towers.

I was surprised to find that many interviewees did not understand my question about how they would determine whether and when novel, or fringe science had been incorporated into mainstream science. The question was intended to further identify what was the essential characteristic of science, but for those who equated science with expert, the question did not make sense. In addition, many interviewees who did understand the question, answered in terms of the theme(s)

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<sup>375</sup> *Daubert v Merrell Dow Pharmaceuticals Inc.* (1993) 125 L Ed 2d 469. Refer to the previous discussion in section 3.2.5.

<sup>376</sup> *McIntyre v Christchurch City Council* [1996] NZRMA 289.

<sup>377</sup> *Shirley Primary School v Christchurch City Council* [1999] NZRMA 66.

that are most significant in their model of science. For example, Judge 5 described the transition between novel and mainstream science as follows:

So what we're saying here is we have areas sometimes where some of the assumptions that are made have never been really tested or don't have a full scientific basis. (J5)

His response to the question covered a range of examples but came back to his emphasis on experimental method and accuracy. Others made reference to the role of the scientific community as the mechanism for determining what is mainstream science. Often this reference was made after I was asked to reframe or explain the question, and so the importance of such references to their models of science is less clear. There were, however, several interviewees who indicated the importance of the scientific community in the strength or context of their comments.

Judge 2 very clearly describes the role of the scientific community when he explains how the Court would assess when novel or "fringe" scientific ideas have become "mainstream".

Do you differentiate between fringe or novel scientific evidence and mainstream science? (Interviewer)

Well, not as such (pause). I think you, you might well say that um if a particular proposition is well, is well um justified in terms of the scientific evidence, then it's irrelevant that it might be novel, but it's usually the established and conventional understandings that, that have an abundance of evidence to support them and if that's in contest with a novel understanding, then it's still going to prevail unless the novel understanding can be shown to be preferable. (J2)

How does that process happen where the novel can move into may be the mainstream? (Interviewer)

(pause) By the regular application of the scientific method to investigations and research and by following the customs in the scientific

community of publication and peer review. The Court is as interested in those methods as ah as the scientific community is. (J2)

And how does that become apparent to the Court? (Interviewer)

By evidence. (J2)

So you would expect to see evidence of publications and so forth? (Interviewer)

Certainly and we'd be interested to know whether the publication, was, was a um one that is reputable in the scientific community. We'd be interested to know whether the publication was peer reviewed or not. We'd be interested to know um (pause) the extent of the acceptance in the scientific community, so that for instance, if there was a publication of somebody's scientific work, we'd be interested to know whether subsequent to ah publication, other scientists had found that they could replicate the results or had found that they were not able to replicate the results, or had, in some other way challenged what was published, perhaps in the same or some other publication. (J2)

In this extract, Judge 2 emphasises that the acceptance of the scientific community is not just measured by evidence that research has been published, but also that publication has been "reputable" and has generated discussion within that community. He notes that information concerning the replication of research results is communicated by the mechanisms of publication and peer review, which he describes as "the customs in the scientific community". This long explanation of what he means by "the customs in the scientific community" and of the requirements of publication imply that the notion of a community of science is an important aspect in his model of science. In fact, this description of how scientific research is encompassed by the scientific community, is the longest and most detailed description that he gives about any aspect of science and is the most explicit reference to any essential indicator of science.

Commissioner 3 also indicates the importance of the scientific community in her explanation of what would distinguish some evidence as not scientific:

You know, (pause) there's a lot of people who would want to think that what they do is science, but ah it very quickly reveals itself to me to be not so. (C3)

What would suggest to you that something wasn't scientific? (interviewer)

Well I suppose when they haven't got the sort of approval material to back it up. Um, and, and again the counsel are very quick to drop on to this. They know these people as well and what their standing is and so on. (C3)

Commissioner 3 refers to "approval material" and to "standing" of witnesses in her explanation of how she would determine the scientific nature of evidence. When she explains how she would differentiate novel from mainstream science, she comments:

Well I suppose they've got to be able to (pause) produce the sort of results, or the sort of thinking that can convince their peers and other scientists. You know it feeds very much off itself, you know this scientific layer. You know does a scientist recognise, someone we recognise as a scientist, you recognise him as a scientist. (C3)

These comments imply that the role of the scientific community is central to her assessment of reliability and credibility of scientific evidence.

In addition, the role of the scientific community was relevant to others for assessing credibility of evidence. Commissioner 12 explained that she would distinguish science from "fringe evidence" by whether the evidence was accepted in the scientific community and by how well the evidence withstood cross-examination. When asked how she would determine whether something had become science, she answered:

When it's not a judgement call. Well I guess for me, it's it's an acceptance in the literature, in the scientific literature by the scientific community. (C12)

And how do you find that out? (interviewer)

Well that should come to us in evidence as you know. You have that knowledge yourself or you have access to it. And the cross-examination and if that doesn't show up, if the evidence doesn't show it up under the cross-examination or not. So it ought to become clear, you know, by the time you've heard all the parties or both parties. (C12)

In this passage Commissioner 12 alludes to the scientific community and to literature as being relevant to the scientific nature of evidence, however, her explanation is not clear about how the two interrelate.

Commissioner 13 also differentiates fringe from mainstream science with reference to the community of science. When asked how she would know that evidence was fringe she answered:

Probably, from the cross-examination. That would really alert us, but probably even just our own basic knowledge and you would probably be able to tell, because it didn't have so many, the traditional credits and peer reviews and all of those sort of things would be sending a signal. (C13)

She also refers (indirectly) to that community in her description of what it is that makes evidence scientific. Her initial response was "Probably the body of that evidence .....-..... Yes" and when asked what she meant by "body of that evidence" she responded:

The body meaning the bulk of that material that is put in front of us. I can't (pause) well, (pause) the fact that it's a scientist. That person would have been called in specifically to present. Scientists, they will be identified as an expert witness in the first place and that would send the first signal. (C13)

This comment indicates that she places credibility on the fact that scientists belong to a recognised body of experts. Commissioner 8 also suggests that credibility is attached to an expert's membership of the scientific community:

I mean one could be facetious and say when one calls himself a scientist you have to accept that their evidence is scientifically based, but again it must be accurate with information that they know must be relevant. (C8)

She implies that being a scientist, and thus a member of the community of scientists, is an indication of a foundation of science in the evidence, however, this factor is clearly not crucial to her model of science.

Judges 7 and 8 also describe how a “novel proposition” becomes mainstream in terms of the acceptance of published papers:

Only when you're told that by people who say, “Yes. Well, there've been so many, you know, this has been studied in various different parts of the world. These are the papers that have been written about it. These papers have been accepted in scientific um, um, forum and these haven't. Ah, this is in this reputable journal and that's not.” Those sort of things. (J7)  
 ... mainstream is scientific evidence, is evidence that has been peer reviewed, I suppose, and evidence that has been accepted by many experts in the field, ... (J8)

Judge 8 then goes on to clarify that just because something is accepted in the field does not make it true:

...whereas novel concepts that come through um (pause) are not so well accepted, but doesn't necessarily mean to say that they are um they're not true, they're not correct. Otherwise um some of the great scientists like Galileo and people who thought the world was round who was he? Whoever he was, I mean when they said those things they were, they were heretical words, weren't they and um and um they turned out to be right. So yeah, so I, I don't know what you mean, what you've got to do is assess each case that comes before you. If someone comes up with some novel theory which he says changes or revolutionises or changes the theory in this particular field, whatever it may be, but you've got to give proper regard to it, you can't just exclude it because it's really novel. Is that what you mean? (J8)

This comment suggests that Judge 8 does not view the role of the scientific community as being essential to his model of science, nor as providing essential credibility for evidence. Rather, his comments serve to explain the difference between mainstream and novel science and imply that the latter may well be just as much science, as long as the criteria key to his model of science are present. For Judge 8 those criteria include evidence of empirical measurement and some connection with traditionally recognised fields of science.

Commissioner 10 refers, indirectly, to the scientific community when she explains how she recognises evidence as scientific. She comments that the language of the evidence will generally be unfamiliar to her, but will reflect a great deal of knowledge held by the witness and “has a linkage to a whole lot of other work that is being done in a specific area.”

### 5.13 Science as Improvement, Prediction or Explanation

For some interviewees, the essential characteristic of science appears to be its perceived output or result, rather than the process or content. Some described this output as the role of science in improving the world or in terms of its utility. Others referred to the power of science as a tool for prediction of future events or conditions and still others referred to the explanatory power of science.

#### 5.13.1 *The Utility of Science*

Judge 8 describes science as an inquiry into “the reality of the physical world”. He notes that this inquiry is linked to the traditional disciplines of chemistry, physics and mathematics, and is directed to:

...make inferences and deductions from those empirical investigations and then you use that to try and improve um, um man’s lot in life, I suppose, don’t you? You apply it to medicine, you apply it to drugs, all those sorts of things. (J8)

For Judge 8 the purpose of science is tied to the empirical process of science and his model of science reflects a technological analogy. That is, that science is a process which is purposefully directed at improving the environment for humans.

His model of science is dominated by the “science includes technology” macro theme.

Judge 1 has a broad definition of science, but he distinguishes hard science from soft science. For him hard science includes empirical measurement and the ability to replicate results. Judge 1 also indicates that hard science has mana as a knowledge form. By this I understand him to mean that he assigns more credibility to hard science. Judge 1 explains his view as follows:

Why does hard science have mana? I mean, I suppose it does because, in fact it has huge explanatory power, doesn't it? Um, not to mention immense utility, we are surrounded by, you know, your tape recorder with it's tiny little size and so on. I mean it's a miracle of science isn't it?. Um, it's just it's sheer utility isn't it and of course you can go into all the reasons about human curiosity and so on, being satisfied with scientific results. (J1)

These comments indicate that hard science has particular significance as a knowledge form, because of its explanatory power and also because it can be applied in a technological sense. Although the explanatory power and utility of hard science contribute to its mana, these factors do not appear to be essential characteristics of hard science. Rather they could be described as fortunate associations. This passage also illustrates the consistency of Judge 1's model of science with the “science includes technology” macro theme.

Commissioner 10 has a very cautious approach to the utility of science. She recognises science's “total impact on the farming industry” and notes the benefits of various advances, but continues:

All that was a part of a scientific process and so I guess providing that is balanced with the other parameters of life, then I think science is crucial. My concern is, I guess, in a bigger picture, would be where in the industrialisation and scientific models that we tend to lean towards, because they have some foundation, we are actually missing the point about what life is really about, in a general sense. (C10)

These comments are entirely consistent with her recognition of science as one particular way of thinking, that is not necessarily superior to other, more spiritual ways of viewing the world.

### 5.13.2 *Science as explanation*

A group of interviewees described science primarily in terms of its explanatory power. Commissioner 7 refers to the explanatory power of science at 4 places in her interview. She has a model in which knowledge is a key theme, and she distinguishes science from applied science on the basis of the explanatory power of scientific knowledge:

In other words, there needs to be a study and if something can be said about it well lets find out what can be said. So I suppose those that are seeking to find out something new and those that are applying what has been found out. (C7)

For example, if you are talking about types of radiation, then if highly qualified neurologists ... can explain how radiation can affect neurons or the operation of neurons, ... if they can explain how that could take place, that becomes more convincing. However, I mean this is scientific argument really, rather than anything we hear anything much about. (C7)

In these passages Commissioner 7 refers to the combination of knowledge and explanation when she describes the role of scientists and of scientific method. She indicates that new knowledge that explains some aspect of the environment is scientific argument and also that such a discussion is not commonly held before the Environment Court. These comments are entirely consistent with her model of science.

Commissioner 3 distinguishes disciplines that are not science, for example philosophy, from disciplines that are science by the explanatory, or descriptive nature of science. For example:

Well (laugh) when you get into determining how people are going to behave or should behave under certain circumstances. It's that "should behave" that, that separates it, I think. Um, you know, now if I apply a

scalpel to you, you're going to bleed, um but if I do something, if you should do something then you may not, you know...(C3)

In this example, she seems to contrast prediction with certainty, implying that the distinguishing feature of science is certainty. Certainty was not a significant theme in the rest of her interview.

Commissioner 10 refers to the explanatory role of science in an entirely different way. When asked to explain what makes evidence scientific, she commented:

The language, I guess. (C10)

What about it? (Interviewer)

Well, I don't necessarily understand it. You know, I mean, and in saying that I guess for me it is about in the context of when somebody is presenting something they know a great deal about. I'm not sure whether that is the answer you are wanting. So it is, for me, it is about understanding what they are saying and knowing that what they are saying has a linkage to a whole lot of other work that is being done in a specific area. Yes. (C10)

Commissioner 10 is one of the group of interviewees that does not differentiate between scientific evidence and any other form of expert (in the widest sense) evidence. She implies that scientific evidence will be presented in (sometimes) unfamiliar language and will be outside of the context of familiar subjects. She also notes that the evidence will be familiar to another particular group, who are presumably scientists/experts.

Commissioner 11 also defines science in terms of its explanatory power as follows:

Ah, no I think, that's for the Court. I think science is much more lively. I would like to think it's out there at the cutting edge, looking at why things are happening and enabling us to understand so that we can take some processes in our own hands to stop it. So ah I think there are other

avenues to science than just sitting there saying, “who’s got” – I like to think of science out there leading the way in how the world works, because if it isn’t we’re going to be in trouble aren’t we? (C11)

### 5.13.3 *Science for prediction*

Commissioner 12 was very specific about this importance when she described the purpose of science:

Well, I think it’s an understanding of, of (pause) of the environment and our universe. It’s an explanation, it’s, it’s a process of explanations for me. So without the understanding of it you can’t make predictions of what might happen under a given set of circumstances. (C12)

And so would you limit it - for you is it just the understanding or coupled with the prediction? (Interviewer)

Oh no, it’s the understanding and able to make the prediction. (C12)

This was the clearest articulation of Commissioner 12’s model of science. During her interview she refers to a collection of data and to the importance of the scientific community in distinguishing fringe from mainstream science, but does not refer to other characteristics. Her clarity about the purpose of science is consistent with the ‘science = expert’ macro theme. Evidence that can provide an explanation of the environment and enable predictions of future events or behaviour will be scientific.

Judge 7 also refers to the predictive power of science when he describes the methodology of scientific experts. His reference is not definitive of his model of science, however, as he observes that the making of predictions is a characteristic of all opinion witnesses.

#### 5.14 A Philosophical Question

Three interviewees directly stated that an understanding or explanation of science was a philosophical question which they had neither considered nor saw the need to consider. Judge 2's approach is illustrated by the following:

Would that also then be your view of what science is? Or is science more or different? (Interviewer)

No I don't, I don't think I, I think about what science is. That's a philosophical question (laugh). (J2)

Commissioner 10 also felt that it was not necessary for her to understand or explain science as follows:

And are you able to articulate your view of science, what you think science is? (Interviewer)

I don't think so. It is a hard question. I think you have found a gap with me. It is not that I'm not clear about it, I've never had to think about it seriously before, really, and it is just part of my job and we deal with whatever comes up in front of us. (C10)

For these two interviewees it is quite difficult to isolate themes that indicate their view of science. Judge 2 was cautious about his comments, having indicated that he had not really considered the meaning of science. His repeated emphatic reference to the role of the scientific community indicates that this is significant to his understanding of how science happens, but in other respects he focuses on expert evidence in a more general sense. Judge 2 does indicate that he differentiates between scientific and other types of expert evidence.

Commissioner 10 is also not specific about the criteria of science. She does note that qualifications are indicia of a scientific expert, and also that the use of specialised language will identify scientific experts as having non-familiar knowledge. These comments are consistent with her view that all expert evidence is necessarily scientific.

Judge 7 is the third interviewee who refers to the philosophical nature of my inquiry. He also comments that his role as an Environment Court Judge does not require him to consider the nature of science:

I mean, I've been a Judge now for [a number of] years and I don't think I've ever had to turn my mind the whole of that time to what "science" actually means, in order to do my job. I've dealt with a lot of sciences and a lot of scientists. I've had them as witnesses and I've had to evaluate their evidence and resolve different opinions, but I don't think I've ever had, felt the need to understand science in order to that, in the sense that scientists would and they may write commentaries on their particular branch of whatever science it is. So I can't quite see the problem.(J7)

However, when I suggested that there may be differences between who and what some members of the Court may classify as scientists and science, he was interested in the issues and fully articulated his own understanding of science.

### 5.15 Science Within a Hierarchy of Expert Evidence

Another key element of this research was to discover not only the extent of difference between each member's conception of science, but also to discover whether science was valued differently from other types of knowledge. In the legal decision making context, such differential valuation could be important when assessing the relative weight that scientific evidence is accorded compared with other types of expert evidence.

I have analysed the interviews to identify whether the interviewees do, in fact, value science differently. I have also analysed the preferences that emerge against each person's model of science. In this way it is possible to identify whether the key themes in their model of science are relevant to how they value scientific evidence as a type of evidence that informs their decision making. As part of this analysis, it emerged that there are a number of ways in which types of evidence are differentially valued. Some of these differences are not directly related to scientific evidence, but do reflect some of the themes evident in individuals' models of science.

Eight interviewees expressed no discernible difference in the way that they value scientific, from any other type of evidence. Some of this group specifically stated that scientific evidence was not special or different, and the others did not indicate any apparent differences in valuation of scientific evidence. Of the other 13 interviewees, the majority indicated some type of positive valuation for scientific evidence. Four indicated some criticism of either science as a discipline, or of scientific expert witnesses.

The analysis of views about science identified a number of categories. The first comprises those comments that indicate a positive preference for science or scientific evidence. The second category addresses the relative weighting of scientific with cultural evidence. The third category reflects the group of interviewees that did not apparently prefer science over other types of evidence. The final category comprises those comments that indicate preference for or criticism of particular types of evidence or witness.

#### 5.15.1 *Positive Valuation of Science*

##### Intellectual Superiority

The majority of positive affirmations for scientific evidence related to the ‘intellectual superiority’ of science. By this, I mean that science or scientific evidence was elevated in the hierarchy of expert evidence by virtue of its perceived explanatory power, special vocabulary, or perceived intellectual difficulty. In the following example Commissioner 3 indicates a view of scientists as an intellectually superior group with a specialised language that is foreign to her:

Once it starts to get into mumbo jumbo I don't understand, particularly the maths, perhaps. Um, I've got to say to myself, "I'm not following this. I don't really understand it. I don't think I've got the background to understand it." So I've got to go back to square one, as it were, and say what does it mean, the whole thing to me in those terms. Um, not very satisfactory from a scientist's point of view, I don't think, necessarily.

(C3)

Why is that? (Interviewer)

Well, well they, they feel that they're entitled, I think, perhaps to talk to somebody at their own level and that's not unreasonable ... (C3)

Commissioner 3 then goes on to advocate a panel of peers that could assess the evidence and translate it for the Court. In this extract, Commissioner 3 explains that she does not have a personal familiarity with scientific language. She also considers that this lack of familiarity is an unreasonable inconvenience for scientific witnesses. When she suggests that it is reasonable for scientists to feel entitled to talk to people with their own level of scientific familiarity, she is elevating the particular knowledge base of those witnesses above the combined knowledge and experience of the Court. She does not indicate that it may be a weakness in communication skills for those witnesses. Commissioner 3 further indicates her own separation from an understanding and perhaps an interest in science, with the following comment:

I was probably going to say to you initially, as everybody would, "Well I've really got nothing to tell you." Your questions are very interesting. They're quite ah probing really, ah. (C3)

Her comment that everybody would feel the same about a conversation concerning science and scientific evidence is interesting in itself, but her assumption that she would have nothing to contribute to a discussion about her own views is particularly enlightening. Her views are consistent with her model of science, in which the concept of a community of peers is a key theme.

Commissioner 1 echoes some of the same sentiments with respect to the specialised nature of science, but she describes this as an admirable quality:

A good science witness doesn't do any of the things I've just indicated. So his evidence is usually somewhat longer, there's more preamble to it, he explains in detail, he doesn't use abbreviation, and he doesn't expect anybody to understand his science, his ah ah discipline as well as he understands it himself ... (C1)

That specialist understanding of a discipline that is more complex and detailed than other types of evidence is viewed as a positive attribute that defines a good science witness.

The following comments from Commissioner 5 also illustrate a view of scientists as having a monopoly on the understanding and interpretation of science:

Um, and lay people can't get involved in scientific evaluation. Again, very critical, but a scientific person can evaluate data and come to a conclusion, which a lay person couldn't do, is not permitted to do. A very important part of the process. (C5)

Commissioner 5 has a model of science in which qualifications and traditional classifications are key themes and this view is illustrated in her separation of the "lay" from the scientific. Presumably scientific evidence is that evidence which is given by scientists, who can be identified by their qualifications, and no one else is to be permitted to evaluate or interpret that type of evidence.

#### Importance of Science

Several interviewees made very clear statements concerning the importance of scientific evidence. Commissioner 5 described the ability of scientific experts to communicate effectively as being an important criterion that separates those experts from other witnesses. This is because their evidence is unfamiliar to non-scientists, but nevertheless critically important to the decision making process:

So they have to use charts, diagrams, that sort of thing and avoid jargon, and while that they can have a very scientific, they may have to give some very detailed scientific work or explanations, they can also have a sort of a lay summary, if you like, of what they have done. Very, very important, scientific evidence is very, very important. It is taken on board and it is very critical. (C5)

Unlike Commissioner 3, Commissioner 5 expects that a good scientific witness will effectively communicate their evidence to the Court.

Commissioner 11 also describes science in terms of its critical importance as follows:

So I start off with a passion for getting the RMA right and a deep and healthy suspicion of everybody I suppose (laugh). Scientists are not always included, because I think - what have you got? You've got a touchstone somewhere. I think that's why the science faculties are so critically important, aren't they? Because parliamentarians, local government, business all rely on getting the science right. The law will come second. All of the other faculties come second, don't they? Can't do without them. I don't think (pause)- Any case worth its soul is going to have some science in it. (C11)

These comments illustrate clearly the importance that she places on scientific evidence. Commissioner 11 has a model of science in which fact and qualifications are key themes. Her confidence in the ability of science to produce the "right" answers adds to the credibility and reliability of that evidence.

Judge 2 refers to the importance of scientific evidence and the responsibility witnesses have to clearly communicate that evidence:

Well I think we expect the scientists to ...understand the responsibility that they're exercising when giving evidence in Court; the importance the Court will give to what they have to say and therefore the need for them to communicate it with precision and effectiveness. (J2)

Judge 2 has a model of science that emphasises the role of the scientific community. His comments regarding the importance of communication are consistent with his model in which publication of research and subsequent academic debate is the measure of acceptance of that research within the scientific community.

Judge 1 ranks scientific evidence very highly against other types of expert evidence. He has a model of science that puts empirically derived evidence at the extreme "hard science" end of a continuum, with non-factually based opinion

evidence at the opposite extreme. For Judge 1, evidence that can be identified with “hard science” will be most important:

(pause) um, well I think experts are essential. Ah, the more scientific they are, the more their evidence is hard science, the more important it is, really.  
(J1)

He appears to value evidence with reference to where that evidence sits on his continuum of science. In the following extracts he approves of other fields mimicking science. The degree to which evidence can be compared with the characteristics of hard science will depend on where it lies on his continuum and thus is directly related to how closely that evidence is perceived as mimicking science.

Well, (pause) I don't think one should discourage any field of sort of human thought of endeavour from trying to be scientific, because I think it's such a desirable quality...

Although, of course it's interesting, it's an interesting sociological phenomenon I suppose, that soft science tries to do the same thing, but without very often, um, empirical results that are repeatedly or replicable and I suppose that simply shows the mana that hard science has that people are mimicking that in form, if not in substance. (J1)

When asked whether he would include engineering evidence under a general umbrella of science he responded:

I think it would be insulting not to really, yes. (J1)

This is perhaps the most striking indication of the importance that he attaches to scientific evidence. His use of the word “insulting” suggests that any evidence that falls outside of a hypothetical science umbrella has a lesser status than does evidence within that umbrella.

### Integrity of Science

Two interviewees expressed a view of science in which the nature of the scientific endeavour was elevated over other disciplines by virtue of its integrity and purity.

Both Commissioner 12 and Judge 1 described science as a pure form of research that is untainted by external factors. For example:

So it is the purity of science, the integrity of a true scientist that I'm looking for and that's, that's paramount. (C12)

Yes, I think most scientists, most really good scientists are in some way inspired just by the love of the knowledge and the working things out. I suppose there probably are some oddballs around, um, they're brilliant scientists, but they only do it for the money. I don't personally know any. (J1)

Judge 1 has a model of science in which traditional associations are a key theme. This model is clearly reflected in the above comments. It is also implicit that he regards scientists and hence their evidence as inherently, professionally honest, unless proved otherwise. Such regard must place that evidence at considerable advantage when weighed against other evidence.

Commissioner 12's comments are also linked to her expectation of objectivity from expert witnesses. She identifies objectivity, in the sense of professional independence and non-advocacy, as an important aspect of an expert witness's role. Her description of a scientific expert seems to combine those two elements of professional independence and scientific purity as representing a good expert. Commissioner 12 includes all expert witnesses under a general heading of science, and thus her reference to "the purity of science" is really a reference to the coherence within an expert's community of peers. Themes of community and common purpose were significant in her model of science.

### Reliance

Another indication of how highly scientific evidence is valued is the degree to which the Court is prepared to rely on that evidence where it is uncontroverted. My question to the members did not explain why evidence may be uncontroverted. Some interviewees asked whether I meant that the evidence was not challenged for lack of opposing witness. Others asked whether this meant that

the evidence was not contested because opposing witnesses accepted the evidence. I indicated that either or both interpretations were of interest.

Commissioner 1 was definite in her reliance on scientific evidence. When asked whether she would be confident to rely on uncontroverted scientific evidence, she responded:

You'd have to accept the evidence. It doesn't mean to say that the evidence would necessarily form um an important part of the decision, but you can't deny incontrovertible scientific fact. You've got to accept it and we do, but we use it as we feel appropriate and you could... (C1)

'Fact' and 'data' are key themes in her model of science and she has confidence in that data. She notes that there may well be non-scientific evidence, for example cultural evidence, that could be more persuasive in a particular situation.

Judge 1 was more representative of the comments indicating confidence to rely on scientific evidence:

Well, again it depends how hard the science is really and what you think of the qualifications of the speaker, um (pause), but one would certainly tend to rely on it. Yes. (J1)

His reliance is expressed in more qualified terms and indicates the factors relevant to that reliance. Data and scientific process are key themes in his model of science, with the hardness of science being associated with the balance towards data rather than opinion in evidence. The reference to qualifications as a qualifier for reliance is the only such reference in his interview.

Commissioner 10 was also confident to rely on scientific evidence depending on sufficient qualifications held by the witness. She has a "science = expert" macro model of science and the evidence of fact and qualifications were the micro themes significant to that model. Her reliance is to be expected given that the existence of qualifications is the key to her definition of evidence as scientific.

Commissioner 11 also expressed confidence in scientific evidence, particularly when compared with other types of expert evidence:

Well, I have to say that I rely on scientific evidence, there are, (pause) cultural issues are another sort of mud wrestling ring really aren't they? We're going to have to work that through. Planners, I don't have a great ah I think um (pause) ...don't give a toss what the planner says about it. ... So my answer is, is the tree sustainable what does the scientist say and not what the planner says. I don't hold with planners. I think it is interesting in what they have to say and if the issue is to be decided on planning alone, then of course they are important beasts. (C11)

While she notes that there may be circumstances in which other types of evidence may be more significant, she expresses confidence in scientific evidence, certainly in preference to planning evidence.

### Weight

Interviewees were also asked whether they would preferentially weight scientific, as opposed to other types of expert evidence when coming to a decision. Most interviewees could not give any generalised comment regarding such differential weighting. However, some of the comments did indicate such preferential weighting.

Judge 4 commented:

So, it it will not, or you may get a case that's really scientifically based and you'll say, "The overwhelming weight is because of this evidence, it was so competent da, da, da, da, persuasive or whatever".

It's [scientific evidence] more interesting (laugh), in my view, mostly. Because it's got a, it's got um, what's the word, because it's got a hard data base it's much easier in a way to evaluate than some of the more amorphous issues, like for instance, landscape, that kind of thing. (J4)

Judge 4 notes that weight will relate to the relevant issues in a case, but he also indicates that it is easier to give weight to scientific evidence because the existence of hard data makes that evidence easier to evaluate. In addition, he

perceives that scientific evidence is more interesting, suggesting that such evidence may more easily capture his attention and therefore attract more weight.

When asked how she assesses the appropriate weight to be given to new scientific theories, Commissioner 4 commented:

Yea. I think that is all part of evaluating scientific evidence, isn't it? I guess you tend to give more weight, or, give more weight, but feel more comfortable with proven science, um. (C4)

Most interviewees agreed that the assessment of new scientific theories was more difficult. The most common view was that new theories are to be accepted and considered as evidence, but that more weight would be given to theories that are more established and have the support of the scientific community.

Commissioner 7 commented that evidence regarding effects would be more convincing where the witness could explain the theories giving rise to those predicted effects:

I think too, what becomes convincing is theories as to effects. For example, if you are talking about types of radiation, then if highly qualified neurologists and atomic scientists and bio atomic people, or whatever they call themselves, can explain how radiation can affect neurons or the operation of neurons, or whatever it might be and axons and synapsis and all that sort of thing, if they can explain how that could take place, that becomes more convincing. (C7)

Commissioner 7 seems to link the ability of experts to clearly explain their evidence with credibility of that evidence. Her argument seems to be that if a witness understands the material sufficiently well to explain that evidence to lay decision makers, then the witness is more likely to be correct, and thus convincing.

Credibility of evidence was usually described in terms of the persuasiveness of the witness, however, where there is evidence given by two equivalent witnesses then the general acceptance of that evidence from within the appropriate

community of peers was significant. The following comment from Judge 2 is representative of this broad approach:

I think you, you might well say that um if a particular proposition is well, is well um justified in terms of the scientific evidence, then it's irrelevant that it might be novel, but it's usually the established and conventional understandings that, that have an abundance of evidence to support them and if that's in contest with a novel understanding, then it's still going to prevail unless the novel understanding can be shown to be preferable. (J2)

The question still remains as to what is considered to fall into the category of “established and conventional understandings” and how that category is assessed within a lay decision making panel.

#### Applied v Theoretical Science

Amongst the group of interviewees for whom data and process are important micro themes, there are some strong indications of the preferential weighting for applied, as opposed to theoretical science. Interestingly, two interviewees that hold a “science = expert” macro theme, also emphasise the importance of applied sciences for weighting evidence. Although both Judges 6 and 3 categorise all expert evidence as being scientific, they value the applied, in terms of data-based sciences, more when attributing weight to that evidence.

Its, ah, the applied sciences, I find are much more useful than the straight sciences, but the, ah the straight sciences are normally used as a springboard for the next opinion. (J6)

Um, I suppose one can say that um where a case is dependent on our being convinced as to the engineering integrity of the design, um if um if the applicant doesn't make that out in limine, then um the case will fall away at that point and um may not have to rely on, on the other areas of um value judgement based on cultural grounds, or um inappropriateness of development in a coastal context, or something of that kind, which the planners might be relying on. (J3)

Judge 6's description of the applied sciences as more "useful" indicates preferential weighting for that type of evidence when forming a decision. Judge 3 also indicates that the availability of technical data-based evidence, such as engineering evidence makes the decision making process easier. His comment that adequate engineering evidence would mean that he would "not have to rely on" opinion evidence indicates that the latter is a fall-back position that he would prefer to avoid.

Commissioners 1 and 2 are very direct in their comments indicating a preference for applied science. Both of these interviewees had data as a key micro theme in their model of science.

I think measurement is probably the answer to that. You stick a thermometer in water and it reads such and such. That is evidence, hard evidence as distinct from 'the water felt warm' or whatever. I think measurement where evidence can be adduced from physical measurement I think that has a stronger standing than evidence based on an assessment basis. (C2)

Now that pure scientist lives in a world of his own, but his benefit is in what he produces for the person who comes after him. ... Now the Rutherfords of this world are absolutely essential, but not for what they produce. It's the people who come afterwards, the Bill Gates if you like, who come afterwards who are the important people and that's where I see, that's what I see as science. (C1)

However, both of these interviewees were also clear that where the issues to be decided did not rest only on technical evidence, then the weighing would change accordingly. For example, where planning evidence as to the interpretation of the objectives and policies of the District Plan, or cultural evidence relevant to s8 – Treaty of Waitangi were significant then that evidence would attract more weight in the decision.

### Science v Culture

Commissioner 11 indicated a preference for scientific evidence, when she was asked whether different types of evidence were weighted differently in the decision making process. She noted that the relevant issues determine how different cases are dealt with, but commented:

Well, I have to say that I rely on scientific evidence, there are cultural issues - are another sort of mud wrestling ring really aren't they? We're going to have to work that through. (C11)

This view was expressed by a number of interviewees in terms of the hearsay nature of cultural evidence. Judge 3 illustrated his concern with cultural evidence as follows:

But then, if you say take the Maori situation where a lot of their evidence is based on word of mouth that has been past down the centuries, that is not scientific. As a matter of fact if you read books on how reliable hearsay evidence passed on from generation to generation it is probably the most unreliable evidence you will ever get. (J3)

The RMA specifically removes the common law rules of evidence from the procedures of the Environment Court but the reliability of evidence that is essentially hearsay is naturally a factor considered by the Court in its decision making process.<sup>378</sup> The opportunity to test scientific, or data-based evidence, is a factor in the weight given to that type of evidence as opposed to largely untestable cultural or spiritual evidence. That does not mean that cultural evidence is not valued by the Court, however. The following comments demonstrate that such evidence is seriously considered as required by the Act:

That [oral tradition] is not scientific evidence, but it is vehemently held by many many people. Therefore that particular belief, if you are going to have regard to the society in which you live, that belief must be accorded - have very, very high weight. Even though it is not scientifically backed. (J3)

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<sup>378</sup> Refer to discussion in section 3.3.4.

... you can ask a question that will sort of show that it's a spiritual thing perhaps that's being relied on and there's no real, there's no real scientific basis for it. And again, there, you may accept that in the long run, of course. I mean that's a firmly held belief that is applicable under the RMA and went through against the science, but you know they in the Waikato River [case] they're quite sure that what's been done is polluting and so on. A scientist comes along and proves it's not right, but perception has still got to be taken into account, yea. (C3)

The weight that we give to a science is the weight that it is perceived to have in the context of the decision. By that I mean, all the science in the world may not be able to overcome an argument where a cultural thing is more important. (C1)

These three extracts demonstrate that even though the Court members may prefer scientific evidence in terms of its veracity, or reliability, a cultural argument may be more significant in a specific decision. Each of Judge 3, Commissioner 3 and Commissioner 1 holds a different macro view of science, but these comments indicate a preference for the credibility of science, even though other evidence may be critical in the end.

Some interviewees indicated a positive regard for cultural evidence which they expressed in comparison with traditional Western science:

I ...see importance in that, [Maori science] but I am not sure whether other members of the Court would (laugh) stand on that situation and probably pure Western science would tend to take priority. You know, I could be wrong, I don't know. (C4)

So the good news gets to when we can actually have some experts that provide us with information that allows us to support, probably what for me, is the spiritual context of whatever is going down, particularly in relationship to Maori. Does that make any sense to you?... I mean if we get into Court and we have to weigh up an old kaumatua against an engineer who says the land fill can be structurally built there and sound

and you have an old kaumatua saying that you can't go in there, because there are urupas and this is waahi tapu, then those are hard. Those are hard because the land fill is dealing to the sustainability of a town and its ability to get rid of its waste and you have got total abuse potentially still happening over there in cultural matters and those are some of the discussions I am in right now and they are hard. (C10)

These commissioners contemplate that cultural evidence may not only be relevant in a given situation, but that such evidence may be credible even when compared with Western science. These two commissioners have completely different models of science. Commissioner 10 includes all expert evidence under the category of science and considers that the presence of fact and qualifications distinguishes evidence as scientific. Commissioner 4 distinguishes science from technology and scientific method is a key micro theme in her model of science. Despite these very different views, both value Maori spiritual views when considering scientific evidence.

#### Science not special

Another group of five commissioners and three judges directly stated that scientific evidence would not be weighted any more or less than other types of evidence.<sup>379</sup> All but one of this group have data or process as key themes in their model of science. The exception is Commissioner 6 for whom knowledge, traditional associations and qualifications are key.

Typical of the comments of this group are the following:

At the end of the day it's a weight issue, which I think is the whole purpose of the Court. So I don't think I could give I'd give a hierarchy and say, "Well the most scientific evidence would get a higher weighting than - Planning or architectural, because they might be quite important in the context of the case. (J5)

You've got to look at each case as it comes and the circumstances and the surrounding facts of and the people involved and apply all those things

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<sup>379</sup> Commissioners 2, 4, 6, 8 and 9 and Judges 5, 7 and 8.

and come to a decision, but it's a human decision. So it's not always right. But you do the best you can, but there's nothing special about scientific witnesses. They're not, they're not a, there's nothing special about them. They give evidence like other evidence. (J8)

So that um, it comes down to a question of credibility of a witness's evidence. Not which is, should be given greater weight – planning or science, or culture. It's an amalgam of those. (C9)

None of this group displayed any particular preference for science compared to any other type of evidence. They predominantly held models of science with a macro theme that included any technical evidence as scientific. Three of this group distinguished science from technology and none were in the macro group that describes all expert evidence as scientific. It is possible that most of those who distinguish science from technology also tend to value the perceived 'purity' of scientific knowledge and or process. Such values are expressed in terms of a preference for that type of evidence. Likewise, those that identify science with all expert evidence, are unlikely to weigh non-expert evidence equally. Cultural evidence was described as scientific so long as it was given by a recognised expert and that identification of expertise in itself indicates preferential weighting.

In addition, there were comments that described a negative perception of science. Judge 5 indicated some dissatisfaction with the way that some scientific experts deliver their evidence:

I mean ... you probably assume that scientists would talk about facts and then about opinions, but they don't, they, there's sort of a merger into a, what I would call a faith system. I know that's strange in terms of science, but it does become effectively a faith system and the way they seem to be taught at university seems to encourage that. Their professors, or whatever seemed to have a walled view, whatever that might be and inculcate their students in that view. Now I don't consider that scientific method, so I think you do actually see that reflected in the end in the way they present.(J5)

Judge 5 is criticising what he sees as a tendency of scientific experts to coalesce fact with opinion. Fact and data are key themes in his model of science, and he expects that these data elements should be clearly separate. Under the rules of evidence that apply in the general courts, expert witnesses give opinion evidence, but do not dictate the conclusions that must be drawn by the court. He seems to suggest that theories as to the effects of an activity on the environment are too often presented as scientific fact. Judge 5 differentiates science from technology and the comment above reflects that difference. Facts and data comprise the knowledge of science, while the application of that knowledge, in terms of predicting future events, falls into the realm of opinion.

Commissioner 11 also expressed some reservations about scientific evidence:

You are a scientist and I think there's some distrust of scientists, born out of Rachel Carson, I suppose and things like that and ah in the finish you simply still have to weigh it one against the other and then we have "the precautionary principle". So I think scientific evidence has to be able to be understood by all the panel. So one of the issues that you should teach your students is the art of communication. (C11)

It is hard to pinpoint exactly what is Commissioner 11's anxiety, however, her comments indicate a level of negativity regarding scientific evidence.

Perhaps the strongest preference for non-scientific evidence was expressed by Commissioner 10:

I think that people who try and control matters are in an illusionary place. So experts can go to that place quite easily, because they are, as much as I absolutely respect that, there is also an element in there that the whole lot could blow up in their face tomorrow, because of a factor over here that nobody has taken into account. (C10)

This comment suggests that Commissioner 10 is sceptical of scientific evidence and considers it no more, and possibly less reliable than other types of evidence. This comment is also particularly interesting because she has a model of science in which she includes all expert evidence under the classification as science. That

does not leave much evidence out and certainly places spiritual evidence in a very positive light.

#### 5.15.2 *Preference for Qualifications*

There were a number of comments that indicated preferential weighting for evidence based on the qualifications of the witness. Most of these comments were made by people with qualifications as a key theme in their model of science. Commissioner 11 was very direct in describing the credibility of witnesses with respect to the source of their qualifications:

I think, for instance, there is presently a difference between a resource management degree of say out of Waikato, than there is out of Lincoln. And if I'm looking at those, an equal, an equal I suppose you eventually, the colour of your belief about the status of the Lincoln degree may be different from that of Waikato or Otago, perhaps. So you have got two people – one has got an Otago degree and one has got a Waikato and one has a Lincoln degree. They both have same experience, who do you believe? Do you think that's wrong or are all universities supposed to be equal? (C11)

This approach was echoed by Commissioner 10 in her comments:

... then you will line up the qualifications of the respective experts and that is what we will go with. So if one has got the extra degree from Oxford, or something else from Cambridge, or whatever. It is interesting, it is fascinating in this country about how many of, I mean it is one of the things that excite me about how many of our experts have international experience and this is my view, this is what I see go down, the Judge may not agree, but at the end of the day if we are looking at should it be 55 dBA or 70 dBA, then and if we want the 55 because of how the case is shaking down, then hopefully the 55 dBA guy is better qualified than the 70 dBA guy. (C10)

These comments not only expressed a preference for the qualifications of witnesses, but also indicates that the Commissioners have established their own idiosyncratic scale for ranking qualifications. Commissioner 11 indicates that

resource management qualifications have more value from Lincoln University, than from either Waikato or Otago Universities, and in another part of her interview, also expresses a preference for Law degrees from Canterbury over Waikato (certainly), and Auckland University, probably. Thus, she has a perception of different New Zealand universities in relation to their particular qualifications. She offered no reasons or evidential support for this perception. Commissioner 10 didn't indicate any particular preference for qualifications from one New Zealand university over any other, but clearly places value on qualifications from prestigious overseas universities. This is despite those experts having no familiarity with New Zealand's unique environment or resource management practices in New Zealand generally. Another significant comment was made by Commissioner 7 who appears to link qualifications with the ability of a witness to explain why a particular effect occurs:

For example, if you are talking about types of radiation, then if highly qualified neurologists and atomic scientists and bio atomic people, or whatever they call themselves, can explain how radiation can affect neurons or the operation of neurons, or whatever it might be and axons and synapsis and all that sort of thing, if they can explain how that could take place, that becomes more convincing. (C7)

For her, the credibility of the evidence appears to be linked to the ability of a qualified person to explain a theory that is understood by that witness, but not by Commissioner 7. It is the package of qualifications and special knowledge that brings about credibility. The ability to explain the theories is almost a gateway to ensure credibility is justified.

Two commissioners also made comments that indicate preferential status for professionals as opposed to other expert witnesses. Commissioner 10 comments:

He is an engineer and he can bring a *professional view* to it. (Emphasis in interview, C10)

When I responded to a question asking which other members of the Court I had spoken to, she replied;

All of them are professionals. (C10)

Commissioner 9 also seems to attribute more status to witnesses perceived to be professionals. When asked to explain the difference between a good and a poor witness, she answered:

Well, the, um, they really, um, don't have a grasp of the subject at all. Um, they see their role in very, as that of a technician more than a professional person.

Oh well the analogy is with a building inspector, or a drainage inspector and a professional person, one – well that's not even an appropriate analogy. Regurgitating the contents of district plans, the, ah, section on this and clause that and never seeing the wood from the trees, never having a, never being able to put the detail into a wider context. Um, that's the major difference between a truly professional person and a clerk. (C9)

Commissioner 9 has some difficulty in defining her criteria for a professional person, however, her view is clearly that professionals are good witnesses, who will attract more credibility than non-professionals. It is unclear whether a professional person (as recognised by most people, for example an engineer or an architect) who failed Commissioner 9's test for a good witness, would then fall to be a technician.

In a more general context, several interviewees made particularly uncomplimentary remarks concerning the evidence given by planners, and planning witnesses in general:

So the question is that there is adequate um the question is, "This piece of bush big enough to be sustainable?" I don't give a toss what the planner says about it. Ah, the plan can be, a plan is a political piece, it's a political document. ... It's about political balance. Planners are caught in the middle between the demands of the politician and that certainty or respect that they crave for in their own general area. So my answer is, is the tree sustainable what does the scientist say and not what the planner says. I don't hold with planners. I think it is interesting in what they have to say and if the issue is to be decided on planning alone, then of course they are important beasts. (C11)

We had one recently, the result of that was that we didn't have to call any planners and planners produce the most awfully boring and tedious and long briefs and so probably we did away with 180 to 200 pages of evidence, because they'd produced the facts and they didn't disagree to such an extent that it required one person to give it. (C1)

Planners were most commonly cited as the example of a poor witness and the foregoing comments are very direct expressions of an overall dissatisfaction with planning evidence.

## 5.16 **Decision Making**

All of the interviewees were asked about the decision making process and the roles of both judge and commissioner in that process. On this issue there was a large degree of consensus with all interviewees agreeing that both judge and commissioners contributed to the final decision. The nature of that contribution varied according to the composition of a particular hearing panel but members of the Court agreed that the majority of decisions were consensual.

### 5.16.1 *Writing decisions*

There was a range of experience described by both the judges and the commissioners regarding the actual writing of decisions. Some judges preferred to write an entire draft decision for comment from the commissioners while others delegated parts of decisions among the different panel members. All agreed that the judge had responsibility for deciding questions of law. The following extracts illustrate the range of practices with respect to decision writing:

I will certainly expect the Commissioners to express their thoughts to me, in their own words, by way of ah (pause) a synopsis analysing the case as they see it and um, then my practice is to um take those thoughts aboard and coalesce them all into a draft which I will then call them together to discuss, if need be by personal meeting, but usually by um forwarding it to them individually, the draft rather, and ah receiving comments and I guess in most cases we, the decision is sorted through by ah e-mail and discussion, um, phone discussion, rather than the need for a full meeting,

but on one or two of the big cases – [reference to two specific cases] it was necessary to actually have um a meeting or two to thrash issues over the draft about and finally get to a conclusion. In other cases, of course, this isn't necessary because at the end of the case one finds that we are of a common mind and the material was that is esoteric that the Judge can say well I'll just do a draft and send it through in the normal way for your comments. (J6)

The Judge normally is responsible for writing the decision, but often, you would get one or other or both Commissioners to write certain passages of it, especially if it's in their field of expertise, but that's after we've discussed and decided what we're doing. (J8)

I personally enjoy that sort of wordsmithing, for the want of a better word. I've only done one really big case and that was the [case name] – 14 weeks. The others have been bits and pieces and we've all worked on researching and writing of the [case name] one in our spare time.

So focusing on areas within your own expertise? (Interviewer)

Areas of interests I guess. We broke it up and we opted to take sections, because we had expertise or an interest and more interest than expertise I would guess. Yea. (C12)

It depends a little on the Judge. Some Judges request that you do a certain amount of writing. Others say well I will put something together and see what you think of it, sort of thing. It works both ways. It depends a little on the case. (C7)

Um, one Judge in particular is, um, may say. Well I'll draft two decisions, one for and one against. See how they, ah, they react to that, which, ah, is an exceptional situation, but nevertheless a very good way to clarify one's thoughts. (C9)

No I haven't done that and I must say I am relieved about that. I mean I've certainly been through evidence and picked up what may be vital, but I've never done any writing and I would find that extraordinarily difficult, because putting things on paper is not easy for me, well that is not true I can write, but I haven't ever had to do that, but that is changing too. (C8)

A commonly described practice was for the judge to prepare a draft decision and then to invite comment from the commissioners, however, a number of interviewees cited examples of commissioners having responsibility for writing specific sections of those draft decisions.

Commissioner 5 was critical of the tendency of some lawyers to talk about decisions as belonging to a particular judge, commenting:

We have to be satisfied that that is what we've, the conclusion we have come to and while some lawyers talk about decisions that Judge So and So said such and such. That is quite wrong. It is a Court decision. So, it is not just, we are not just there to fill up numbers. (C5)

The actual process of decision writing varied according to the individuals involved and their length of experience as members of the Court but all agreed that there was input from all members of the hearing panel.

#### 5.16.2 *Consensus*

All interviewees noted that it was unusual for there to be disagreement about a final decision and that dissenting judgments were rare. Those views are illustrated by the following comments:

What normally happens is, ah, it is remarkable how few decisions there are with any diversity of opinion at all. Normally when we are fairly close we sit down and say, "What do you reckon?" and A,B,C,D and then the Judge says, "Right well I might be able to draft the decision" and so we knock out a decision. (J3)

I have ever only had to write (pause) two small sections of dissenting opinions, but I think it would be fair to say that along with my colleague,

whoever that might have been we have managed to change the Judge at times, because cases are very often right on the centre line and could go one way or the other, only I can recall one many many years ago where the Commissioners didn't agree with the Judge, that a car park could go out on to a local street, that sort of thing, and we managed to get the Judge to agree with us on that. (C8)

Sometimes you come to a decision in discussion and it is really only a case of the Judge putting the thoughts together really. Nothing may be written at all.

Does the panel normally agree? (Interviewer)

Oh yes I would say they do.(C7)

Their role for me is more in, um, (pause) after we've had initial discussion as to the direction we're going in, um, close analysis of the evidence to make sure I've got that right and close analysis about our reasoning and um to make sure that we've got that right and that we've got, um, a fair result that achieves the purpose of the Act. (J1)

Even where there are dissenting views the interviewees noted that it is uncommon for a separate dissenting decision to be issued. It is more usual for there to be a single decision that may record particular matters not agreed by all of the Court as illustrated by the following comment:

No, just noted within the decision that they had disagreed on that point and that the majority, being the two Commissioners, had - In the end it got tossed out on another issue. (J5)

Judge 2 commented that while diversity of opinion is healthy, if dissenting decisions became too frequent that could lead to uncertainty:

In a high proportion of cases, as you know, the Court is able to present one unanimous decision and that arises because members of the Court um in deliberation and discussion can moderate each other's points of view, in many cases, without having to forego their own individual ah

independence as judicial officers. Occasionally we have ah a split panel and ah one member or another expresses a dissenting point of view and I think that's healthy, um, so long as it doesn't happen too often, because that can lead to uncertainty. (J2)

There were also comments indicating that in some instances decision making has a democratic flavour with the majority view giving rise to the decision of the Court. For example:

Almost always they are unanimous and I had the first occasion, you know, with a case where we had a two to one split where the Commissioners outvoted the Judge, which is even more unusual. ... but ah I don't have a problem if they outvote me, but normally they've had, you know that's the balance between legal vs practical and for the most part you wouldn't get down to that point,...(J5)

What a lot of people don't understand is that the two Commissioners can outvote the Judge. (C1)

Where there is disagreement that cannot be overcome it is possible for a dissenting decision to be issued. Several of the interviewees commented on the options for dealing with dissent:

Each decision has to be countersigned by each of the Commissioners before it can be sent for final approval, or final printing and if a Commissioner does not approve of it he is entitled to write a separate decision and that has happened on a number of occasions. (C1)

I think it is terribly important that the Commissioners do have a real role in the decision making; that if they are not happy with the decision, then they jolly well shouldn't sign it. I have always been very fussy about that. (C8)

Does the panel normally agree? (Interviewer)

Oh yes I would say they do. Yes, because there is the opportunity to write a dissenting opinion and it has been done.

Pretty uncommon though, isn't it? (Interviewer)

Yes very uncommon. I never did it, because it has got to be, well .... There have been cases where Judges have written a dissenting opinion. ... But if a Commissioner had a dissenting opinion, Judges on occasions have assisted them to write it, if you get the idea. (C8)

What happens if there is a dissent? (Interviewer)

Well, the majority decision is put out, um, and the minority opinion can be, can be given by that person.

It's fairly rare, isn't it? (Interviewer)

Yes, it's fairly rare. Yes, [name has] done two. And it's quite straight forward, very acceptable – you're entitled. (C3)

The foregoing interview extracts demonstrate both the differences and similarities of approach to decision making within different divisions of the Environment Court. The differences relate to the roles of commissioners judges with respect to writing decisions. Some judges invite active participation by commissioners in that writing process. Other judges go further and delegate sections of decisions to be written by commissioners. For other divisions of the Court it is more usual for judges to prepare draft decisions and invite comment from the commissioners. The actual role of commissioners in the writing process varies depending on the individuals within a given hearing panel and their own expectations, willingness and competencies.

The similarities relate to the preference for consensus that is most commonly reflected in a single decision and the acceptance that disagreement can give rise to a dissenting decision that must also clearly articulate the reasons for dissent.

### 5.17 Summary

This chapter sets out the results of interviews with members of the Environment Court concerning their views about expert evidence, expert witnesses and the meaning of science. The analysis of those interviews identifies a number of themes that are relevant to members of the Court when deciding how to classify expert evidence and how to determine what is and what is not science.

I have separated those themes into two broad groupings: macro themes and micro themes. The macro themes describe how members of the Court differentiate between science, technology and expertise. There are three of these macro themes. The largest group, comprising nine individuals, describes science to include technology, for example engineering and medicine. That macro theme reflects the views of 4 judges and 5 commissioners. The second group, comprising 2 judges and 6 commissioners, distinguishes technology from science. The third macro theme represents the views of 2 judges and 2 commissioners who do not distinguish between science, technology or expertise. For the members of this group, all expert evidence is by definition scientific.

The micro themes reflect the criteria that individuals value when deciding whether or not evidence is scientific. These micro themes form the boundaries around individual models of science and separate scientific evidence from non science. I have identified nine micro themes that are relevant to individuals when articulating their views about science. Within those micro themes there are some further sub themes that illustrate the particular criteria significant to an individual's model of science. For example, within the 'process' micro theme some interviewees identified specific features of the process, for example replication of results or experimentation, as being significant.

Many of the micro themes were identified in responses of individuals within each of the macro theme groups and were not determinative of those macro themes. The micro themes were also not identified as being equally significant for each individual. That assessment took into account the number of references to a particular micro theme, or criterion, and also the degree of evidence given to that criterion as part of the interviewee's response.

This chapter also includes an analysis of the interviewees' preference, or weighting given to scientific evidence compared with all expert evidence. That analysis focuses on the first two macro themes given that the third group does not distinguish scientific evidence from expert evidence generally. The analysis of the interviewees' prioritisation of scientific evidence is in terms of their own models of science as interpreted from their interview responses and not against my model of science. The analysis of the thematic composition of individual models of science is based on the verbatim interview transcripts as described in Chapter Four. In order to manage the data I tabulated the responses to reflect the frequency and significance of different macro and micro themes across all of the commissioners and the judges. Those tables are reproduced in Appendix 1 for reference.

Finally, this chapter sets out the results of interview questions to discover the roles of Court members in the decision making process. Those roles vary between judges and commissioners and between different divisions of the Court. However, the interview responses consistently agree that there is involvement of all members of the Court in the decision process and most often those decisions reflect a consensus of opinion. Where there is dissent this is addressed by further debate leading to agreement, or in some cases to a majority decision that may identify matters in dissent. In rare occasions a dissenting decision may be issued.

In the following chapter I discuss these results with reference to the research questions and to the literature review undertaken in Chapters Two and Three.

## CHAPTER 6

### DISCUSSION

#### 6.1 Evidence of Boundary Work

In this chapter I discuss the research results detailed previously in Chapter 5 in light of the research questions articulated in Chapter 4. This research has shown that there are differences between members of the Environment Court in their perception of science and scientific expertise. Some of those differences are consistent with models of science described in Chapter 2 while other differences are not previously identified in my review of discourses associated with the relationship of science with law. The discussion in this chapter locates the views about science expressed by members of the Environment Court in relation to the models of science described in Chapter 2 and the legal rules and judicial authority described in Chapter 3. The discussion also demonstrates how boundary-work is undertaken by individuals in order to distinguish between science and non-science in terms of individualised criteria significant to that distinction.

This chapter also sets out the implications of this research for members of the Environment Court, parties and experts appearing before the Court and for the application of rules of evidence in a common law adversarial system generally. This research also contributes to the theoretical discourse concerning the relationship of science, technology and law in terms of both the adjudicative and policy development functions of law within modern society. Finally, this chapter sets out some further questions for research.

The results of my analysis of interviews with the Environment Court show a large number of examples of boundary-work where members of the Court try to articulate their model of science with reference to criteria that are individually significant to them. Boundary-work was most evident in those interviewees with a continuum model that involved the classification of specific evidence and witnesses according to the degree to which criteria significant to their understanding of science were evident. However, boundary-work was also evident in the conversations with Court members with a defined model of science irrespective of the degree to which those models had any similarity with the

models of others who were equally clear about the boundaries between science and non-science. For example Judge 8 and Commissioner 6 both classify science in terms of the traditional connections with the fields of chemistry, physics and biology. They then describe the features of those fields that support their models of science with reference to knowledge and qualifications (Commissioner 6) and data and purpose (Judge 8). Witnesses that are not giving evidence on matters arising from those fields are outside the boundary of science and are therefore non-science experts. Where that boundary became blurred for Commissioner 6 was when she considered the role of engineers who had academic qualifications and gave evidence on matters arising from the field of physics. She displayed boundary-work when considering when and why specialist engineering evidence would fit into her category of science but the evidence of an “ordinary engineer or a traffic engineer” would not. Likewise, Commissioner 10 also had well defined boundaries for her model of science. For her a scientist is equivalent to a professional, qualified person. She demonstrated boundary-work in her explanation of how qualifications can enhance the weight to be given to expert evidence, with the logical inference that lesser qualifications, or a complete lack will result in little or no weight being given.

There were some parallels with the categories of boundary-work proposed by Gieryn when he analysed communications by scientists.<sup>380</sup> To the extent that Judge 8 and Commissioner 6 have defined boundaries in terms of subject matter they are excluding other types of evidence from their category of scientific evidence. Exclusionary boundary-work was also evident in Commissioner 1’s response to questions about the nature of scientific evidence. She was definite in her view that neither sociology nor psychology was science because both were too inexact. Her model of science has data, process and qualifications as significant themes and witnesses lacking those characteristics in their evidence were excluded from her categories of scientists.

Expansionary boundary-work was also evident in combination with some examples of exclusion. For those with a model of science strongly focussing on qualifications, without the association with traditional subject areas, the category

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<sup>380</sup> See discussion in Chapter 2.4.

of science and scientists could expand to encompass anyone with accepted qualifications. For Commissioner 10 that meant that astronomers and astrologers could equally be included into her category of scientific experts provided they had qualifications accepted by their relevant peer communities.

Elements of monopolising boundary-work were also evident in those interviewees for whom science and scientists held an elevated status in terms of evidence. For example the comments by Commissioner 3 when she describes the specialist language used by scientific experts indicate that such people have a rightful monopoly on both the use and understanding of that language. Likewise the comments of Judge 1 refer to the non-hard sciences as mimicking science in terms of process but lacking the capacity to provide empirical results that are repeatedly replicable. The inference is that data-collection, experimentation and testability are features pertaining to a science monopoly.

There were no apparent examples of protectionist boundary-work. That is not surprising given that this type of boundary-work was used by Gieryn to describe behaviours of scientists when communicating with others for a variety of different purposes. None of the interviewees indicated any concern or desire to protect the interests of science and in fact some of the negative comments concerning the giving of opinions by scientific witnesses challenged any perceived superior status of those types of witness. Those interviewees that did preferentially value scientific evidence appeared to consider that scientists had established that superior status by virtue of their scientific expertise and did not indicate any challenge to that status that may require protective measures.

The results of these interviews demonstrate the boundary-work being done by individuals who receive communications from scientific experts. While attempting to articulate their views about science each interviewee describes the considerations significant to them when locating the boundary between science and non-science. That preliminary boundary-work then forms the basis for valuing expert communications given by expert witnesses.

### 6.1.1 *The meaning of science*

The interview results have demonstrated that there are as many different combinations of criteria significant to the Environment Court's collective model of science as there are individual members of the Court. A close scrutiny of the interview transcripts identified in 10 different micro themes that reflect the various criteria relevant to the interviewees' views about science. Those micro themes encompass some sub-ideas, for example the purpose category encompasses the ideas of explanation, utility and prediction and as such reflect my own perceptions about the connections and importance of those ideas. The micro themes also represent categories that I expected to find because they are relevant to models of science discussed previously in Chapter 2. The objectivity micro theme is an example of that expected category and the low number of responses linking objectivity to science, in fact an absence of responses showing objectivity to be significant to any model of science, demonstrates some of that process of analysis. I began from a particular standpoint with certain expectations and then analysed the responses to try and find evidence of a particular theme. Thus while the micro themes themselves covered the broad range of expected criteria some of the conclusions that followed from individuals' models of science were very unexpected and that is due to the range of different combinations of micro themes forming boundaries for those models. For example I did not anticipate that any member of the Court would or could include astrology under the general umbrella describing science. However in the context of Commissioner 10's model of science it is a very logical conclusion. Commissioner 10 has a view of science that has fact and qualifications as significant themes and she equates science with expertise generally. Given those boundaries it is entirely consistent that astrology could be included as science. I note that the Commissioner did not specifically describe astrology as being a science. Rather, she used astrology as an example to demonstrate how she would determine what is and what isn't science. Following her argument such fields as aromatherapy, iridology and cartography would also qualify as sciences provided a witness giving evidence to the Court about such matters could establish the significant qualification and fact-based criteria significant to her model.

I had anticipated that interviewees could have difficulty articulating their understanding of the meaning of science. I found that exercise difficult personally and that was despite a background in academic science and teaching. For that reason the interview questions were designed to give the interviewees a range of opportunities to talk around the issue and to explain the characteristics of science that they considered important. It may be that the difficulty in articulating their understanding of science is why so many members of the Court referred to a continuum analogy to explain their view of science when that view depended on a number of different factors. It is unclear the extent to which the different micro themes are linked in different models of science or what effect differing combinations could have for the resulting location of evidence on the science-non-science continuum. For example it is unclear whether evidence of data and an experimental process from a population expert would be sufficient to locate that evidence as scientific in Judge 1's model despite there being no link with the traditional fields of chemistry, physics or biology.

The responses recorded in Table 1 of Appendix 2 demonstrate that the presence of some form of experimentation or scientific method together with collection and presentation of data are important criteria for many members of the Court. That result was expected given their experience with hearing detailed expert evidence and their personal experience of secondary and sometimes tertiary education in which science teaching and learning often incorporates experiment and data collection. However, an analysis of the Tables in Appendix 2, together with an analysis of the interview transcripts shows that no two individuals have a model of science comprising the same combination of micro themes, even when all micro themes, both significant and non-significant, are considered. Given the number of individuals that emphasised both process and data themes, I was surprised at the overall variety of criteria that the members of the Court described as relevant to the meaning of science.

One of my research questions was to determine how members of the Environment Court describe the meaning of science. That question is answered by reference to the 10 micro themes analysed and recorded in Chapter 5. Science means something different to all 21 individuals interviewed as part of this research and

their explanations of the meaning of science draw on as many as five different micro themes, in the case of Judge 5, or as few as one in the case of Commissioner 4.

### 6.1.2 *Separating science from non-science*

Three further research questions ask how members of the Environment Court define the boundary that separates science from non-science and how they as individuals differentiate between scientific and non-scientific evidence and scientific and non-scientific witnesses. Again those questions are answered in terms of the criteria that are significant for each individual's model of science.

The location of the epistemological boundary that separates science from non-science is closely related to each individual's articulation of the meaning of science. In some cases that articulation was not directly forthcoming and the respective models of science have been inferred from the significant micro themes that explain where and why an individual would locate the boundary between science and non-science or from responses about specific types of evidence, for example engineering and medicine.

While questions about the boundary between scientific and non-scientific evidence and witnesses were intended to help interviewees by providing a wider context and framework for describing their understanding of science, those particular questions proved to be a puzzle for the group that does not distinguish science from expertise generally. I expected to find a difference between those that included only the physical sciences and those that included the social sciences in their classification of science. I also expected to find a difference between those that included technology or applied science in their classification and those that separated the application of science from the pursuit of new knowledge. For the purposes of analysis I decided to treat those who distinguished technology as a different macro group to see whether there were any commonalities within and differences between each group. I had not predicted that there would be members of the Court that considered all expertise to be scientific or to equate admissibility of evidence with it being necessarily scientific. That omission relates both to my own, essentially Kuhnian model of science, my experience of teaching and

learning in the physical sciences, and the wide literature review that underpins this research. Neither the wide range of views from philosophers, commentators and practitioners of science nor the views from the legal community that are described in Chapter 2 suggested a general connection between science and expertise.

I do not believe that these four individuals are an isolated and idiosyncratic group linked only by their common professional bond within the Environment Court. In order for such a conclusion to be likely there would need to be some other connection between the criteria that they each cite as important features of science. However, an analysis of the interview responses from this group shows that there are still six different micro themes relevant to their separation of science from non-science with a further two different themes that could be relevant to a less than significant extent. Because these individuals consider that all expertise is scientific they do not identify criteria such as traditional subject areas, experimentation or knowledge base as being essential to a scientific expert. To do so would be to exclude a number of experts in the more values-based fields such as landscape architecture or town planning and their model of science by definition includes those experts. I note that Judge 3 does refer to data collection and measurement as significant for scientific experts but that reference is to the volume of documentation that should support an expert opinion rather than any necessary quantitative component.

The questions asking about the differences between scientific and other types of evidence or witnesses clearly caused confusion for some members of the 'science = expert' macro theme group. My introductory letter outlined the general topics of the interview including reference to questions about differences between scientific and other experts. That reference was sufficient for Commissioner 12 to ask at the outset whether I was interested in any specific type of non-scientific expert because she was unable to think of such an example. When the interview came to questions about expert scientific witnesses she again acknowledged that this was not a distinction that she had previously contemplated but the nature of the question indicated to her that there were different views. Judge 6 also included all types of expert evidence into his classification of science and gave similar responses to questions about experts and about scientific experts as if the

questions were no more than reframing the same inquiry. However, Judge 3's responses showed frustration at this line of inquiry that he described as "just playing with words". For him there was no difference between expert evidence and scientific evidence and any opinion evidence that is admissible is therefore scientific. My questions that sought to determine how he distinguished between scientific and other evidence were initially an irritation for him because he did not consider that there was any such distinction. It was not until I suggested that some evidence on cultural issues might fall outside my own view of science that he was prepared to elaborate on the distinction with examples to demonstrate when hearsay evidence would not be admissible.

For the members of the Court in the other two macro theme groups the distinction between scientific and non-scientific evidence and witnesses related largely to the micro themes significant for their models of science. The variety in responses provided some useful insights into the Court's expectations of expert witnesses. Those commonalities and differences of expectation are discussed further below.

### 6.1.3 *Models of science: Judges*

The research results demonstrate that the Environment Court judges interviewed held individually different views about the nature of science and of scientific evidence but there were some criteria more commonly referred to by this group. Irrespective of the macro theme describing their distinction between types of expert most judges relied heavily on the fact, process and data themes as being significant for their model of science. The exception in this group was Judge 2 for whom the credibility of the witness and their evidence within the relevant peer community was the single most important indicator of science. All judges referred to process matters, either experimentation or a scientific method as being relevant to their model of science. In addition four judges referred to fact or proof as being relevant criteria. This emphasis on fact, data and experimental method appears to be much more pronounced for the group of judges than for the commissioners. Only four of the commissioners demonstrated a significant relationship between experiment or scientific process with their view of science. Of that group, only two also linked process with the need for data collection. That

is an interesting difference in light of the high proportion of judges for whom data or measurement was significant.

None of the judges referred to objectivity as being a scientific criterion although Judges 7 and 1 used the word to refer to independence and integrity of opinion respectively. Both references were in the context of expert witnesses rather than science or scientific experts specifically.

Another difference between judges and commissioners is the lack of reference by judges to academic or professional qualifications being a criterion of scientific expertise. That omission may be for several reasons. As suggested in Chapter 5 the judges may place less emphasis on qualifications due to them each having a minimum university degree qualification in law. Having that qualification may mean that they attach less status to the university qualifications held by others including the experts giving evidence before them. It may also mean that years of interacting with law practitioners who all have the same minimum legal qualification and who come from a variety of institutions both in New Zealand and from throughout the world has demonstrated that a qualification of itself is no indication of a person's professional ability. Likewise years of experience spent briefing and cross-examining expert witnesses may remove any expectation of a link between academic or professional qualifications and expertise when required to decide that evidence in a judicial capacity. On the other hand the judges are also all familiar with the common law rules of evidence previously discussed in Chapter 3. Those rules include a requirement of all experts that they have proven knowledge and experience and are relevantly qualified to assist the court with their opinions. Thus the judges interviewed as part of this research may well expect that appropriate qualifications will be an inherent characteristic of all experts, including scientific experts where the difference was recognised, and thus there was little need to specifically mention that requirement as being significant to whether or not evidence was scientific. Having said that it is still interesting that no judge referred to an expert's qualifications when responding to questions asking about the basis for deciding evidence from differing experts. At least one commissioner perceived that the nature of an expert's qualifications could be an important factor in the judge's decision between conflicting evidence.

Commissioner 10 commented that consideration of a noise expert's qualifications including the international reputation of the academic institution could be the additional factor when deciding between differing opinions. Her comment was in the context of having that additional support from a third party (to the extent that the academic institution has recognised the expert's ability) may help cement a difficult decision on the appropriate noise limit. Her comment also added the caution that the Judge may not agree with that analysis which suggests that Commissioner 10 has inferred that the ranking of qualifications as part of decision making is a common tool used by herself and the Judge without perhaps any specific discussion on the process. It may also be significant that the evidence and status of qualifications is the single most significant theme in Commissioner 10's model of science. I consider that it is reasonable to assume that she also expects that theme to be significant in the views of science held by other members of the Court including the Judge.

There is also some evidence of qualifications being significant in reported decisions of the Court. In his decision in the *Fast Ferries*<sup>381</sup> case, previously discussed in Chapter 3.3.1, Judge Treadwell included in his reasoning for the decision the comment that the NIWA scientist did not have the same qualifications as other experts and his evidence, although considered, was not referenced to the same extent as those others in the written decision. It is possible that the NIWA witness did not impress the Court as being credible and reliable, particularly in light of the evidence given by others and the reference to his qualifications was a tangible feature on which his evidence could be distinguished.

While the judges have different views about science and the relationship of science to expert evidence generally it is unclear the extent to which they are aware of those differences. Different judges do participate from time to time as presenters of courses designed to instruct experts on the Court's expectations of them and their evidence. Expert witness courses are periodically offered by the New Zealand Law Society, the Resource Management Law Association and have been initiated by the Court itself and run in conjunction with Ministry for the

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<sup>381</sup> *Marlborough District Council v New Zealand Rail* [1995] NZRMA 357, 374-376.

Environment officers. There is usually one course for expert witnesses run each year at various venues throughout the country and at least one course designed for experts appearing before the Environment Court every two years. I am aware of at least three different Environment Court judges who have presented papers at expert witness courses run in Auckland and would assume from the similarity of those presentations that there is some communication between judges about course content. However, my interview results also suggest that there may be a certain degree of 'talking past each other' in terms of the language and meaning used when judges discuss scientific evidence and expert evidence generally. The difference between the macro themes is but one indication of that incomplete communication. Another indication is the use of the terms hard and soft science when used to describe different types of expert evidence. Judges 1, 4 and 7 use the terms to describe the types of evidence that contain more of the characteristics that they individually associate with science. Judge 1 distinguishes hard science from resource management and planning evidence that he would locate at the soft end of his evidence spectrum. Judge 1 has a model of science that emphasises the data and experimentation/process micro themes. Judge 7 uses the hard/soft science terminology to distinguish between the social and physical sciences referring to the physical sciences as hard sciences. He has a model with fact and knowledge as significant micro themes and appears to identify the physical sciences of chemistry, physics and biology as representing recognised and accessible bodies of knowledge. My analysis of his interview suggests that he includes biology into his category of hard and thus physical sciences. His example to demonstrate his meaning of hard science was with reference to a telecommunications case in which evidence was given about the nature and effect of radio frequency towers and the effects of radio waves hitting things and people. Judge 4 also uses the term hard science to distinguish the social sciences. He does not specifically refer to physical sciences but emphasises the hard database associated with hard sciences in contrast with his experience of evidence from the social sciences. Like Judge 1 he has a model of science in which both data and process/experimentation are significant micro themes however, unlike Judge 1 he differentiates scientific evidence from technological evidence.

Those references to hard and soft science and the common theme contrasting hard science with social science suggest that there is some discussion between the judges and consistency of understanding around those terms. However, Judge 6 also refers to hard and soft science but in a way that links the terms to their intellectual difficulty and specialist nature making their content more difficult for the Court to “assimilate”.<sup>382</sup> Judge 6 does not differentiate scientific evidence from other types of expert evidence and his reference to hard science is linked to his description of the type of evidence that the Court does not hear often and is therefore hard to comprehend, process and decide or is particularly technical and specialised. He contrasts hard science with the types of evidence most frequently heard such as traffic engineering and planning while he illustrates hard science with reference to particularly technical aspects of civil engineering evidence. Judge 6’s boundary between hard and soft science may fall in a similar place to the same boundary for Judges 1, 4 and 7 but the reasons for that location are very different. His use of the term hard science relates to the intellectual difficulty associated with technical or data based evidence while Judges 1, 4 and 7 use the term to distinguish between the less data and process related fields that they would describe as social science.

#### 6.1.4 *Models of science: Commissioners*

The views of the commissioners are also very varied with few commonalities. The commissioners are also distributed across the three macro theme groups with relatively more differentiating science from technology than do the judges. It is interesting that one commissioner, Commissioner 7, who clearly distinguishes applied science including engineering from her category of science, was referred to by name as an example of a scientist by several of the other interviewees. Her profession was also directly linked with science by most of the interviewees that included technology in their classification of science.

Four of the six commissioners within the macro theme group that distinguishes science from technology also have professional qualifications in either a physical science field or in a technology related field. It is possible that their experience of tertiary educational science courses gave them more direct contact with practising

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<sup>382</sup> Refer to the interview extract in Chapter 5.4.2.

scientists and caused them to differentiate their professional experience, or that of the technical experts giving evidence, from their own understanding and experience of science. The results also indicate that most of the commissioners in this macro theme group refer to qualifications as a significant theme in their model of science. There are also two commissioners that have knowledge as a significant theme.

On the other hand, four of the five commissioners in the 'science includes technology group' also have professional qualifications in a technical field. Those commissioners tended to value empirical measurement, data and process micro themes as significant to their model of science. For them the process used to obtain the data that supports expert evidence is what crystallises the scientific nature of that evidence. None of the commissioners in this macro theme cited the body of knowledge associated with science as being significant to their view of science.

The single theme most frequently referenced by the group of commissioners was the importance of process/experimentation to their classification of science. Those results include multiple references by Commissioners 8, 9, 1, 11, 7, 4 and 3. However the theme that was significant in the model of science for the greatest number of commissioners was qualifications. Seven commissioners discussed qualifications in a way that I assessed as significant to their model of science. That is five more than for any other micro theme and reflects the highest degree of consistency within the group.

The micro theme which fewest commissioners referred to in a way significant for their model of science was knowledge. The only two commissioners with that significant theme both fell into the macro theme group that separates technology from science. Given that the members of that macro theme group do not inherently connect measurement or data with science their criteria for distinguishing science and technology must lie with other characteristics. For most it is qualifications but for Commissioners 6 and 7 the body of knowledge associated with science is a significant theme.

It follows from the previous discussion that the reason why there are no commissioners in that macro theme group having a significant reference to measurement and data also relates to their distinction between science and technology. It is difficult to find an example of technological expertise that does not involve measurement or data and some of the experts from technical fields commonly appearing before the Court have considerable amounts of data as part of their evidence. Various types of engineers are obvious examples. Thus data of itself is unlikely to be a significant characteristic of science for those individuals that distinguish science from technology.

#### 6.1.5 *Models of science: consistency in the Environment Court*

The interview results show that there is a wide range of different views about the meaning of science throughout the members of the Environment Court who participated in this research. While some Court members had relatively clear criteria for distinguishing scientific evidence from non-scientific evidence others had difficulty in locating that separation and relied on the presence of significant themes when making that judgement. When I describe some members as having clear criteria, I mean that the criteria are clear to them and are readily articulated. Those interviewees with a model of science that values qualifications in one of the physical sciences or a connection with the physical, or traditional sciences are examples of members with clear criteria.

Most interviewees did not have a single strong theme as the means to locate the boundary between science and non-science and for them the combination of criteria significant in their view of science forms the basis for deciding that boundary.

The interview results do not suggest any awareness by members of the Court that there are different views about the nature of science held by their colleagues. Several interviewees questioned whether I had received any different responses from others that I had interviewed. Those questions were always at the end of the interview when reflecting on the range of topics discussed. A number of interviewees also commented that these were not matters that they normally considered and found articulation of the reasons why they classified certain

evidence as scientific or not to be an unexpectedly difficult exercise. Those comments support my conclusion that while there are numerous differences in the models of science held by members of the Court, together with numerous reasons for those differences, there is little or no recognition of those differences between individuals or within the Court as a whole.

## 6.2 Essentialist views

Two further questions underpinning this research ask whether members of the Court have views of science consistent with those in the science community and or the legal community. As discussed in Chapter 2 Gieryn identifies two different perspectives when interpreting the boundaries between science, technology and society. Those perspectives are essentialism and constructivism. Essentialist perspectives involve the identification of invariable and unique characteristics that are essential to the categorisation of a knowledge or activity as science. The classical and empiricist models expounded by Enlightenment philosophers such as Descartes, Kant and Bacon are early examples of essentialist theories. Those theories were further developed by the logical positivist school of thought characterised by Popper, Kuhn and later Merton.

Essentialist views are identifiable in a number of members of the Environment Court for whom there is a single or group of essential characteristics that separate science from non-science. Clear examples include Commissioners 5 and 6 and Judge 8 for whom an expert's relationship with the traditionally recognised physical sciences is a significant theme. Without that essential feature evidence may still be expert but will not be scientific.

Commissioners 6 and 7 also exhibit essentialist views in their emphasis on the need for science to demonstrate a contribution to a body of knowledge. Without that goal research would not have the unique quality that characterises science. Commissioner 6 expands on her view by explaining how contemporary social research acquires a scientific quality by building a body of knowledge that is accessible to others and can provide reference support for research that is essential when contrasting science with opinion.

Other examples of essentialist views can be more closely identified with the logical positivist theories detailed in Chapter 2 as follows.

### 6.2.1 *Empiricism*

The interviewees with the models of science most directly comparable with empiricist views are reflected by those who referred to empirical data and empirical measurement. Judge 8 has a strongly empiricist model of science with multiple references to the term empirical (or empirically) with respect to the activities of analysis, research and investigation. His interview extract reproduced in section 5.6 demonstrates a strongly essentialist view when he describes the close connection between scientific theories and empirical research. He notes that some scientific evidence is not strongly empirical in that it may be based on models, however, those models will typically have a mathematical base which of itself imbues the data with an empirical quality.

The dictionary definition of ‘empirical’ is:

1. based or acting on observation or experiment, not on theory.
2. *Philos.* Regarding sense data as valid information.
3. deriving knowledge from experience alone.<sup>383</sup>

The first of these definitions fits particularly well with the way Judge 8 uses the term when he describes his understanding of the difference between “novel” or “fringe” science and mainstream science.

Judge 5 also strongly links his view of science with the need for a scientific method or process involving data collection. He seems to equate an opinion with a hypothesis but it is not clear whether an expert opinion given as evidence has the status as an untested or a tested hypothesis. Interestingly, he separates the testing of a resulting hypothesis from the initial collection of data and his description is remarkably Baconian in that respect. The following interview extract emphasises this Baconian approach:

And I believe it’s that initial step [collection of data] which has led to many of the errors that have been made in scientific, scientific assessment

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<sup>383</sup> Concise Oxford Dictionary, Ninth edition.

really. They are working from an assumption back to, and one, and we've seen, sure I mean, sure you've found more than me, where scientific method has been sacrificed to get the right results. One has ignored them, on occasions, I remember in some of - I remember in physics a lot of the results were treated as random results, when in fact um if they had taken them into account, they would have got a much different answer to the hypothesis they were working on. (J5)

To Judge 5, the operation of science by starting with an assumption, (by which I understand him to mean a theory or a paradigm), and working backwards doing testing of data is described as sacrificing scientific method. However, that is the basis of the scientific model that is described by both Popper and Kuhn.

### 6.2.2 *Logical positivism*

#### Popper

The clearest examples of interviewees having models of science consistent with the logical positivists are the references, sometimes emphatic, to the need for data to be tested or replicable. Commissioner 1 has a view of science that closely links the need for repetition of results with a goal of producing "incontrovertible fact".<sup>384</sup> Her description of social science, and particularly of psychology, as garbage was intended to emphasise her view that such research is not science because it cannot produce replicable results. Her view has close similarities with Popper's falsification theories through her references to the need for repeated testing of results. Although Popper believed that scientific theories could never be provable, he proposed that the best theories would be those that survived continued and rigorous testing. To that extent, a theory would continue to represent the closest approximation of truth until disproved by testing. Commissioner 1 also describes science in terms of having proof, or fact that can be relied on provided it withstands repeated testing.

Other interviewees that referred to the need for testing or replication of results include Commissioners 7, 8 and 9 and Judge 1. Commissioner 9 also referred to the process of replication of data and thus the conclusions derived from that data

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<sup>384</sup> Refer to the interview extract in Chapter 5.5.

as evidence of science and of the boundary between science and social science, which she described as “social studies”.

### Mertonian norms

Merton’s norms are the goals of communalism, universalism, disinterestedness, originality and scepticism.<sup>385</sup> While those interviewees with references to the promotion and availability of scientific knowledge and to the need for testing of data and conclusions show similarities with Merton’s model of science, the lack of any link with a requirement for objectivity by the researcher is a significant difference. Only 2 interviewees referred to objectivity in terms of their explanation of science. Commissioner 7 referred to the process of evaluating and presenting data without previous bias and Commissioner 8 contrasts science with valued based fields such as landscape architecture, which she described as being subjective compared with the evidence of a scientist, which is “usually more objective”.

The other references to objectivity were all in respect of a general requirement of expert evidence rather than to scientific evidence or science specifically but that requirement does reflect the Mertonian norm of universalism.

At least two interviewees indicated an expectation of disinterestedness from scientific experts. The Norm of disinterestedness refers to an expectation that scientists will be motiveless with respect to their research. Commissioner 12 referred to the “purity of science, the integrity of a true scientist” while Judge 1 had an even stronger reference to disinterestedness when he said:

Yes, I think most scientists, most really good scientists are in some way inspired just by the love of the knowledge and the working things out. I suppose there probably are some oddballs around, um, they’re brilliant scientists, but they only do it for the money. I don’t personally know any.  
(J1)

Judge 1’s comments were surprising given that before accepting judicial office he would have had considerable experience of instructing experts and presumably

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<sup>385</sup> See discussion in Chapter 2.3.2.

would be aware of their business needs and fees. His comments seem to ignore the reality of the modern professional scientist who must either rely on private contract work or face an endless competitive round of public and private funding applications to ensure payment of the mortgage and the other accoutrements of everyday life. However on closer analysis of his model of science I note that he has an emphasis on traditional subject associations when determining what is and what is not science. It is possible that in his pre-judicial professional experience most experts that he would classify as scientists would primarily work as university academics or government scientists. Neither group relies on such contract work for their salaries and research by university academics has historically been a requirement of the position. Thus some university academics giving evidence as an expert witness may only require payment to cover preparation of the evidence and time and expenses involved in the appearance.<sup>386</sup> In addition, until relatively recently many scientists not working in academic institutions worked in government funded research centres. Recovery of actual costs by such institutions (to the extent that they remain in existence) has also been a relatively recent phenomenon following state sector reforms of the 1980s and 1990s that imposed a business model on many government service providers. The other group of experts that Judge 1 would consider to be scientists are those employed by local authorities. I am not aware of the present pay rates that apply to local authority technical officers but have never heard anyone suggest that such positions are financially lucrative and filled by “oddballs” who are “brilliant scientists” but only doing it “for the money”. That description raises an image of the Machiavellian scientists typical of James Bond movies and the like. Perhaps the reality of Judge 1’s comment relates to his experience of scientists being genuinely interested in research that many others could find totally mystifying or dull, while working for relatively modest incomes.

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<sup>386</sup> I have personal recent experience of contacting a university soil scientist who agreed to provide the evidence of his academic research in a case involving riverbank erosion. His fee was extremely modest being sufficient to cover 10 hours of his time spent preparing evidence and appearing at a hearing together with his travel expenses.

### 6.2.3 *Science as a social construct*

Constructivist models of science critique the traditional modernist paradigm by focussing on the context in which science is practised. That context includes the social environment of the scientist (past, present and future) the context of the research itself and the ways in which research results are used. In short constructivist models of science explore the boundary-work done by those connected with scientific endeavour.

There were a number of interviewees with models of science that had a strong constructivist connection. That group includes many of those who described a continuum-based model of science and also those with references to the importance of the scientific community and peer review. The other indicators of a constructivist approach are references to the connection between science and its purpose.

### 6.2.4 *Continuum models*

Interview responses from a number of both judges and commissioners indicate difficulty in specifically locating any particular type of evidence on a continuum between science and non-science. For many of those individuals their categorisation of that evidence as scientific or not could depend on a number of factors such as whether or not it has data supporting a value judgment and whether or not it is relevant. Those references to a continuum or pendulum indicate that the interviewee recognises that their model of science does not have a rigid or formal boundary. Rather, it is a concept that changes according to their own interpretation of the criteria significant to the science concept. For example, Commissioner 12 comments:

Well, (pause) I guess I should have got a line of demarcation between cultural and science. I mean there's obviously going to be overlaps I suppose. I can't think of them, but I sort of have a clear idea in my head and I mean I, I, I can't tell you the line, but I can tell you good examples where I'd put it I guess. It seems to me it's never something that I've had to um think about. (C12)

That extract demonstrates that Commissioner 12 has a process for deciding the difference between science and culture. She may not be able to articulate the process but could apply it to specific examples. She is describing how she constructs her view of science according to criteria that are significant to her view. Another comment demonstrating this flexibility in defining science was given by Judge 5:

You know there are people like landscape, but in the way I suppose that it is a science, to some extent, although that's greater opinion, but I suppose looking at my um my continuum we don't have science here and art here. I suppose I see science as something of an art in itself when it gets to the point of view of their opinions. So I don't see that that, that black and white definition between science and, and the other sort of callings. (J5)

Here Judge 5 specifically recognises that there is an element of “art” or value judgment in the way that scientists form opinions from their research. He is acknowledging that there is a subjective component to that construction of knowledge. He also indicates flexibility when deciding what is and is not science when he refers to the lack of a black and white demarcation between science and non-science.

I have previously referred to the model of science described by Judge 3. He falls within the ‘science = expert’ macro theme group and does not distinguish between scientific evidence and any other kind of admissible evidence. Judge 3 also indicates a constructivist model of science in his reference to science being “so much part of the world, today and is contributing to our knowledge of it”. That comment indicates acceptance that science is connected to and inseparable from the modern world – science has a social context.

Another comment indicating the social contextual nature of science was given by Commissioner 5. She observed:

Ah, when I first kicked off, we didn't have traffic engineers or landscape architects. All these things have developed and then you have got to say, are they scientists or are they what? ... It's really an evolving thing.

...So the word “scientist” is being used, like consultants, very, the picture is changing. (C5)

Her reference to the evolving nature of any category of science reflects a contextual view in which science changes depending on the needs within society. Where landscape architects were once infrequent witnesses before the Court they are now regularly called to give evidence on a range of visual amenity and landscape matters. Commissioner 5 notes that these types of witness may now be within her category of science expert where they were formerly not even recognised.

Whether or not the interviewees that refer to a continuum or spectrum of science or to a difficulty describing how they would classify science are actually referring to the contextual nature of science, they are describing their own individual boundary-work process. Each of those comments reflects a self-recognition that the individual must construct their own definition according to variable criteria. This research has identified what those criteria are together with the combinations that are significant to each individual when locating specific expertise in relation to their own model of science.

#### 6.2.5 *Scientific community*

The references to the importance of the scientific community when determining whether or not scientific testimony may be relied on also acknowledge the social context of science. When Judge 2 explained the need to consider whether or not the propositions contained in evidence had been peer reviewed and the level of its acceptance within the scientific community, he was reflecting a non-essentialist view of science. Thus it is not the presence or absence of any given characteristic that would determine whether or not a novel proposition could be accepted and relied on in expert testimony. Rather, its acceptance by the scientific community is what would be significant when measuring its reliability against other evidence.

The various interviewee references to reliance on evidence of acceptance for a proposition from the science community raise two different issues. Firstly, there is the inherent conflict between the expert’s role which is to assist the Court but

without deciding the matter. Thus the common law rules of evidence allow expert opinions to be given while retaining the decision making role to the Court. It is difficult to imagine a situation involving issues focussed on environmental, rather than cultural, planning or social effects, in which the Court could decide a matter contrary to the advice of an expert, where that expert meets the various criteria for reliability set out in decisions such as *Daubert v Merrell Dow*<sup>387</sup> or *Shirley Primary School*<sup>388</sup>. The fine line between expert opinions that inform a decision and expert conclusions that form a decision is evident in the comments of several interviewees who express their confidence in relying on scientific evidence.

Secondly, both the *Daubert and Shirley Primary School* decisions refer to the need to consider acceptance of scientific propositions by the relevant science community. That of itself is recognition that science is not a knowledge-form or practice that is independent of and separate from those involved in its production. That is, science is perceived subjectively by those both receiving and producing information that is presented to the courts. The requirement to assess peer acceptance of scientific propositions acknowledges that science is, at least partly, what the science community says that it is.

#### 6.2.6 *The utility of science*

There were a number of references by interviewees to the interconnection of science with its purpose within society. Judge 8 referred to the application of science to “try and improve...man’s lot in life” and Judge 1 discussed the immense utility and explanatory power of science with reference to the micro-sizing of technology as “a miracle of science”. Those comments indicate that science not only occurs within a social and community context but also has a contextual purpose. Commissioner 11 gave perhaps the clearest example when she described science as follows:

...I think science is much more lively. I would like to think it’s out there at the cutting edge, looking at why things are happening and enabling us to understand so that we can take some processes in our own hands to stop it. So ah I think there are other avenues to science than just sitting there

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<sup>387</sup> *Daubert v Merrell Dow Pharmaceuticals* 125 L. Ed 2d 469, 113S. Ct. 2786 (1993).

<sup>388</sup> *Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66.

saying, “who’s got” – I like to think of science out there leading the way in how the world works, because if it isn’t we’re going to be in trouble aren’t we? (C11)

That comment demonstrates a view of science as being both progressive and proactive. She does not describe a disinterested process involving the testing of hypotheses to discover new unifying theories of the world. Rather, her view of science describes an active endeavour with a purpose to lead the world forward. The comment invokes an analogy of science as a crusader on behalf of society searching out new and better horizons.

### 6.2.7 *Objectivity*

While I was surprised at the lack of references to objectivity in the context of science or scientific expertise that lack may reflect a general expectation of neutrality or independence on the part of all experts. The 2005 Environment Court Practice Note<sup>389</sup> requires expert witnesses to assist the Court “impartially on relevant matters within the expert’s area of expertise” without advocating on behalf of their instructing client. That is a restatement of the common law as it relates to expert evidence. The requirement is specifically addressed in the Practice Note to reflect the Court’s expectations of expert witnesses. As discussed in Chapter 3.3.1 the Court is not bound by the rules of evidence and thus the Practice Notes are an opportunity for the Court to communicate its expectations of parties and their witnesses during all parts of the litigation process. I have previously questioned whether it is reasonable or indeed practical to expect expert witnesses to give entirely impartial evidence in light of the context of their participation in the proceedings.<sup>390</sup> It is not possible for any expert to separate him or herself from the context of the evidence and that context is defined by the scope of the client’s instructions. The impartiality requirement also ignores the practicalities of expert appearances. The expert is engaged and paid by the client. The expert is also called to appear on behalf of the client and any expert who prepares evidence that includes propositions materially in conflict with the client’s position is unlikely to be called to appear at the hearing. That

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<sup>389</sup> See discussion in Chapter 3.3.6.

<sup>390</sup> See discussion in Chapter 3.2.3

point of conflict rarely occurs because experts routinely provide reports at an early stage in the litigation and those reports provide the basis for evidence if the matter actually proceeds to a hearing.

My analysis of interview responses that do refer to the need for objectivity on the part of an expert indicates a strong relationship between the need for experts to be independent of their client. A tendency by a witness to advocate on behalf of the client was described by several interviewees as causing a significant detriment to the weight that would be given to that evidence. That view was most strongly articulated by Commissioner 1 who described the effect on the Court of a partisan expert witness as “the weight of his evidence was lost to us completely, because he lost his objectivity”. The desire for impartiality from expert witnesses relates to the purpose of their evidence, which is to assist the Court with opinions on matters within their expertise. Reliance on expert opinions is grounded in the data, methodology and presentation of evidence but also on the status of the expert within his or her own expert community. That status is measured by some of the Commissioners with reference to academic and professional qualifications. That status is measured by other members of the Court with reference to academic publications and to evidence of peer review and acceptance. If an expert displays an advocacy role when providing evidence, then that expert is effectively appearing in a dual capacity – both as representative of the client and as a representative of the relevant expert community. That dual role interferes with the Court’s ability to contextualise the evidence as a reliable construction of knowledge that is independent of the client’s overall goal. No critics of expert witness partiality suggested that the appearance of enthusiasm or support could be linked to the strength of the witness’s conclusions with respect to a proposal or to their professional preference for one outcome over another.

It is also possible that the lack of references to objectivity being an essential, or even a desirable characteristic of science may be that the Court recognises scientists, like everyone, work within a social context and from a particular personal standpoint. The following comments from Judge 4 best illustrate that approach:

I don't see science as being different from the way it's constructed and produced. Um, I think the issues are different as between the different scientific disciplines. Um, but at the end of the day they're not all too different in the ways they're built up from the grundnorms particular to that particular issue. (J4)

His reference to the construction of science is direct acknowledgement that science is not just out there waiting to be found in any classical Cartesian sense. Instead it is something that is constructed with reference to the grundnorms or paradigms that are relevant to that construction process. In addition, he refers to issues that are different between scientific disciplines. That reference also acknowledges the social context of science that involves different intellectual and practical institutions that give rise different disciplines that operate within the accepted grundnorms.

#### 6.2.8 *Law and science*

I have discussed above the views expressed by two judges and two commissioners that identify all expert evidence with science. Those are not views that I had previously identified from a review of relevant literature and are, in fact inconsistent with the line of judicial authority leading from *Frye v United States*<sup>391</sup> to *Daubert* and *General Electric Co v Joiner*.<sup>392</sup> The interviewees were not asked any questions about the relationship between law and science and any discussion about that relationship focussed on the role of expert witnesses and the Court's expectations of those witnesses as now recorded in the Practice Note.

In terms of the views on that relationship previously discussed in Chapter 2.5 there were no references to the Court's own decision making process that expressed a need or desire for a scientific basis. None of the interviewees suggested that their own process of deciding between experts was in any way scientific. That is perhaps surprising given the emphasis by some commissioners on the importance of qualifications and professionalism when determining

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<sup>391</sup> *Frye v United States* (1923) 293 F 1013. See discussion in Chapter 3.2.5.

<sup>392</sup> *General Electric Co v Joiner* 522 US 136 (1997). See discussion in Chapter 3.2.5.

whether or not an expert is a scientific expert. There seemed to be a separation between the interviewees' perception of the process involved in giving evidence and the process to decide that evidence. Without interview data I am unable to comment further about any consistency between models of science described by members of the Environment Court with legal theories proposing a scientific status or process for law.

#### 6.2.9 *Valuing science: the significance of boundaries*

Another of the questions for this research is to discover whether the Court weighs, or values scientific evidence differently to other types of expert evidence. I have equated the process of weighing and valuing evidence because every decision to prefer evidence A over evidence B involves a value judgement. That judgement may consider a variety of different matters, for example: the credibility of the witness based on confidence, directness, or consistency with previous evidence given to the Court; the volume and relevance of data supporting conclusions; or statutory requirements such as those requiring certain matters to be taken into account as a matter of national importance. The interviewees were asked a number of questions aimed to discover whether they value scientific evidence more highly than non-scientific evidence. Most responses were very consistent in commenting that all evidence is weighed as part of the decision making process and that the issues significant to any given decision will depend on the particular circumstances of the case. The following comment from Commissioner 1 summarises that general response:

The weight that we give to a science is the weight that it is perceived to have in the context of the decision. By that I mean, all the science in the world may not be able to overcome an argument where a cultural thing is more important. (C1)

However, my analysis of comments to questions about how the Court decides between differing experts and how the Court decides that a new scientific proposition can be accepted indicates that science is valued above other types of evidence for a number of the interviewees.

That positive valuation is reflected in the comments of Commissioners 1, 3 and 5 with respect to the intellectual superiority that it attributed to scientific experts. Such experts are described as being entitled to communicate on their own level without the need for lay people to have the same level of understanding or even to be involved in evaluation of the data. Those commissioners have reasonably similar micro themes in their models of science although they fall within two different macro theme groups. Commissioner 3 has a view of science that emphasises the role of the scientific community in the interpretation and evaluation of scientific propositions, thus it is not surprising that she attaches a high intellectual status to that community. I note that Commissioner 5 disagrees with Commissioner 3's expectation that scientific evidence is entitled to be less comprehensible to the Court. Commissioner 5 expects scientific evidence to be supported with diagrams and a summary to ensure that the Court can and does comprehend the content, especially as "scientific evidence is very, very important" – even "critical". Commissioners 1 and 5 both have data and qualifications as significant micro themes. A preference for qualifications would seem to give scientists an initial head start over other witnesses, even before their evidence is heard.

Other clear examples of a positive valuation of scientific evidence include comments that:

- social sciences are "mimicking" the form of hard science, which is described as having "mana"; (Judge 1)
- science is a "touchstone" that will be found in any case "worth its soul"; (Commissioner 11) and
- scientific evidence is "more interesting". (Judge 4)

The micro themes significant to individuals' models of science also contribute to the value those individuals attach to evidence. Commissioner 1 has a strong link between and science and fact. While commenting that evidence of an "incontrovertible scientific fact" will not necessarily form an important part of a decision, she continues to say that "you've got to accept it and we do, but we use it as we feel appropriate..."

My analysis of the interviews also identified a preference by some members of the Court for evidence from the applied sciences rather than the “straight” or “pure” sciences. Such preferences can be inferred from the responses of two of the judges and two of the commissioners. Those preferences tended to be linked to the data micro theme being significant in their models of science.

When considering the implications of any preferential valuation of science over other forms of evidence it is important to remember that each individual member of the Court has a different view of science. What is science for Commissioners 1 or 11 is very different to each other and to what is science for Judges 1 or 4. When Commissioner 1 refers to real science being “based on the improvement of the lot of the planet that we live on” she includes all expert evidence with a data-based context. That means all types of engineering and medicine, including psychiatry, but excludes the social sciences and particularly sociology and psychology. On the other hand Commissioner 11 distinguishes technology from science and has a continuum-based model of science with qualifications and fact as further significant micro themes. She does not include engineering evidence in her classification of science.

#### 6.2.10 *Implications of this research*

These results confirm the work of researchers such as Gieryn and Edmond who have studied the way that scientists and judges use boundary-work in order to create meaning from scientific and technical data within a legal framework. Gieryn focussed on the way that scientists use language in order to promote or protect their own personal or professional interests. Edmond took that work further in studies of the Lindy Chamberlain hearings to show how experts and counsel used boundary work to promote opposing interests through the laboratory trials undertaken to assess the behaviour of wild dingos. That work also studied judicial responses to that evidence and their boundary-work discernable from trial transcripts and from the written decisions. This research has been able to identify differences in the way legal decision makers perceive and value science through analysis of how those individuals actually describe concepts of science, technology and expertise rather than relying on the context of their comments within the judicial environment.

My analysis of the interviews with the Environment Court indicates that people weigh evidence differently depending on the type of evidence, the witness and the circumstances of the case. Whenever decision makers differentially value scientific evidence over other types of evidence, their own model of science becomes relevant. Where people classify scientific evidence differently from each other, this differential weighting of science, whether positive or negative, can lead to inconsistent decision making.

It is important that those responsible for shaping the role of science in law recognise that there are differences in perception concerning the goals, processes and scope of science. Those differences reflect personally held models of science in which the boundaries defining what is and is not science can be based on a range of criteria. In turn, the giving, receiving and assimilation of scientific evidence also involves boundary drawing so that the preferred narrative will be shaped by the context, content and character of the proceedings, including the players, themselves.

This research has implications for the way in which parties prepare and present expert evidence to the Environment Court and for the way in which the Court assesses that evidence. It is reasonable to assume that the differences apparent in the interview responses from Environment Court members will also be apparent in other branches of the judicial system and those differences give rise to implications for decisions concerning admissibility of evidence, particularly where those decisions set binding precedents. But perhaps the most significant implication of this research is for the discourse concerning the relationship of science with law. Arguments that promote separate science courts to assess scientific evidence or the availability of permanent technical advisors to assist judges miss the point completely if those arguments do not recognise the very wide gulf in perception about science that can and does exist between legally and technically trained individuals who are likely to assume those roles. Likewise arguments that promote the adversarial system as an efficient and effective mechanism to test the credibility and relevance of scientific evidence ignore the

very wide differences between similarly qualified individuals in their categorisation of what is and is not science.

The discourse concerning the relationship between science and law also largely ignores the boundary-work undertaken both by expert witnesses when they communicate their opinions and by decision makers in the assessment of those opinions. That boundary-work is carried out to emphasise the criteria of significance to the individual who is either communicating or receiving the information. Any theoretical discussion concerning the appropriate role of science within our legal system should recognise that the criteria specific to an individual's model of science will differ because of the socially constructed nature of knowledge and the different social environments that contribute to each individual's knowledge, expectation and valuation of science. The criteria that are significant to that model of science will determine the boundary-work done in order to assimilate, order and prioritise scientific expert opinion.

My comments concerning the implications of this research focus primarily on the adversarial system of judicial decision making given that the research results arise from interviews with the Environment Court. However, this research also has implications for the policy and lawmaking functions of central and local government. The 2003 discussion document prepared by the office of the Parliamentary Commissioner for the Environment, *Illuminated or blinded by science?* sets out to "explore ways in which environmental policy and decision-making can be effectively supported by science and research to achieve effective environmental management and good outcomes."<sup>393</sup> That document sets out the authors' model of science<sup>394</sup> but assumes that model is universal and that the word

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<sup>393</sup> Parliamentary Commissioner for the Environment, *Illuminated or blinded by science? A discussion paper on the role of science in environmental policy and decision-making* (Wellington: 2003) 3.

<sup>394</sup> "... 'science' is a system of knowledge and a model of inquiry, organised in a particular way. Science seeks to understand things such as natural phenomena, their causes and effects. It does so through a process of putting forward a supposition (hypothesis) for how something works, then gathering evidence (via experiments) that seeks to falsify the hypothesis." In Parliamentary Commissioner for the Environment, *Illuminated or blinded by science? A discussion paper on the role of science in environmental policy and decision-making* (Wellington: 2003) 20.

science will have a commonality of meaning for the contributors to the document as well as for those reading and responding to the discussion it raises. I consider that the document's goal is worthy of research and discussion because of the importance of environmental policy making for the protection and sustainable development of New Zealand within a changing global environment. That policy will be, and should be supported by ongoing scientific research. At the interface between the experts that undertake, assess and communicate that research, and the legal and social framework that decides if and how that research should be implemented, are policy makers and lawmakers with their own individualised models of science. They must also recognise that the common language used to describe science and scientists encompasses wide variations in meaning, expectation and value attributed by different individuals to those terms.

On a more practical note, this research also has implications for decision making within the Environment Court and for the appropriate and fair preparation of expert witnesses for their role in that adversarial process. Those implications are discussed more fully below.

#### 6.2.11 *Environment Court decision making*

So does it matter that every member of the Environment Court has a different model of science? At least two interviewees commented that the question is not important to their everyday practice in the Court. Judge 2 responded to a question about his view about the nature of science with:

I don't, ...I don't think about what science is. That's a philosophical question. (J1)

And Judge 7 commented:

I don't think I've ever had, felt the need to understand science in order to that, in the sense that scientists would and they may write commentaries on their particular branch of whatever science it is. So I can't quite see the problem. (J7)

Throughout the process of data collection and analysis I have been struck by the considerable differences in the way people describe and value a concept that

otherwise appears to have a universal quality. Different individuals have different criteria for distinguishing science from non-science, some have different expectations of scientists than from other experts and some value science over other types of evidence. It was clear very early in the interview process that there were very different views about science between individuals and that there were no obvious trends within either the judicial or commissioner group. The majority of interviewees were surprisingly open and unguarded in their comments and I appreciated receiving some very forthright responses to a variety of questions. I have tried to ensure that interviewees cannot be identified from the context of the extracts recorded in Chapter 5 and have not included a number of very emotive comments that serve only to illustrate or emphasise points already made in the interview. However, the interviews themselves and the results in Chapter 5 demonstrate that some members of the Court have very strong feelings about expert evidence, expert witnesses and also scientific expertise. The members of the Court clearly had discussed their expectations of and frustrations about expert evidence prior to my interviews. That informal discussion was referenced in a number of interviews and there had been an Environment Court workshop that considered the topic of expert evidence held several weeks before my first interviews. In light of those discussions it was even more surprising to discover the range of views not only about science but also about expert evidence generally.

In terms of the theoretical framework underpinning this research I can confirm that members of the Environment Court construct their own individual views about science using criteria that are familiar and significant to them in the context of their professional and social environment. That epistemological construction process involves boundary work to select for values that they identify with science and scientists and to select against those values that they associate with non-science. For some individuals that boundary work begins even before the evidence is heard - at the point when based on qualifications or subject matter, a view is formed about the scientific status of the evidence.

I considered the implications of these different views for the process of decision making in the Environment Court, particularly in light of the preference for

scientific evidence as a basis for deciding a matter that was articulated by some interviewees. Do the different views about science give rise to unfair, biased or ill-considered decisions? Does it matter that judges and commissioners value scientific evidence differently from each other? Does it matter that they may value scientific evidence over other types of evidence? My academic, professional and personal instincts say that it must matter but my analysis of the reasons supporting those instincts suggests that the implications for the Environment Court are considerably reduced because of the Court's unique procedure and decision making process.

One of the very few matters on which all interviewees agreed was the consensual nature of the overwhelming majority of decisions. Several commissioners could recollect a small handful of decisions in which a dissenting judgment was produced but there was general agreement that most cases involved a consensus as to the outcome, if not the reasoning of a case. All of the interviewees agreed that it was the judge's role to decide and record the legal issues relevant to a matter but that all members of the Court contributed to the overall written decision.

The interviews demonstrated that within the divisions of the Court there is a range of different approaches to actually writing the judgment. Those approaches include:

- participation by the commissioners in an editorial capacity only
- preparation of sections of the judgment by the commissioners at their request
- the judge delegating to one or more commissioners the responsibility for writing specific sections of the judgment
- one or more commissioners accepting responsibility for writing the entire judgment with editorial comment from the judge.

In cases where the responsibility for writing part of the judgment is either requested by or delegated to a commissioner that decision may relate to the commissioner's background and special knowledge of evidence significant to the agreed outcome. However, several commissioners commented that their involvement in writing a specific part of the judgment has also stemmed from

their own interest in matters raised as part of the hearing process even though not necessarily related to their professional expertise.

That consensual decision making process is unique to the Environment Court within New Zealand's judicial system. The Environment Court is the only New Zealand Court that includes non-judicial members as part of its usual composition. It is also the only Court of first instance that ordinarily sits with more than one decision maker to hear and decide a matter. Other courts with multiple members who may hear a matter include the Supreme Court and Court of Appeal, the High Court, the Maori Appellate Court and the Employment Court. With the exception of the High Court, which rarely sits with more than one judge, those are all appellate bodies comprising only members of the New Zealand judiciary. The only court of first instance that ordinarily has multiple membership is an armed forces Court-martial constituted under the Armed Forces Discipline Act 1971. Court-martials must have a quorum of 4 members and entirely comprise members of the armed forces. Thus the Environment Court is the only New Zealand court that comprises both judicial and lay members and ordinarily sits with a panel consisting of one judge and two commissioners.

Despite the wide range in views about both science and expert evidence the interviewees consistently agreed that the Environment Court's decision making process includes discussion and input from all members and almost always involves a consensus decision. That finding suggests that even though members of the Court may mean different things when they discuss scientific evidence and expert evidence generally, that discussion process results in a decision that is acceptable to all members of the hearing panel. The Court is not bound by common law rules of evidence and can and does hear any relevant evidence that is adduced. The United States authorities dealing with admissibility of expert evidence and novel scientific evidence do not directly apply because the only criterion for admissibility is relevance.<sup>395</sup> Thus the collegial nature of decision making within the Environment Court may serve to remedy any undetected differences in perception or understanding between members of the Court. That

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<sup>395</sup> *Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66 and see discussion in Chapter 3.3.4.

same collegial decision making opportunity does not exist in the District Court, Family Court or High Court. In those jurisdictions judges decide cases based on the evidence before them and according to the written precedent of higher courts that bind them. I consider that it is very likely that there will be just as broad differences between the models of science held by judges in those jurisdictions as between judges in the Environment Court. Even judges in the appellate courts who do have any degree of collegial decision making process may not recognise that they are using terms such as science, scientist and expert in very different ways from each other.

#### 6.2.12 *Environment Court practice*

Where the Court's individually different views about science may be significant is with respect to the weight or value that is accorded to scientific evidence. Some interviewees were adamant that scientific evidence would be a component of any case "worth its soul". That view is not available to the parties appearing before the Court. While many cases may require technical expert evidence in order to address matters specifically raised by submitters or in the local authority decision being appealed it is not a requirement to provide such evidence as a matter of course. Some of the views recorded in Chapter 5 that express a strong preference for scientific expert evidence suggest that this should be communicated to parties to assist their preparation for a hearing. Such information could well form the basis for a further Practice Note or could be communicated at the judicial conference when the timetable for exchange of evidence is agreed.

The interview results also demonstrate that data-based evidence can be preferred over qualitative evidence depending on the models of science held by the hearing panel. For a commissioner with a strong preference for scientific evidence such as Commissioner 5 it would be advisable (even critical – in her words) to include data-based evidence, even if the main issues would otherwise appear to relate to economic or cultural effects. Commissioner 5 has a wide, although data-based model of science, and so any supporting engineering evidence is likely to be well received. On the other hand it would not be cost effective to present sociological or psychological evidence to a panel comprising Commissioners 1 and 5 and Judge 1. Commissioner 1 expressed a strong aversion for that type of evidence

and in combination with Commissioner 5 and Judge 1 is likely to produce a hearing panel with a preference for data-based technical evidence from the traditionally recognised fields of science and a corresponding lack of enthusiasm for qualitative evidence.

#### Expectations of expert witnesses

Another finding of this research with implications for the Court's practice relates to the very different expectations of expert witnesses and of what constitutes effective presentation of their evidence. The parties are entitled to know what the Court considers to be helpful evidence, both in terms of its content and in terms of its presentation. It is unlikely that many counsel or their expert witnesses are aware of the low regard accorded to planning witnesses, particularly by the commissioners. The interview results indicate that low level of regard relates to the volume of their evidence, the value-based rather than data-based support for their opinions and the considerable overlap with judicial expertise when assessing planning documents and applying the provisions of the Act.<sup>396</sup> The last in that list challenges the very status of planning evidence in terms of the common law rules for expert evidence. There may be many litigants with limited resources that would gladly dispense with the cost of expert planning assistance for a hearing provided there were other experts able to comment on the various environmental effects and counsel able to interpret and apply the relevant planning and statutory provisions.

Another important factor relates to the academic and professional qualifications of an expert. While most counsel will attempt to obtain expert assistance from suitably qualified advisors it is unlikely that they, or their instructing clients will be aware of the emphasis that most commissioners place on qualifications. For a well resourced litigant that information could be important when initially approaching potential expert witnesses.

The interview results also demonstrate that there are different expectations of the presentation and style that characterises a good witness. Those differences include whether technical evidence should be presented in full or in summary

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<sup>396</sup> Resource Management Act 1991.

form and whether there should be visual aids to assist with comprehension of the information.

The results do not indicate an awareness of any divergence in views concerning the nature of science or the expectations of expert witnesses. In fact there are several responses that suggest quite the reverse. At least one interviewee commented on her perception of the Judge's position in relation to the importance of qualifications. My interview with the Judge did not detect any such emphasis. Other examples include the responses of two commissioners who were openly surprised that I had heard a variety of responses to the interview questions.

### Recognising difference

In order for the Court to ensure a fair process when hearing expert evidence its members need to know that they have very different views about what constitutes preferred evidence and preferred presentation of that evidence. For those that prefer scientific evidence, and also for those that have a negative view of science, it is important to clarify just what factors give rise to that preference. When Judges 4 and 1 positively refer to the nature of scientific evidence, it is unlikely that they are aware that all expert evidence is scientific for Judge 6 and that all admissible evidence is scientific for Judge 3. Those differences must be relevant in discussions about the role of experts in Environment Court hearings.

The Court has released one Practice Note that addresses the conduct of expert witnesses and is involved in seminars preparing potential witnesses for their role. It is essential that those formal lines of communication between the Court and litigant advisors effectively address the issues relevant to ensure best practice. Those issues include:

- The preferred form of witness briefs
- The preferred style of presentation
- Preference for experts with senior academic qualifications or proven acceptance within their relevant peer community
- Evidence of data collection or measurement
- The criteria for attributing weight to the evidence of social scientists
- The expectations of planning witnesses

I also consider that the negative perception of planning evidence and witnesses that was evident in the responses of many interviewees is a matter that should be addressed directly with the New Zealand Planning Institute and with educators responsible for the administration and provision of planning qualifications in New Zealand's tertiary institutions. Resource management consultancies appear to be a thriving business area and I am personally aware of six different planners in the Waikato area who in the past 12 months have either left existing consultancies to begin their own practice or have joined consultancies having gained experience with local authorities. I am also aware of a shortage of experienced planners (which I define as having three or more years experience) working for local authorities in the Waikato. That shortage was recently emphasised in the decision by Thames Coromandel District Council (TCDC) to offer two annual scholarships for students intending to complete either planning or engineering qualifications. A condition of the scholarship includes a period of bonded employment with TCDC following qualification as well as employment during university breaks.

While I accept that the majority of planners working either for local authorities or for private consultancies will not be regularly involved in appearances before the Environment Court, I consider that it is significant that these highly sought-after professionals comprise the least preferred group of expert witnesses that do appear. There is a disjuncture between their prominence in resource management practice in New Zealand and their value to that practice as perceived by the Court. That disjuncture may reflect a lack of focus on communication skills by planning professionals themselves or on the part of their education providers but is something that should be openly addressed in order to enhance the overall standard of both hearings and decisions.

#### 6.2.13 *Questions pending*

There are a number of questions arising from this research that could form the basis of further research. Those questions are as follows:

1. Whether the micro themes identified as significant in a person's model of science are also significant to that person's assessment of an expert witness generally;

2. Whether the micro themes identified as significant in a person's model of science as also significant when deciding how to weigh or value the content of expert evidence;
3. Whether the differences in views about science identified in the Environment Court also arise in other New Zealand jurisdictions and in other legal decision making for a;
4. The legal position in New Zealand concerning the admissibility of expert evidence in general and scientific expert evidence in particular;
5. How to measure and ensure best practice for the preparation and presentation of expert evidence?
6. How to measure and ensure best practice and consistency when deciding expert evidence?
7. What decision making structure (or structures) provides the best opportunity for consistent and fair legal decision making in light of the analysis of boundary-work undertaken in this and other research?

The questions above fall under two broad headings. The first four questions concern the role and significance of boundary work undertaken by legal decision makers with respect to their understanding and valuation of science. The next two questions involve determining ways to improve communication between the Court and expert witnesses with a view to enhancing the decision making process. That focus shifts away from looking at the significance of science to individual decision makers, to improving the professional education opportunities for all expert advisors involved in litigation. The last question proposes a boundary-work approach to the deconstruction of judicial decision making with a view to finding appropriate structures and processes for deciding matters involving expert evidence.

### 6.3 Final comments

It is not an answer to problems associated with hearing and deciding matters involving a wealth of expert evidence to shift a greater measure of that burden to the experts themselves or to establish a host of specialised, technical tribunals. To do so would be to ignore the significant differences in interpretation that already exist between those experts. The Environment Court is an example of a specialist

tribunal comprising members with a range of relevant skills applicable to their decision making roles. This research shows that even within a diverse range of relevantly skilled decision makers there will be a variety of different interpretations of and preferences for the expert information before them. The real benefit of the Environment Court structure may be in the opportunities for discussion and cooperative decision making.

There have been many changes to the legal, social and physical environment since I first began this research in 1998. Those changes relate to the international and national arenas as well as to my personal situation. There have been legal changes in Britain to require more cooperation between expert witnesses and to limit the number of experts who are accredited and recognised as experts for the purposes of judicial hearings. In the United States of America decisions on the admissibility of expert scientific evidence have broadened the gate-keeping role of judges to apply strict legal tests to all expert evidence. Those changes in themselves may indicate the difficulty faced by the courts in distinguishing scientific evidence from other types of expertise.

In New Zealand there is no longer regular and vehement public opposition to the placement of cell phone towers or other telecommunications equipment. However, that does not mean that there is no public debate over science and technology research and its implications for society. Community concern with health-related adverse effects seems to have shifted from cell-sites to the proximity of high voltage electricity wires to dwellings and to the potential for adverse effects from genetic modification of organisms. Issues involving risk assessment of potential adverse effects from a variety of new biochemical developments pose important and difficult questions for decision makers within public institutions such as the Environmental Risk Management Authority and ethical committees of various research and professional bodies. Those issues, together with identification and management of risks to New Zealand's biosecurity, are also the subject of a wealth of expert opinion before policy makers and service providers at national, regional and local governmental levels. The nature of the dialogue will continue to change as the community struggles to interpret and assess the risks inherent in change – whether it be technological,

social or associated with our physical environment. What will not change is the need for decision makers to decide those risks in terms of the applicable legal framework and in light of the expert advice available to them.

On a personal level I am no longer working as a legal academic having moved to private practice in 2001. I am regularly involved in matters that require the preparation and presentation of expert evidence before local authorities and before the Environment Court and am acutely aware of the importance of that information to a successful outcome for my clients. As a former legal and science educator I am also convinced that effective communication of expert evidence does not happen through oral or written delivery of that evidence alone. People construct their own understandings of the world around them and that includes expert evidence if that is part of their world. Effective communication must involve recognition of that construction process and provision of opportunities for decision makers to construct meaning that is consistent with the meaning intended by those giving the evidence. The first step to that recognition, and thus to effective communication, is to identify what knowledge constructs are already in place and to build on those existing and individually different constructs in order to achieve an outcome consistent with the legal framework in operation.

**APPENDIX 1 - THEMES****A Background**

- A1 qualifications
- A2 experience
- A3 interests
- A4 appointment
- A5 background other eg school

**B Nature/composition of court**

- B1 advantages
- B2 disadvantages
- B3 other

**D Decision making**

- D1 re public law
- D2 disagreement?
- D3 writing of decisions
- D4 role of commissioner
- D5 role of judge
- D6 decisions other eg process

**E Experts**

- E1 good qualities
- E2 bad characteristics
- E3 objectivity/independence
- E4 method of evidence collation
- E5 expert v scientific expert
- E6 choosing/differentiating between experts
- E7 Other
- E8 Precautionary principle

**F Court appointed experts**

- F1 good idea
- F2 bad idea
- F3 circumstances
- F4 problems/difficulties

**G Technical evidence**

- G1 sci v technology v law v hard
- G2 fact / proof
- G3 measurement/data
- G4 qualifications/background
- G5 historical connection
- G6 method
- G7 objectivity / subjectivity
- G8 knowledge/body of/system of
- G9 peer review / publication
- G10 replication / experiment
- G11 technical other

**H Science v tech/applied**

- H1 sci v technology v law v hard
- H2 fact / proof
- H3 measurement/data
- H4 qualifications/background
- H5 historical connection
- H6 method
- H7 objectivity / subjectivity
- H8 knowledge/body of/system of
- H9 peer review / publication
- H10 replication / experiment
- H11 technical other / explanation / prediction

- I Science = evidential = law**
- I1 sci v technology v law v hard
  - I2 fact / proof vs opinion
  - I3 measurement/data
  - I4 qualifications/background
  - I5 historical connection
  - I6 method
  - I7 objectivity / subjectivity
  - I8 knowledge/body of/system of
  - I9 peer review / publication
  - I10 replication / experiment / research
  - I11 technical other / explanation

**K Scientific method**

- K1 fact vs opinion
- K2 measurement
- K3 objectivity / subjectivity
- K4 peer review
- K5 replication
- K6 other / honesty / reasoning

**L Examples of scientific evidence**

**M Hierarchy of knowledge / status**

- M1 science elevated
- M2 re other evidence
- M3 cultural issues

**O What is science?**

- O1 different from law/technology/social science
- O2 fact / proof / precise / exact
- O3 measurement/data / empirical
- O4 qualifications/background
- O5 historical connection
- O6 method
- O7 objectivity
- O8 knowledge/body of/system of
- O9 peer review / publication / acceptance
- O10 replication
- O11 technical other / improvement
- O12 Continuum/scope of definition
- O13 research / experiment / testing
- O14 other / explanation / prediction

**P Purpose of science?**

- P1 different from law/technology
- P2 fact / proof
- P3 measurement/data
- P4 qualifications/background
- P5 historical connection
- P6 method
- P7 objectivity
- P8 knowledge/body of/system of
- P9 peer review / publication
- P10 replication
- P11 technical other / improvement
- P12 Explanation / understanding
- P13 Research / experiment / testing / prediction
- P14 Other

APPENDIX 2 – DATA TABLES

	Continuum	Fact	Data	Process	Objectivity	Knowledge	Traditional	Qualifications	Community	Purpose
J4	√		√√√	√		√√				
J5	√√√	√√√√	√√√√	√√√		√√	√		√√√	√√
C3				√√				√		
C4				√√√						
C6			√√			√√	√√√	√		
C7				√√√	√	√√√√		√		√√√√
C11	√√√√	√√		√√√√			√	√√√√		√
C13	√√√√							√	√√	
J3	√√	√√√	√	√√						√√√√√
J6	√√		√	√√				√		
C10	√	√√	√	√√				√	√	√√
C12	√					√			√	√
J1	√√√√√		√√√√	√√√√			√			√√√√√
J2			√	√√√					√√	
J7	√	√	√	√√		√√√√√			√√	√
J8		√	√√√√	√			√√		√√	√
C1		√√√	√	√√√√			√	√√√		√
C2	√		√√√√	√		√√√√				
C5	√		√√				√√	√√		
C8		√√√√		√√√√	√					
C9			√√√	√√√					√	

Note: Results include both significant and non-significant references

Table 2

Micro Themes	Science is different from Technology (J4, J5, C3, C4, C6, C7, C11, C13)	Science includes Technology (J1, J2, J7, J8, C1, C2, C5, C8, C9)	Science = Expert (J3, J6, C10, C12)
<b>Continuum Models</b>	J5 C11, C13	J1	J3 C12, C10
<b>Fact/Proof/Certainty</b>	J5, C11	J7 C1, C8	J3 C10
<b>Empirical measurement/data</b>	J4, J5,	J1, J8, J2 C1, C2, C5, C9	J3
<b>Process</b>	J4, J5 C4,	J1, J2 C1, C8, C9,	J3, J6 C10
<b>Objectivity</b>			
<b>Knowledge</b>	J5 C6, C7	J7 C2	C12
<b>Traditional association</b>	C6,	J1, J8 C5,	
<b>Qualifications</b>	C6, C7, C11, C13	C1, C5,	C10 J6
<b>Scientific community</b>	C3	J2	C12 C10
<b>Purpose of science</b>	C7	J8 C1	C12 C10



= Not a significant micro theme

Table 3

	Continuum	Fact	Data	Process	Objectivity	Knowledge	Traditional	Qualifications	Community	Purpose
J4	(N)		√	√		(N)				
J5	√	√	√	√						
C3				(N)			(N)	(N)	√	(N)
C4				√						
C6			(N)			√	√	√		√
C7				(N)	(N)	√		√		(N)
C11	√	√		(N)			(N)	√		
C13	√			(N)				√	(N)	
J3	√	√	√	(N)						
J6	(N)	√	(N)	(N)				(N)		
C10	(N)	√	(N)	(N)				√	(N)	(N)
C12						(N)			√	
J1	√	√	√	√			√		√	(N)
J2			√	√						
J7	(N)	√		(N)		√			(N)	(N)
J8		(N)	√	(N)			√		(N)	√
C1		√	√	√			(N)	√		√
C2	(N)		√	(N)		√				
C5	(N)		√				√	√		
C8		√		√	(N)				(N)	
C9			√	√						

Key:

J = Judge C = Commissioner    √ = A significant micro theme    (N) = theme not significant





Macro Themes:  = Science different from technology     = Science includes Technology     = Science = Expert

Table 4

	Data	Process	Qualifications	Fact	Continuum	Purpose	Traditional	Knowledge	Community	Objectivity
J4	√	√			(N)			(N)		
J5	√	√		√	√			√		
C3		(N)	(N)			(N)	(N)		√	
C4		√								
C6	(N)		√				√	√		
C7		(N)	√					√		(N)
C11		(N)	√	√	√	(N)	(N)			
C13			√		√				(N)	
J3	√	(N)		√	√					
J6	(N)	(N)	(N)		(N)					
C10	(N)		√	√	(N)	(N)			(N)	
C12								(N)	√	
J1	√	√			√	(N)	√			
J2	√	√							√	
J7		(N)		√	(N)			√	(N)	
J8	√	(N)	√	(N)		√	√		(N)	
C1	√	√		√		√	(N)			
C2	√	(N)			(N)			√		
C5	√		√		(N)		√			
C8		√		√					(N)	(N)
C9	√	√								

**Key:**

J = Judge C = Commissioner  
 √ = A significant micro theme (N) = theme not significant  
 Macro Themes:  = Science different from technology  = Science includes Technology  = Science = Expert

## APPENDIX 3 – FRAMEWORK FOR INTERVIEW QUESTIONS

### Introduction and Background

- 1 Can you outline your professional background and qualifications?
  - why choose those courses/path?
  - why environmental law?
- 2 How did you come to join the Environment Court?
- 3 Do you have any interests that in your view are related to science?

### Environment Court as a Specialist Court

- 4 What are the strengths of the Environment Court structure, in terms of composition– as a specialist court?
  - any weaknesses?
  - why?
  - impact of different backgrounds for the hearing?
- 5 What is the role of the Environment Commissioners in the decision making process – for example in a resource consent appeal?
  - actually write decisions?
  - are the different backgrounds relevant to decisions?
  - why?
  - what if you disagree?

### Expert witnesses

- 6 What is the role of an expert witness in hearings?
  - can you describe characteristics of a good expert?
  - poor?
  - how common are poor witnesses?
  - does poor witness affect weight of evidence?
    - - how?
- 7 Does the Court ever call its own expert witnesses?

- in what circumstances?
- why not?
- can you give an example in relation to a scientific expert?
- how did/would the Court choose such a witness?
- any advantages/disadvantages?

- 8 Are there different characteristics of a good scientific expert witness?
- are any of these characteristics more important than the others?
  - any common features in their evidence?
  - how are scientific expert witnesses different from non-scientific experts?
- 9 Typically, where or how have the scientific experts obtained their evidence?
- 10 Do opposing scientific expert witnesses often agree?
- is agreement unusual?
  - case example of disagreement?
  - why
  - common source of disagreement?
  - how to choose between?
  -

### **Nature of Science**

- 11 What areas would you include under the general umbrella term of science?
- eg physical, biological, applied( medical or engineering), social sciences
  - why?/why not? / what is common?
  - what types of evidence do scientific experts give?
- 12 Can you suggest a case in which scientific evidence was crucial or pivotal to the outcome?

- 12 If scientific evidence at a hearing is uncontroverted, do you feel confident to rely on it?
- why? any exceptions? examples?
- 13 Is it possible to attribute different weight to different types of evidence in a general sense?
- eg planning, cultural, scientific evidence.
- 14 Do you differentiate between fringe or novel scientific evidence and mainstream scientific evidence?
- how/why
  - how do you identify the difference
  - how / when does the 'novel' become mainstream?
- 15 What makes evidence scientific?
- is that the same as your view of what is science?
  - why? - differences?
- 16 In your view, what is the purpose of science?

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