INSTITUTIONALISING THE AGORA: INVESTIGATING THE EVOLUTION OF PUBLIC ACCOUNTABILITY IN AUSTRALIAN MEDICAL RESEARCH INSTITUTES

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This thesis contains no material that has been accepted for the award of any other degree or diploma in any university. All experimental work is original and was carried out by the author. Furthermore, to the best of the author's knowledge and belief it contains no material previously published or written by another person, except where due reference is made in the text.

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As a scientist, I know that a person's intelligence centres on the brain but Aristotle thought that intelligence was set in the heart. With this I sometimes agree. It is not with my head that I have made the choices that have brought me to this place, but with the heart. It was with my heart that I chose to pursue a PhD in Science Communication, something that I am passionate about, and passion can only come from the heart.

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ABSTRACT

Research institutes potentially play a large role in developing the agora; the public arena where negotiations and consultations between science and the public take place. Developing this agora would not be possible without considering first how research organisations have evolved in response to increased public calls for accountability in science in exchange for research funds.

This thesis explores how two mechanisms of public accountability; the communication and commercialisation of science have been integrated into such a culture. This thesis analyses the relationships between scientists and the professional offices within the research organisation that are responsible for the communication (PR) and commercialisation (BD) of science. It also provides recommendations on how to reduce the tensions between different modes of knowledge production and highlights ways in which scientists respond to external influences. The study also investigates how these influences affect the publishing behaviour of the scientists. To do this, it compared the structure and strategies employed by the internal PR and BD Offices and the opinions of scientists towards these offices in five Australian medical research institutes.

Each PR office was found to employ a number of techniques with which to promote the institute and its research. Two separate modes of communication were classified in this thesis: awareness and promotion. The awareness mode of science communication is run by the scientists themselves and involves a dialogue between the scientists as physicians and their patients. In contrast, the promotion mode of science communication is run primarily by the institute's PR office in order to positively promote the institute and attract funds.

These modes of communication can, however, be mutually beneficial. The challenge for research institutes, however, is to balance both modes of communication responsibly.

The results also showed that scientists were open to the role of communication in science, a finding that runs counter to reports in the literature which state that scientists are either unwilling or incapable of communicating effectively with the public. This thesis proposes that a main catalyst for this revolution of thinking amongst medical scientists is the presence of the professional, internal PR Office.

Although previous research has recommended research organisations keep scientific and commercial aspects of knowledge production separate (Etzkowitz, 2003), this thesis showed that there are advantages to combining these aspects together within a research institute. A major mechanism for the success of this model, however, was the willingness of the internal BD office to adapt their policies to accommodate the academic needs of the scientists.

The effect that these external influences have on the publishing behaviour of the scientists was investigated separately from the main argument. By analysing the institute's publications for 1999-2005, significant interactions were found for the number of publications over time and between institutes. In addition, a significant change in the level of collaboration was found with the total number of authors per paper increasing linearly with time. Although a number of additional interactions were identified in this thesis, this change in publishing behaviour cannot be directly related to either the increased emphasis of public accountability or the introduction of the PR or BD Offices.

These results have implications for the way in which research institutes incorporate their public accountability responsibilities into the organisation's culture. Achieving an agora within the scientific culture may be an ideal model for the engagement of the public with science. However, experiencing this agora would not be possible without considering how institutes have evolved to respond to the public's demands for greater accountability in science through the development of the internal office that facilitates the commercialisation and communication of science.

ABBREVIATIONS

ANU	Australian National University
ARC	Australian Research Council
BAA	Backing Australia's Ability
BD	Business Development
BSE	Bovine Spongiform Encephalitus
CBCRC	Clive Berghofer Cancer Research Centre
CHD	Cancer and Haematology (Including Cancer Research)
COMET	Commercialising Emerging Technologies Programme
CoPUS	Committee of Public Understanding of Science
CRC	Cooperative Research Centres
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSL	Commonwealth Serum Laboratories
DIISR	The Department for Industry, Innovation, Science and Research (formally DEST)
DNG	Neurobiology
EPI	Epidemiology
GARVAN	The Garvan Institute of Medical Research
GBI	Genetics and Bioinformatics
Go8	Group of Eight Universities
HBP	High Blood Pressure
IMM	Immunology (Basic Immunology)
INF	Infection and Immunity (Infectious Diseases, Vaccines)
IP	Intellectual Property
ISI	Institute for Scientific Information
JCSMR	The John Curtin School of Medical Research
JIF	Journal Impact Factor

JPS	Proteomics
MBD	Molecular Biology (Basic Molecular Biology)
MGC	Molecular Genetics of Cancer
NCBI	National (US) Centre for Biotechnology Information
NHMRC	National Health and Medical Research Council
NIAS	National Innovation Awareness Strategy
NIH	National (US) Institute of Health
NLM	National (US) Library of Medicine
NPK	New Production of Knowledge
OTHER	Other Miscellaneous Research Areas
PAWS	Public Awareness of Science
PEST	Public Engagement with Science and Technology
POWMRI	The Prince of Wales Medical Research Institute
PR	Public Relations
PUS	Public Understanding of Science
QIMR	The Queensland Institute of Medical Research
R&D	Research and Development
RAE	Research Assessment Exercise
RQF	Research Quality Framework
RTLA	Reach Through Licence Agreements
SBD	Structural Biology
SCI	Science Citation Index
UK	United Kingdom
UNSW	University of New South Wales
US	United States
WEHI	The Walter and Eliza Hall Institute

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Chapter 1: Introduction

The scientific community is a social organisation, one that has its own set of norms, reward mechanisms, standards and hierarchy. However, government policy and public expectations have changed in relation to science and these non-epistemic influences have been shown to have profound effect on the conduct of scientists (Glaser, Spurling, & Butler, 2004). The government expect, as the public expects, to see a return on their taxpayers' funding. In other words, science is becoming more accountable to the public. Achieving accountability is not always easy, however and the language and personalities of scientists can sometimes leave the public wondering what is in science for them.

In this thesis, I will explore the effect that this increase in public accountability has had on the workings of five major Australian Medical Research Institutes. In particular, I will focus on the increased expectation for the communication of research to a wider public, and increased expectation for scientists to commercialise their work and bring their research from the bench to the bedside. Finally, I will examine any change in publishing behaviour in addition to the rise of competitiveness in science through the use of citation metrics to evaluate individual scientists, institutes and fields.

In Australia, government policy has emphasised a level of public accountability for scientists. The first official federal government policy for scientific research was only first established in 1999 with Backing Australia's Ability Policy. Through this policy it was stressed that scientists had a 'duty' to communicate their research in receipt of public funds, a view that echoed the earlier UK Royal Society Report in 1985. The policy went further, however, and highlighted the ultimate endpoint for all Australian research which was the application of results in Australian through the commercialisation of current research. This changed the face of scientific research, science was now more accountable to the public in receipt of tax-payer funded research and the 'ivory tower' was crumbling.

1.1 The New Production of Knowledge (NPK)

Authors such as Etzkowitz and Leydesdorff (Etzkowitz, 2002; Etzkowitz & Leydesdorff, 1995, 2001; Leydesdorff & Meyer, 2003) describe a triple helix in which the main institutions of the knowledge-based economy are universities, industries and government working in a complex inter-relationship. In 1994, Gibbons, Limoges, Nowotny, Schwartzman, Scott, & Trow (1994). introduced the new production of knowledge or, as it has come to be abbreviated, Mode 2 knowledge production. Prior to World War II, the main function of universities was teaching and 'disinterested' research; this became known as Mode 1 production of knowledge (Gibbons et al., 1994). Indeed for Mode 1, the heavy public investment in university-based research was both a cause and an effect of what was called the 'cognitive complex' (Parsons & Platt, 1973, p.48). This was further described as a process whereby universities served as 'intelligence banks' that received public funds in exchange for contributions 'toward the welfare and value implementation of society' and came to wield power and influences based on the social utility (relevance) of these contributions (Jacobson, Butterill, & Goering, 2004). The cognitive complex of the mid-twentieth century maintained the tradition of the 'academy', in particular, it allowed scholars to determine their own research agendas and made individual academics accountable not to society or even their institutions, but to their own disciplines. However, observers worried that the balance between this autonomy (the 'ivory tower') and the relevance of research was precarious (Blau, 1973; Parsons & Platt, 1973). As a result, a new research economy emerged as governments and industry increased their funding for university-based 'programmatic' research (Jacobson et al., 2004) but, with this increased amount of research funding, came larger responsibilities for science.

The introduction of Mode 2 knowledge production has been termed a *second academic revolution,* where the emphasis on universities has moved from teaching to a more applied and society focused research concentration. Mode 2 knowledge production involves non-hierarchical relationships with stakeholders (e.g. industry, government policy-makers, health care decision makers and the public) to collaborate on a research issue situated in a specific health care context (Gibbons et al., 1994). In this sense, Mode 2 is based on the needs of end users and is arguably a more socially accountable form of knowledge production. The research, which described the change from Mode 1 to Mode 2, was built on Merton's 1942 norms of science and the work of other sociologists of science who attempted to describe the scientific community and the effect of outside influences on how scientists work. In this new environment, research funding agencies are less open to research whose sole purpose is to advance scientific knowledge, communicating only with other scientists (Estabrooks, Norton, Birdsell, Newton, Adewale, & Thornley, 2008). The research literature surrounding the conflicts between Mode 1 and Mode 2 knowledge production will be discussed further in the Literature Review chapter of this thesis.

1.2 Introducing the *'Agora'*

The characteristics of NPK were re-evaluated in 1999 (Nowotny, Scott, & Gibbons, 2001). Amongst the variations was a description of the changes in various institutions involved in knowledge production. In particular, they introduced the concept of 'contextualised science' which basically meant that society now 'spoke back' to science. According to the authors, the participation of a wider range of non-scientific actors in the knowledge production process, in an arena, termed the *'agora'*, enhanced its reliability. The agora, according to Nowotny et al. (2001) was a theoretical arena where controversies in science were played out. For Gibbons et al. (1994) and later Nowotny et al. (2001), the distinction between science and society, which had been the basis for modern science, was no longer valid. Instead, the public is heterogenous and came into contact with the producers of knowledge (scientists) within the framework of the *'agora'* which aimed to develop 'inverse communication' between these two groups. The *agora*, therefore, is a metaphorical public arena where negotiations and consultations between science and society can take place.

This theory emphasised the social relevance of science and lends its theoretical basis to the new range of science communication attempts which insist on 'engagement with the public'. The concept of the *agora* is a reoccurring theme within this thesis as is the extent to which the participating institutes have adapted themselves to be more receptive to Mode 2 knowledge production activities. This is of particular interest as the presence of macro level pressures does not guarantee that new initiatives will be embraced. In fact, the ability of organisations to change depends on the willingness of individuals to adopt supportive norms, routines and behaviours (Whelan-Berry, Gordon & Hinings, 2003).

1.3 The Challenge of Public Communication

Universities and research institutions around the world have attempted to respond to this change in accountability by implementing internal rules and policies that are designed to help their researchers meet these public expectations. Indeed, the increased emphasis on knowledge and technology transfer across university-industry boundaries has led to the creation and implementation of a variety of transfer-orientated policies. These include the establishment of business development or technology transfer offices; academic spin offs and joint ventures, science parks and business incubators. Such new arrangements all reflect the multi-faceted role of research institutes (van Looy, Ranga, Callaert, Debackere, & Zimmermann, 2004b). Despite this change in focus on behalf of universities and research institutes, there has been very little research on an institute level to investigate how they and their scientists have evolved to embrace this new level of public accountability.

Additionally, the role of public communication has grown within the scientific research community. Communication is an under-acknowledged Mode 2 endeavour and its emphasis is on application, public accountability, public awareness and the public understanding of science. In addition, communication activities are open to participation from all scientists whether they are involved in applied or basic science. All scientists are expected and able to engage in public communication activities, regardless of their research concentration, as an expectation of receiving taxpayer funded research money.

Stocklmayer, Gore, & Bryant (2001) outlined how the opinions of scientists in response to a 3-day workshop on science communication were hostile. Some senior scientists expressed resentment and could not comprehend the importance of communicating science to the public at all. Further, the scientists themselves did not see the value of participating in these communication activities, preferring to 'let other people do the communicating'. Likewise the public have responded to the scientific community's lack of appreciation for the need for their support. A common 'draw a scientist' test has revealed that members of the public have frequently drawn stereotypes lacking clear lines of communication about science and scientists. These images also illustrated the presumed 'madness' and 'cruelty' of scientists (bubbling test tubes and animal experimentation) in addition to depictions of Frankenstein-like experiments that highlighted a misunderstanding of 'scientific practice' itself.

It was obvious that science required a public image makeover, one that institutes and universities were happy to help initiate with the introduction of science communication and community liaison policies. In addition, the rise of science communication both as an academic field and profession has been a catalyst for the recognition by universities of the need for professional, in house, science communicators both to facilitate the communication of research results to the public and to remain an internal reminder of the need for researchers to communicate. These policies were also based on the premise that scientists were unable to communicate effectively to the public without the help of professional communicators or journalists.

1.4 The Challenge of Commercialisation

The establishment of internal offices housed by communicators and business people also faces its own set of challenges. According to the literature, these institutional offices face inherent structural barriers from the individual scientists and the universities themselves. These somewhat unwelcome structural barriers and tensions between scientists and the people employed to facilitate communication and commercialisation to the community are numerous. In regard to commercialisation, there has been a wealth of reports warning about the losses scientists can incur by being involved in industry funded and product driven research (Blumenthal, 1992a; Blumenthal, Campbell, Anderson, Causino, & Louis, 1997; Blumenthal, Causino, Campbell, & Louis, 1996b). The barriers have been described in the literature and are based on growing tensions between researchers and professionals and the perceived differences of opinions, rules, norms and reward systems. There have also been reports of withholding behaviour in science and delays in publishing as a result of the increased presence of commercialisation in science (Campbell, Weissman, Causine, & Blumenthal, 2000a). In addition, changes in government policy have revived the public's interest in science and, more importantly, increased the public's expectations of a return on its investment. Preliminary evidence suggests that scientists' behaviour has changed in response to new behaviours that run against Merton's described norms (Etzkowitz, 2000). Such reports outline scientists withholding results for both commercial and competitive reasons as well as delays in publishing (Campbell et al., 2000). There are also reports of commercially funded scientists not being allowed to publish or present their results at conferences as a result of commercial engagement. More alarming are the descriptions of scientists being gagged by commercial companies and incurring penalties for talking about their research with their colleagues in the hallways.

The first reports of secrecy and withholding behaviour were by Blumenthal et al. (1997) who reported that scientists involved in industry research were more involved in withholding results from other scientists at conferences than scientists who were not. In addition, delaying publication for more than six months was very common amongst scientists with industry linkages. Research has implied that the same is true of Australian scientists (Harman, 2002), with the issue particularly true for the prestigious Go8 (Group of

Eight) Universities despite industry investment in research in Australia being comparably smaller than in the United States. Merton (1942) stressed that a scientist's claim to intellectual property was 'limited to that of recognition and esteem'; this seems to no longer be the case as this thesis will attempt to show. There is, however, still some uncertainty about the way scientists and institutes have responded to an increased accountability to the public, especially in the way that they conduct research. In particular, there is still some uncertainty about how an increased expectation to commercialise has affected the way institutes support scientific research and yet balances the expectations of their scientific community.

There has also been some concern about the effect that engagement in Mode 2 endeavours has on the traditional role of a scientist. Some argue that changes in university research agendas have become increasingly orientated toward promoting an applied research agenda at the expense of traditional science (Florida & Cohen, 1999). Known as the skewing problem, it is underpinned by the assumption that research engaged in more Mode 2-type activities will be more applied and that this will in-turn be detrimental to the overall scientific agenda. Other research has even suggested that Mode 2 endeavours such as commercialisation and communication are incapable of co-existing with science with its emphasis still on Mode 1 activities (Nowotny, Scott, & Gibbons, 2001). Despite this, some research has found that engagement in entrepreneurial activities coincides with increased publication outputs without affecting the nature of the publications involved (van Looy et al., 2004b). Tijssen (2004) found that the number of corporate industry research articles had declined over the period 1996-2001, especially in regard to papers authored exclusively by industry researchers. This overall uncertainty about how engagement in Mode 2 activities can affect scientific publishing tends to promote fear in the scientific community and dissuades researchers from ever being involved in commercial activities.

All these reports point to a disjunction between science and industry and many authors have suggested that these two cultures are incapable of ever co-existing. Etzkowitz (2003) hypothesised that in order to avoid tensions, one of four main approaches could be implemented. These included; (1) prohibition of the activity; (2) a requirement of disclosure; (3) separation of activities; or (4) integration of the activities. After rejecting the ideas of prohibition or disclosure, Etzkowitz (2003) outlined how the *separation* model, in which the financial interest is separated from the research interest by defining boundaries or creating structures that mediate between the two activities, is preferable over the *integration* model. In this thesis, I will be mainly dealing with the integration model in which research and commercialisation are combined under a common organisational framework. Etzkowitz (2003) stated, however, the separation model will always be chosen when an attempt is made to combine new roles with existing missions. Likewise, in regards to communication, the tensions described in the literature holds little hope for the reconciliation between these entrepreneurial/Mode 2 activities and science (Etzkowitz, 2003).

1.5 Measuring Productivity

No doubt, one of the most unwelcome cultural changes in science recently has been the creation of quantitative methods to evaluate individual scientists, institutes, universities and research groups. The impact factor and the creation of other metrics (h-index, h-b-index and g-index) that measure and compare science have inflicted increased pressure on scientists to perform to a, sometimes, impossible level. In addition with applied and industry research consistently performing at that higher level (Kulkarni, Busse, & Shams, 2007), scientists can be forgiven for rushing to attract industry research dollars as well as withholding results in order to increase their impact. However, in relation to citation metrics and the affect on the practice of science, within the literature there is little evidence describing the influence these metrics have of how scientists work within their own institute. In addition, how the institute being judged by these metrics influences its scientists is yet to be determined.

These behaviours are, again, at odds with the idealistic norms of science described by Merton (1942) and other sociologists. This is not to say that the premise of this thesis agrees with Merton's norms, or that they have not changed. Rather, this demonstrates a drawback of traditional sociological research - that states that observing the inputs and outputs of a community is sufficient evidence with which to make judgements regarding the state of that community. In regard to the tensions described above, there have been many concerns about how the change towards a Mode 2 focus as well as the introduction of an evaluation climate will affect how institutes and scientists behave. Additionally, it has been noted that there is currently a contradiction for researchers who must progress through the academic ranks meeting established Mode 1 benchmarks while also competing for funding in a climate where the criteria for assessment is changing towards a Mode 2 orientation. While engagement in knowledge transfer (commercialisation and communication) activities has become a Mode 2 expectation for university-based researchers, many academic units continue to operate under historical (Mode 1) conditions that emphasise the primacy of disciplinary authority. The importance of knowledge transfer may be endorsed in rhetoric, but rewards and resources (and thus priorities) reflect the enduring values accorded by more traditional academic activities.

1.6 The Role of the Internal Communication (PR) and Commercialisation (BD) Office

Despite these perceived tensions and disjunction between rewards for Mode 1 and 2 activities, the universities and institutes have opted to increase the size and role of the Commercialisation (BD) and Communication (PR) Offices and continue evaluating research. This thesis will analyse why and how these Offices have become important to the scientific research endeavour. By analysing scientists and their institutions together this thesis will examine how this change is being introduced to five Australian Medical Research Institutes.

In particular, this thesis will also examine how scientists have adapted their behaviour and opinions due to the presence of the professional Commercialisation (BD) and Communication (PR) Offices and the increased pressure from governments and the public to see a return on their investment. This thesis will also map the publishing behaviour of the scientists within the five Medical Research Institutes. Individual scientists still highly value scientific publishing, and it is hypothesised that the competition for research funds combined with the rise of the evaluation culture has had a significant effect on institutional publication output. This thesis will attempt to identify whether there has been any change in the publishing behaviour over the period 1999-2005 and, using statistical modelling, will attempt to map this behaviour in order to gain a better understanding of where and why the significant changes are happening.

This research is one of the first comprehensive studies that investigates the roles and interactions of scientists and the professional offices within scientific organisations, triangulating the results with a quantitative outcome of science. In their review of the organisational factors necessary to influence knowledge transfer, Jacobson et al. (2004) outlined a need for further study into what organisational influences affect scientists' engagement in knowledge transfer activities. Likewise, there was an expressed need for qualitative evaluations to assess the extent to which changes in the identified domains actually improve the quantity and quality of university based research's knowledge transfer efforts.

1.7 The Definition of an Institute

For the purpose of this thesis, an 'institute' is defined separately from a university, a research group, or another type of research organisation. This is done for two main reasons. First, the majority of previous research has concentrated mainly on large organisations and small research groups. Second, the five participating research 'institutes' in this study differ in their structure and purpose when compared to large universities or small research groups sufficiently enough to warrant a separate investigation. These points are described in more detail below.

Whereas a university is a large organisation consisting of many different faculties and research groups from a variety of research fields, an 'institute' is a smaller group of scientists within an academic setting who are united by a common field of research, mission statement and a shared understanding of the direction of their research. Within a university, there exists multiple groups of scientists and fields and this therefore presents difficulties when studying a variety of scientists under common organisational boundaries. In addition, the function of a university as viewed by the community is primarily for teaching, whereas an 'institute' is not seen as having this function. An 'institute' must define its purpose as a knowledge factory and promote its research programs as just as worthy of public funding as a university. Both Mode 2 and related theories investigate 'universities' as knowledge producers and not the smaller, 'institutes' as we have defined above. There is therefore currently a gap in the literature, as few empirical studies have linked individual actions and the influence of organisational subunits to the implementation of strategic initiatives.

Institutes are of particular interest when analysing the effect of external pressures on the practice of science especially in relation to a number of different theories related to academic organisations achieving a level of public accountability. Studies have investigated the effect of external pressures on universities and the ability and mechanisms universities use to adapt. However, from the definition given above, universities are different from the smaller institutes. With this in mind I can hypothesise that different interactions and rules would apply than those observed in previous studies. This thesis provides one of the first micro level studies on the effect of external pressures such as the increase in public accountability as expressed through the communication and commercialisation of research and how scientists within institutes adapt (de Zilwa, 2007). In addition, with the institutes only recently adopting their own internal representative of these external influences, examining the opinions and motivations of scientists to engage in these Mode 2 activities in light of the presence of these professional offices will provide new information regarding the evolution of public accountability within science.

In this thesis, 'organisation' will be used collectively as a generic term for all research organisation types, however, the term 'institute' will hereafter be used as described above and as it refers to the five participating research institutes in this study.

1.8 Research Questions

Outlined below is a list of the research questions that will be explored in this thesis;

Research Question 1

What are the responsibilities and communication strategies of the internal PR and BD Offices within Australian Medical Research Institutes?

Research Question 2

How do the scientists in these institutes view the role of these Offices and more broadly, communication and commercialisation, in their research?

The research question below is separate from the main argument of this thesis as outlined in Research Questions 1 and 2. However, the discussion of the results presented in Appendix III is both essential to test the validity of the claims made by the interviewees in response Research Questions 1 and 2. Research Question 3 also aims to investigate how any change in the institutional culture in relation to the increased emphasis of communication and commercialisation has influenced scientific output. Research Question 3 is therefore to be considered in addendum to the above research questions and separate from the core aims of this thesis, which is to investigate the evolution of the internal PR and BD Offices within the five participating MRIs.

Research Question 3

Has there been any change in scientists' publishing behaviour as a result of the increased level of public accountability in science and/or the introduction of these internal Offices?

In order to investigate these issues a combination of qualitative and quantitative methods is used. The results are presented in Chapters 4, 5 and Appendix III. A summary of the specific methods relevant to each results chapter is outlined at the beginning of each of these chapters. These methods are discussed in more detail in the Chapter 3: General Methods. To help frame the results of this thesis in relation to the research questions described above, a description of each chapter of this thesis is described below.

1.9 Outline of the Thesis

In Chapter 2, I review the contemporary literature, highlighting key themes and unresolved issues. This includes an analysis of the Sociology of Scientific Knowledge, research into the prevalence and effect of industry linkage on modern day science as well as literature surrounding citation analysis and the recent advances of research evaluation metrics. Finally it will give a detailed analysis of the evolution of the Australian Government's Science Policy in respect to the public accountability of science and the expectations each new policy puts on Australian scientists and scientific institutes. This chapter will also describe the rationale behind using Gibbons et al. (1994); *New Production of Knowledge* (NPK) as the framework with which to analyse the results of this thesis.

In Chapter 3, I will outline the general methodology used as well as detail the histories of each participating institute. The history of each institute is extremely important in relation to the field differences in medical research and will be particularly important when analysing each institute's results in Chapter 6. Additionally, the institutes' histories will be important when analysing the opinions of the scientists presented in Chapter 5. The advantages and disadvantages of the methods applied will also be discussed in relation to previous studies in the sociology of science and citation analysis (Appendix III) as well as in relation to current science communication research.

Chapter 4 outlines the results of the interviews of the communication (PR) and commercialisation (BD) office professionals from each participating institute. It pays close attention to the history of the offices, the challenges each office faces within the institute, how these have or have not been overcome, the techniques used by each office to communicate with the scientists and finally the success of the office in becoming a recognised part of the institute by the scientists. This chapter will be particularly important to the analysis of the Research Question 1.

Chapter 5 explores the issues surrounding Research Question 2, by analysing the scientists' opinions concerning the role of Communication (PR) and Commercialisation (BD) in science. This will also be done with special reference to the role of their internal institute's BD and PR offices and their effect on the scientists' research. In addition, it will evaluate the scientists' opinions on the nature of scientific research, concentrating on the aspects of competitiveness in their individual fields, role of commercialisation and communication in science and their individual experiences. The results of this chapter will also illuminate aspects of Research Question 1, by triangulating the results from Chapter 4 with the interviews from the scientists within the institute.

Separate from the core argument, but to be considered alongside the results presented in Chapters 4 and 5 of this thesis, is the analysis presented in Appendix III. Here, I use quantitative bibliometric methods to analyse the publication lists from each institute about the effect of external influences of the publication output of the scientists. I analyse each relationship with regards to the interview data presented in Chapters 4 and 5, in particular, the main issues scientists face with regard to publishing. Additionally, the results of this chapter, based on the reward maximisation model (Kochen & Tagliacozzo, 1974) and other mathematical models of journal publishing behaviour (Oster, 1980), will outline the potential for a new field classification methodology that highlights current restrictions of the current classification systems used in bibliometric research.

Chapter 6 will discuss the results presented in the two results chapters (Chapters 4 and 5), along with the results in Appendix III, with regard to the literature described in Chapter 2 and the research questions outlined above. Chapter 7 will address the reflective conclusions of this thesis and will recommend future areas of research in examining the relationship between the professional BD, PR Offices and scientists within scientific research organisations.

It is hoped that this research will identify trends for the successful integration of BD and PR into modern medical research institutes. The research will therefore offer insights for other scientific research organisations that may be experiencing difficulties with their scientists' engagement of BD or PR activities or who are considering establishing or restructuring their own internal BD or PR Offices. The results can also be used when considering employment of future BD or PR personnel.

Chapter 2: Literature Review

2.1 Introduction

This chapter reviews the literature relating to the data presented in this thesis and the conclusions drawn. Also, considering the multidisciplinary nature of the field of science communication, the literature covered in this chapter is grouped into sub-headings to illustrate the overall trends and further justify the research questions outlined in Chapter 1.

Very little research has been conducted into how scientific organisations have adapted themselves in response to the increased expectation for public accountability in science. Even less research has focused on how scientists work and their opinions about science communication and commercialisation as a result of these changes. Communication and commercialisation are two aspects of science that fulfil scientist's obligations to the public in receipt of taxpayer funded research. Indeed, the few studies that have indirectly investigated the change in the culture of science have produced very little empirical evidence for their findings. Finally, research supporting theories of an academic revolution resulting in a culture shift towards greater accountability in science have primarily focused on large and diverse organisations such as universities. Research investigating the effects of these culture changes have failed to measure these effects in the smaller, more specialised organisations that this thesis labels 'Institutes'. Indeed, organisational research suggests that the effects of this change would be felt more acutely in a smaller organisation such as an institute (DiMaggio & Powell, 1983).

Australian government science policy has emphasised the contract science has with society. This, in turn, has altered the criteria by which scientists and the public assess research resulting in a change in the way that funding is distributed. It has also potentially increased competition between scientists and organisations for research funds and, as a result, scientists and organisations alike are now seeking alternative funding avenues to sustain their research programs. Another unknown factor to be highlighted in this literature review and thesis is how these institutes have positioned themselves to adapt to this increased public accountability and how to attract these alternative funding avenues.

In the following literature review, areas of investigation have been drawn from a variety of different disciplines. This only serves to further highlight the multidisciplinary nature of science communication research. Additionally this chapter will explore how these areas of investigation have not previously been combined in order to illustrate the way science communication and commercialisation operate behind institutional walls.

2.2 Sociology of the Scientific Culture: Attempts to Characterise the Behaviour of Science and Scientists

To many scientists, the idea of science as a culture is surprising. After all, no one considers their everyday actions as being primarily influenced by a culture with its own rules, norms and ideals. To scientists, even more surprising is the idea that the culture of science, including its belief systems, has been a topic of fascination for sociologists, philosophers and scientific communicators for some time.

2.2.1 The Norms of Science

Science, being assorted and dynamic, requires that its imperatives be shared by members of its community. This is the notion of Robert Merton, who, in 1942 defined these imperatives and called them the 'norms of science'. These norms were seen as basic cultural rules that promoted the growth of science. Merton described four essential norms of science: Universalism, Communism, Disinterestedness and Organised Scepticism. These norms, embodying the underlying principles of science, are those with which scientists operated in accordance and to which they adhered. They were also linked to the allocation of rewards and the use of sanctions in science. *'The mores of science... are binding not only because they are procedurally efficient, but because they are believed right and good. They are moral as well as technical prescriptions.'* (Merton 1973 [1942], p.270)

Universalism refers to how knowledge claims are accepted or rejected through *'pre-established impersonal criteria consonant with observations and with previously confirmed knowledge'*(Merton, 1973 [1942], p.607). In other words, scientific results should be analysed objectively and be verifiable and repeatable. The claimant's own personal or social attributes are irrelevant to the validity of truth claims as scientific truths should be observable and testable despite national, political or religious boundaries (Merton, 1973 [1942]). Communism is the norm that states that scientists share their work with their community for the common good and is also the most difficult norm to apply to modern research. The major goal of most scientific discoveries is the widespread acceptance of results and theories. As the scientific community accepts more results and theories, it gains additional respect and distinction. Merton wrote that *'The substantive findings of science are a product of social collaboration and are assigned to the community...The scientist's* *claim to 'his' intellectual 'property' is limited to that of recognition and esteem'(Merton, 1973 [1963], p.610-611).*

Essentially, progress in science comes through cooperation and collaboration between individual scientists and between generations of scientists that share a common goal – public and complete dissemination of results for the benefit of the scientific community (Merton, 1973 [1957]). Disinterestedness is the norm that states that scientists should have no emotional or financial attachments to their work, and is essential to avoid any conflict of interest in science that may affect a scientist's ability to make an independent judgement of his research and the importance of any results. As with the norm of Communism, Disinterestedness also states the reward comes through recognition of scientific achievement, not through monetary gains as scientists should look at results independently (Merton, 1973 [1942]). Even though this is the most difficult norm to follow, most scientists will claim to practice Disinterestedness and remain focused on uncovering natural phenomena. Finally, Organised Scepticism refers to the practice of judgment of a knowledge claim by a scientist and it is accepted that one should be sceptical of results and be certain to replicate all significant findings.

'The scientific investigator does not preserve the cleavage between the sacred and the profane, between that which requires uncritical respect and that which can be objectively analysed'(Merton, 1973 [1942], p.277-278). The process of paper submission alone exhibits the importance of replication, because one must have shown many times and often by more than one mechanism, that a discovery is accurate to gain approval from a panel of reviewers.

Merton was interested in one limited aspect of science as an institution; namely that there were cultural values governing the activities termed 'scientific'. One problem with Merton is that he assumed that the above norms would apply to science overall. He did not consider that the existence of institutional norms or, in other words, the norms of scientific practice within a specific organisation, could potentially override his original norms of science.

Research organisations are varied both in their purpose and aims of research. The way in which the research is funded may also vary and could change the ethos of science or 'the norms of science'. Additionally, the 'unwritten rules' of each organisation may differ and hence create a difference in the research outcomes. Merton today can be seen as overly idealistic, naïve and out of step with the social and fiercely competitive, commercial nature of modern science and is especially blind to the influence wielded by surrounding stakeholders. Erno-Kjϕlhede (2000) suggested that the conflicting demands between Merton's norms as an idealistic conception of science on the one hand and the realities of organisational and political demands for capitalisation and practice-orientated research on the other may be a prime source of many of the disagreements and cooperation problems currently faced by researchers (Erno-Kjolhede, 2000).

Critics of Merton's norms of science argued that the norms were created solely based on basic research in universities and on the experimental sciences with well-established theories (Erno-Kjolhede, 2000). In addition, developments in science since Merton's norms including the rapid expansion of science (in terms of the number of scientific subjects and increased number of people and institutions involved in research), mean that the norms cannot be used to explain the practice of research. Another limitation is that technology has changed the way that science and research is conducted and where it is done. The concept of science becomes blurred, along with the expectations of scientists and what it means to be a scientist. Merton's norms cannot, in their current form, be applied to this ever changing scientific community (Etzkowitz, 2000). For example, for a researcher pursuing a corporate career and hired to do specific research, the 'norms' are especially difficult to adhere, since, in Merton's terms, researchers clearly own their research projects and are solely concerned with the production and not application of their research. Despite this, Communism, Universalism, Disinterestedness and Organised Scepticism cannot be ruled out completely.

This was the view of Ziman (2000) who commented that Merton's norms were difficult to abide by, both individually and communally, and also they did not accurately describe 'modern day science' as opposed to the state of science at the time that the norms were written in 1942. Instead, he proposed his own norms, the PLACE norms. These norms took into account the rise of commercial research and included: *Proprietary*, exclusive ownership of knowledge, usually by a company; *Local*, that knowledge is primarily created to solve local problems; *Authoritarian*, that research is hierarchically managed; *Commissioned*, research that is based on external commissions aiming at practical utility and not on the internal development of a research area; and finally, *Expert*, where a researcher is a paid problem solver, not a creative individual. These norms, though a negative view of the scientific community, have one very important aspect in common with the Mertonian norms. That is, the scientific community has a set of rules by which all members are expected to abide and that these norms reflect the challenges faced by the scientific community in the production of knowledge.

2.2.2 Studying a Dynamic Science

Despite the acceptance of the concept of the norms as a unique method of analysing scientific culture, some sociologists argue that the concept of norms is static. Merton, Hagstrom, Glaser and other sociologists who have attempted to characterise science by identifying rules do not show interest in the individual motivations of scientists. The concept of norms assumes that scientists are propelled by powerful values and the questions of when and where a scientist decides to accept these, and why he does, is considered irrelevant (Whitley, 1972). Whitely (1972) argues that studying the mechanisms with which knowledge is produced is more important. One failure of Merton and his colleagues was that they failed to enquire why scientists come to hold specific values and norms. Whitely (1972) hypothesised about what he considered the functional interrelationships between science and society in terms of values that are common to both. Whitley (1972) argues that identifying how knowledge is constructed and what social mechanisms stimulate this should be the focus of all sociologists. This view in favour of the sociology of scientific knowledge rather than the sociology of science uses the concept of the black box to explain why science should be viewed as a dynamic rather than static sociological environment. A black box view restricts the viewing of a scientific system to its observable inputs and outputs only. A translucent box, on the other hand, studies how different sets of ideas about the natural world are evaluated, and how the ideas are defined in different spatio-temporal locations.

Further to the concept of a 'dynamic science', Thomas Kuhn published *The Structure of Scientific Revolutions* and suggested that science wasn't done by the average scientists but by the elite (Kuhn, 1962). Kuhn (1962) denied that scientific research was merely a cumulative enterprise that gradually built up knowledge over time and resulted in truths about the external world. Instead, he claimed that the accepted theories and methods of science can occasionally be abandoned by scientists for alternative ones in dramatic episodes he called '*scientific revolutions*' (Kuhn, 1962). This view was also in line with Whitely's (1972) opinion about the strength of studying the sociology of scientific knowledge rather than a static scientific culture and its rules by emphasising the role of intellectual and social authority. Nonetheless Kuhn claimed that science could be displayed as a whole rather than simply in many bits and pieces and he named this holistic structure of science the 'Paradigm' (Kuhn, 1962). The 'Paradigm' is a framework of theory, assumptions and methods under which scientists in a particular discipline conduct their research (Kuhn, 1962). However, a stage that exists before the development of a 'paradigm' called the 'pre-paradigmatic state' is of particular interest. In the pre-paradigmatic state there exist several schools of thought as to what constitutes the basis of any given field of research. For example, the discipline of physical optics was pre-paradigmatic before the publication of Sir Isaac Newton's 'Opticks' in 1704. The same applies to Charles Darwin's '*Voyage of the Beagle*' for the field of evolution and creationism (Riggs, 1992). The way that one pre-paradigm defeats another is by attracting practitioners to their schools of thought and over time one school will attract more practitioners than the other and will eventually have a more noticeable effect on the research in the field. As a result the dominating pre-paradigmatic school will appear superior by being able to offer its practitioners more. Defection to the dominant school follows and the rival schools cease to function. The winner of this pre-paradigmatic debate then becomes the new paradigm and is described as 'normal science' until a new pre-paradigmatic competitor arises. Pre-paradigmatic competitors usually arise from the inability for the normal science to solve puzzles. When this occurs, the cycle of the scientific revolution of paradigm change will begin again.

The flexible nature of science was of interest to a number of sociologists of science. Knorr-Cetina (1999) viewed the notion of the laboratory beyond a mere physical space in which experiments are conducted, and instead saw it as a set of differentiated social and technical forms, carrying systemic weight in the understanding of science. According to this idea, laboratories are malleable and consist of three distinct features. These features include that the laboratory does not put up with an 'object' as it is instead it can substitute transformed and partial versions of that object in order to study it. Additionally, the laboratory does not need to accommodate the natural object where it is or, finally when it happens and hence can manipulate it further in order to study. In other words, the laboratory allows for experiments to take place away from the natural conditions (and reality) and therefore subject only to the contingencies of the local (laboratory) conditions. In addition, laboratory sciences subject natural conditions to a social overhaul and derive epistemic effects from the new situation. These features allow scientists within laboratories to conduct scientific experiments and produce knowledge. Laboratories not only improve upon natural orders but, in a sense, they also upgrade social orders. Knorr-Cetina (1999) stated that previous studies of the sociology of science were not interested in how features of the social world, and more general of everyday life are played upon and turned into epistemic devices in the production of knowledge. This is of particular interest as laboratories inherently realign the social and natural influences on their environment in order to produce scientific knowledge. Finally, Knorr-Cetina (1999) stated that both objects and scientists are malleable with respect to a spectrum of behavioural possibilities. In the laboratory particularly, scientists are the methods of inquiry; they are part of a field's research strategy and therefore a technical device in the production of scientific knowledge.

For the purpose of this thesis, it is not clear at what point laboratories refer to an organisation or an institute. Laboratories were defined as relational units that gain power by instating differences with their environment: difference between the reconfigured orders created in the laboratory and the conventions and arrangements found in everyday life (Knorr-Cetina, 1999). One can link laboratories as relational units to at least three realities; to the environment they reconfigure, to the experimental work that goes on within them and is fashioned in terms of these reconfigurations, and to the field of other units in which laboratories and their features are situated. This definition could also be used to relate to an institute where the scientists are grouped by a common field within an institute. Additionally, the rise of collaboration in science makes individual laboratory boundaries obsolete within a common scientific institute and therefore it is of particular interest to study the evolution of an institute in relation to the 'epistemic' influences. Knorr-Cetina (1999) emphasised that scientists have been shaped and transformed with regard to the knowledge of agents and processing device they use in inquiry and therefore the production of scientific knowledge will also be changed.

Latour & Woolgar (1979) influential study of the Salk Institute is another important piece of work with regard to the role of the institute. By spending time with scientists, within their laboratories, Latour & Woolgar (1979) were able to make revolutionary observations of how scientists produce scientific knowledge. Mulkay (1977) and Mulkay & Gilbert (1982) also emphasised the role of social contexts in influencing how science is constructed or performed and this consideration is maintained throughout the interviews in my study.

Interestingly enough, a similar study to Latour's Laboratory Life was conducted at the WEHI, an institute that also participated in my study (Charlesworth, Farrall, Stokes, &

Turnball, 1989). One of the more relevant conclusions made to the research questions in this study was that the scientists at the WEHI seemed oblivious to the ethical or social implications of their science (Charlesworth et al., 1989). One must also consider that at the time of this study, in 1989, that science was under a difference set of rules in relation to social accountability of scientific research and that the institute's environment would have changed to reflect that. It is hypothesised that as the WEHI has evolved to better position itself in response to the call for greater accountability of science, so too have the opinions of the scientists towards their social contract with science. This will be particularly true as science is indeed a dynamic, ever-changing culture. In this thesis I will investigate this further by analysing how these opinions of scientists at the WEHI have changed in light of the increased public accountability in science. Likewise, I will investigate how the institute as a whole has evolved and adapted itself in order to meet this increased level of public accountability.

As can be seen from the studies described, science has been regarded as a culture by academics since the description of Merton and his 'norms'. Though the norms may not be relevant to modern science, the culture of science is one that can profoundly affect the way a scientist conducts research. This culture can even be studied empirically using bibliometrics, as demonstrated by the work of the Cole brothers (discussed later). However, when a culture changes it is assumed that the practice of science will also change. Public accountability is a new idea that justifies its place within science with the increased obligation of scientists to be able to provide a return to the public for research funds. In this thesis, I will attempt to evaluate how each institute has adopted the public's requirement for greater accountability in science. In particular, it will evaluate the individual motivations of the scientists and how such motivations can affect how scientists produce scientific knowledge, a consideration that was not taken by Merton (1973).

2.3 The Academic Revolutions: Theories since WWII

A number of different theories describe the increased level of accountability in modern science. This section will outline and describe each of these theories in relation to the research questions. It will pay particular attention to the theory described by Gibbons et al.(1994) in *The New Production of Knowledge* and the Leydesdorff & Etzkowitz (1998) *Triple Helix Theory of industry-government-university involvement.* This section will highlight the similar components of all these theories about academic revolutions.

2.3.1 Mode 1 and Mode 2 theories of Knowledge Production

The New Production of Knowledge (NPK) stated that science was undergoing a culture shift from the traditional practice of science which is known as the Mode 1 production of knowledge, to the more socially reflexive Mode 2 knowledge production (Gibbons et al., 1994). Mode 1 knowledge production emphasised the traditional role of universities or what has been described as the traditional ivory tower view of the academy where the emphasis was on curiosity driven enquiry and positivist epistemology (Parsons & Platt, 1973). In this mode scientists were allowed self-determination of research agendas and academic accountability to scientific disciplines rather than to the public. Gibbons et al. (1994) argued that the new form of knowledge production is context-driven, problem focused and interdisciplinary. It involved multidisciplinary teams brought together for short period of time to work on specific problems in the real world – this was labelled 'Mode 2' knowledge production. Gibbons et al. (1994) argued that the contextualisation of research around the interest of stakeholders fosters a more 'socially robust' knowledge that transgresses disciplinary and institutional boundaries. Hence multiple stakeholders bring heterogeneous skills and expertise to the problem solving process; Mode 2 recognises other frameworks of intellectual activity that may not fit the traditional disciplinary structure. It is argued that within the context of the application, new lines of intellectual endeavour emerge and develop (Nowotny et al., 2001).

Mode 2 knowledge production is defined by five specific characteristics; context of application, transdisciplinarity, reflexivity, research conducted, at a greater diversity of sites and exhibits novel forms of quality control. The first criterion, in the context of application, does not suggest that Mode 1 activities are incapable of producing practical outcomes; rather that Mode 2 research in the context of application described the total environmental in which scientific problems arise, methodologies are developed, outcomes are disseminated and uses are defined. Transdisciplinarity refers to the mobilisation of a range of theoretical perspectives and practical methodologies to solve problems. This definition goes further from inter- or multi-disciplinarily as it is not necessarily derived from previous disciplines. Transdisciplinarity as a characteristic of Mode 2 knowledge production is embodied in the expertise of individual researchers and research teams as much as it is encoded in conventional research products such as journal articles or patents. Related to the third characteristic, reflexivity, which in Mode 2 when compared to Mode 1, is a dialogic process capable of incorporating multiple viewpoints. It states that researchers are becoming more aware of the societal consequences of science. In this sense, Mode 2 knowledge production is based on the needs of end users and is arguably a more socially accountable form of knowledge production. In addition, in Mode 2, sensitivity to the impact of the research is built into the research project from the start and therefore forms part of the context of application. Indeed, according to Gibbons et al. (1994), operating in Mode 2 makes all participants more reflexive. The fourth characteristic, greater heterogeneity and organisational diversity relates to how science in Mode 2 is conducted at many different sites and by many different groups. Whereas Mode 1 knowledge production was primarily conducted in universities, Mode 2 is conducted at universities as well as in industry, non-governmental agencies, specialised institutes and is not restricted to one particular type of organisation. These sites are linked through networks of communication and research is conducted in mutual interaction (Hessels & van Lente, 2008). Characteristically, Mode 2 research groups are less firmly institutionalised and people come together in temporary work teams which dissolve once the problem in solved. The fifth and final characteristic of Mode 2 is related to the description of the quality control mechanisms in place for science. Whereas in Mode 1, quality control was an internal process through peer review, quality control in Mode 2 involves additional criteria that are related to the research being conducted in the context of application. Quality control on Mode 2 now incorporates social and economic criteria. However there is a fear within the scientific community that enforcing such criteria may fail to emphasise strong control in science resulting in lower quality research being conducted.

Another major concern regarding the move towards Mode 2 knowledge production is underpinned by an assumption that researchers engaged in Mode 2 type of activities will undertake more applied research and that this will in turn be detrimental to the overall scientific agenda. This is known as the 'skewing problem'. These concerns are based on a discourse about the necessity to turn to alternative funding sources and hence form alternative alliances and the changing value of knowledge – increasingly regarded more as intellectual property rather than as public good (Estabrooks et al., 2008; Nowotny, 2003).

Another problem with the concept of Mode 2 knowledge production is based on the way that universities and research organisations (such as institutes) operate in regards to Mode 2. In particular, scientists and researchers alike must still progress through the academic ranks meeting established, Mode 1 style benchmarks while also competing for scarce research dollars in a funding climate where the criteria for assessment are changing to reflect more Mode 2 orientations.

Not surprisingly, there were a number of critics of Mode 2 many of them challenging the originality of the theory. Many of the competing theories are presented below but for many researchers the idea of Mode 2 is not unique (Hessels & van Lente, 2008). Referring to historical studies of science, several scholars claim that at least some of the attributes of Mode 2 have always been present in modern science (Etzkowitz, Webster, Gebhardt, & Cantisano-Terra, 2000; Rip, 2000). Etzkowitz and Leydesdorff (2000) argue that in the historical sense it is Mode 2 and not Mode 1 that is the traditional and therefore original format of science. Pestre (2003) argues that the elements of Mode 2 have always existed in modern science and that knowledge producers have never isolated themselves and have always paid attention to the interests of states and economic elites relating to science. Moreover, *'science has always directly contributed to, and has been a major resource for, changes in social ideologies' (p250).* Furthermore, Godin (1998) argues that fundamental research has always been inspired by more applied knowledge and applied research has always shown interest in the fundamental understanding of nature.

Another criticism is related to the empirical validity of the Mode 2 studies conducted by Gibbons et al. (1994) and Nowotny et al.(2001). There is particular concern regarding the empirical evidence regarding the transdisciplinarity characteristic of Mode 2. Hicks & Katz,

(1996) observed a growth in 'transdisciplinary' journals. However, according to Hessels & van Lente (2008) the definition of transdisciplinary research used differed from the original definition by Gibbons et al. (1994). Hicks & Katz (1996) define transdisciplinary journals as ones that cannot belong to a single field or discipline. No empirical evidence such as the Hicks & Katz (1996) study is used in the original NPK or the following *Rethinking Science* theories. There is also no empirical evidence provided for the reflexivity characteristic, and it is suggested by some that reflexivity is more applicable to policy relevant knowledge (Weingart, 1997). The issue of reflexivity deserves further investigation (Hessels & van Lente, 2008) and this thesis will attempt to provide this empirical analysis.

There are still researchers who doubt that a shift towards Mode 2 is occurring. One of the major criticisms revolves around the generalisability of Mode 2 and how it fails to account for differences between disciplines and fields in science. Weingart (1997) states that some of the attributes of Mode 2 are more prevalent for the scientific fields that are close to policy-making such as environmental research (especially in relation to climate change). Accordingly, the Mode 2 theory is drawn only from a small subset of academic research and therefore the theory cannot be accurately applied to the entire science system (Weingart, 1997). Weingart (1997) does not, however, specify the application of the characteristics of Mode 2 knowledge production in medical research; however the nature of medical research suggests that it is especially applicable to Mode 2 characteristics. The failure of Gibbons et al. (1994) to draw conclusions from a variety of scientific fields remains a major criticism of NPK. Gibbons et al. (1994) and Nowotny et al. (2001) do state that there are cases where Mode 1 and 2 interact with each other. In these situations it is stressed that Mode 2 is not supplanting but rather supplementing Mode 1 knowledge production.

Mode 2, however, is still an attractive theory to a majority of researchers and despite the criticisms; the idea of Mode 2 has initiated some interesting studies into how scientists work under these cultures. Hessels & van Lente (2008) stated that the strength of the Mode 2 diagnosis was indicated by its reception in the scientific literature. By analysing the *Web of Science* and *Scopus* databases, it was found that the paper by Gibbons et al. (1994), NPK, had received over 1000 citations in scientific journals and that this number is still rising. Additionally, by defining Mode 1 and 2 knowledge production activities under the rubric of dissemination, Estabrooks et al. (2008) investigated the knowledge translation activities of health researchers from different disciplines and faculties including universities, hospitals, industry and a combination of all three. Their assumption was that Mode 2 knowledge production was based on the needs of end users in the health care system and is arguably a more socially accountable form of knowledge production. This is similar to the assumption in my study that medical researchers would be more involved in commercialisation and communication activities compared to other types of researchers. Estabrooks et al. (2008) found that applied researchers engaged in more Mode 2 activity and perceived their work as having more impact and reported higher levels of relational capital when compared with basic researchers. In particular, applied medical school researchers achieved a balance of both Mode 1 and 2 activities. Applied health researchers from other health science faculties (not medicine) reported the most Mode 2 activities but the fewest number of scholarly publications. This could potentially point to a skewing problem. The authors did question whether the balance achieved between Mode 1 and 2 activities by medical school researchers was the result of other research factors, such as the characteristics of physicians in general. In addition, unfortunately, the study did not measure change over time so cannot ascertain whether this effect is a new phenomenon or an old one that is more related to the organisation rather than a change in attitudes over time.

The attraction to Mode 2 and the NPK in this thesis is in the important role that the public and society play in the research endeavours of scientists. Moreover, the focus of this thesis is firmly on how the institutes have adopted Mode 2 behaviours into their internal structures. Gibbons et al. (1994) commented that the rate with which Mode 2 was adopted by the scientific community *'will be determined by the degree to which Mode 1 institutions wish to adapt themselves to the new situation. (p10)'*. The way in which the five participating institutes have adapted themselves to be more receptive to communication and commercialisation of science is a major focus of this study. Mode 2 production of knowledge, however attractive to the premise of this thesis does not mean that science is more publically accessible despite the definition of Mode 2 five characteristics. Issues with the method of translation because of the use of jargon, the receptiveness of the audience as well as the enthusiasm of scientists to participate in reflexive communication when the scientific culture still rewards Mode 1 endeavours is still a major concern. This is despite research being conducted in the context of application

2.3.2 The Agora in NPK

In 2001, the original authors of NPK published another piece in order to clarify some of the original characteristics of Mode 2 knowledge production in light of the criticisms it had received. In clarifying Mode 2, Nowotny et al. (2001) developed some additional characteristics of the state of Mode 2 knowledge production and extended the definition to include the humanities as well as the sciences. Another important addition to the Mode 2 definition was the concept of the '*agora*'.

In ancient Greece, the '*agora*' was a marketplace where citizens were able to meet, discuss and debate topics of importance. Modern examples of an agora have been identified, the most famous being the internet (Lippert, 1997). The internet, like the agora, serves as both a meeting place and a marketplace and provides an example of the open public communication and debate that is characteristic of the agora (Gumpert & Drucker, 1992).

In regards to scientific knowledge production and according to Nowotny et al. (2001) the agora is the problem-generating and problem solving in which contextualisation of knowledge production takes place. It is populated not only by arrays of competing 'experts' and the organisations through which knowledge is generated but also by members of the public. The agora is a domain of primary knowledge production through which people participate in the research process and where Mode 2 knowledge is embodied in people and in projects. The role of controversies in realising scientific potential is also played out in the agora. Nowotny et al. (2001) also referred to a society that consisted of 'transgressive' institutions. These changes are observed in industrial and governmental researcher institutes, research councils and in universities. In particular they introduce the concept of 'contextualised science' which basically means that society 'speaks back to science', yielding socially robust knowledge which has a different epistemological status than Mode 1 science.

Frode Frederiksen, Hansson, & Barlebo Wenneberg (2003) looked at the metaphor of the agora in relation to research analysis. In this paper, the authors argue that research is becoming evaluated by more socially relevant assessment criteria and is therefore developing more towards the concept of an 'agora'. Davenport & Leitch (2005) further investigated the concept of an 'agora' in science by analysing the success of New Zealand's Royal Commission on Genetic Modification. Both these papers define the concept of the agora differently. One major disadvantage of Nowotny et al. (2001) original description of the agora was that there was little empirical evidence which allowed for interpretation. Indeed, two studies of the agora in a scientific knowledge production setting both contradicted each other in relation to a number of characteristics of the agora. Whereas Davernport & Leitch (2005) expressed that the agora provides a defined physical space where the negotiations between science and society can take place. Frode Frederiksen et al. (2003) stated that this physical space need not exist and instead used a more theoretical definition of the agora in order to evaluate current assessment criteria for the value and importance of science. The differing definitions of what constitutes an agora are advantageous for this thesis, which aims to investigate the state of public accountability in medical research institutes in relation to the concept of the agora. With this in mind the framework of the agora used in this thesis is similar to the one described in Frode Frederiksen et al. (2003) where the concept of the agora is used more openly to refer to a conceptualisation of an open marketplace or network with a number of difference actors, values and competing scientific knowledge claims. The concept of the agora is of particular interest in this thesis when considering how the five participating research institutes have evolved to be more open to communication and commercialisation in science.

2.3.3 The Triple Helix

Mode 2 production of knowledge seems to be constantly competing with the concept of the triple helix model. Despite this, the two models have many similarities. Both models emphasise a change in the culture of science and how science is supposed to behave and both emphasise an increase in the level of accountability in science. One of the major failings of Mode 2 production of knowledge is that it fails to *'recognise that the university, business and government all function in a national setting'* (Shinn, 2002, p.610). Indeed, the triple helix model states that a university can play an enhanced role in innovation in increasingly knowledge-based societies. This is done by focusing on the overlay of communications and expectations that reshape the institutional arrangements between universities, industries and governmental agencies.

The triple helix model of innovation assumes that universities, industry and government are independent and therefore need to be studied in co-evolution. Research must take all three helices into account when studying the 'dynamics' of knowledge production. This is mainly because, unlike Mode 2 model of knowledge production, the Triple Helix model assumes that the balance between universities, industry and government are always in a state of flux. This is an observation of reflexive communication between universities, industry and governmental agencies. According to Etzkowitz & Kemelgor (1998) and Etzkowitz & Leydesdorff (2000), there is also a tendency for these spheres to overlap. The Triple Helix 1 model describes the historical relationship between universities, industry and government. In this configuration the nation state encompasses academia and industry and directs the relations between them. This model is largely viewed as a failed developmental model with too little room for 'bottom up' initiatives and where innovation was discouraged rather than encouraged (Etzkowitz & Leydesdorff, 2000). A second policy model, Triple Helix II, consists of separate institutional spheres with strong borders dividing them and highly circumscribed relations among the spheres. Triple Helix II entailed a laissez-faire policy and is currently advocated to reduce the role of the government in the Triple Helix I model. Finally, the Triple Helix III model is generating a knowledge infrastructure in terms of overlapping institutional spheres with each taking the role of the other and with hybrid organisations emerging at the interfaces. This model is, at present, the one that most countries are trying to attain. The common objective is to realise an innovative environment consisting of university spin offs, strategic alliances among firms, governmental laboratories etc. These arrangements under the Triple Helix III model are encouraged but are not controlled by government. The former linear model of knowledge production takes into account market pull and technology push and was insufficient to induce transfer of knowledge. It attempted to link basic research to utilisation through programs such as government initiated intermediary programs that facilitate interaction between universities and industry, such as incentive schemes or cooperative research centres.

Both the Triple Helix and Mode 2 models of innovation are in agreement with regard to research being conducted in the context of application and in the organisational diversity of science. In regards to transdisciplinarity, there are some differences with Etzkowitz & Leydesdorff (2000) stating that new disciplines arise through synthesis of practical and theoretical interests. Most importantly, the authors of the Triple Helix model disagree in relation to the traditional state of science. In their opinion, the original state of science is closer to the description of Mode 2 and not Mode 1. In addition they argue that Mode 2 represents the material base of science – how it operates and that Mode 1 is just a construct that is built upon that base in order to justify autonomy for science. This was especially important in an earlier era when science was still a fragile institution and needed all the help that it could get. The statement that Mode 2 is a description of the traditional state of science and the rejection of a change in the level of reflexivity in science is one of the main objections that I have with using the Triple Helix model. My study assumes that the public would play an equally important role in the production of knowledge as industry or government. In addition, public communication is considered, for the sake of this thesis, an essential role of science and scientists in universities and industry. Despite this, the Triple Helix Model has not explicitly described the role of the 'public' in its model.

This was discussed by Leydesdorff & Etzkowitz (2003). In their opinion, the conceptualisation of the public as merely a fourth helix narrowed it into another private sphere rather than seeing civil society as the foundation of the enterprise of innovation. Indeed, this view was developed further and it was decided that the Triple Helix was flexible enough for the role of 'the public' to be subsumed under it (O'Malley, McOuat, & Doolittle, 2002). Additionally, the Triple Helix model could be broken down into sub-theories and then models, all of which connect to the overarching theoretical framework that includes government, industry and universities. Therefore, the role of the 'public' is, according to the authors, sufficiently represented in each helix and there is no need to develop a separate 'public' helix to the model.

As a result of this exclusion and despite the emphasis on the triple helix model of the involvement of industry in research innovation, this thesis does not use the triple-helix model but instead goes beyond the university boundary to look at institutes. Institutes cannot be considered businesses as they are mainly non-profit and still focus on the production of knowledge. Institutes can neither be considered extensions of universities as they maintain separate corporate identities and presence in the community. As the Triple Helix does not take into account the role of public communication as part of knowledge production (Leydesdorff & Etzkowitz, 2003), it is concluded that it is not a suitable model with which to evaluate the results of this thesis.

2.3.4 Academic Capitalism

Academic capitalism is another theory of knowledge production, based on empirical observations, that describes the effect that the increasing level of market like activities are having on science and universities. According to the authors, the term 'academic capitalism' refers to two specific activities occurring in science and in universities; first, the increased level of competition among scientists for external funding; and second, the increased level of 'market like' activities in universities that emphasise 'for profit' activities such as patenting, spin off companies and royalty and licensing agreements (Slaughter & Leslie, 1997). This academic capitalism is the result of the increased pressure on universities to innovate, so much so that industry is now targeting university research to provide help in this. Also, as a result of the diminishing level of public funding for universities and for research, universities are now more open to engaging in 'capitalist activities'. However the authors are quick to point out that such activities occur outside of the science system (Slaughter & Leslie, 1997).

The development of the theory of 'academic capitalism' was based on an empirical study of four countries (Australia, Canada, US and the UK) where governments promoted the concept of 'academic capitalism' as a way to stimulate economic growth. These policies were successful in all participating countries, except in Canada. However, it was recorded that only some of the universities in the US managed to make money as a result of these government policies and additionally the study identified some considerable risks of engaging in such activities for the universities, businesses, researchers and their managers. These risks included business failure, the neglect of students and failure to meet societal expectations. In order to counteract the potential for these negative effects, Slaughter & Leslie (1997) recommended that governments create monetary incentive schemes for universities and researchers to engage in academic capitalism activities. A curious observation was highlighted by Hessels & van Lente (2008), where the researchers in the Slaughter & Leslie (1997) study were ambivalent to the concept of 'altruism in science' where 'benefitting mankind' was not the first priority of researchers. Interviews with these researchers, Slaughter & Leslie (1997) revealed that they felt that they were being pushed in the direction of academic capitalism and, as a result, were doing everything in their power not to become Mode 2 researchers. The researchers showed no intention of leaving the university system and instead preferred to remain, as they described, 'state-supported entrepreneurs' (p206).

2.3.5 Postnormal Science and other theories

Funtowicz & Ravetz (1993) 'post normal science' framework with its guiding principle, quality, requires the participation of an extended peer community engaged in dialogue and the resolution of the issues at stake. They argue for a reassessment of the role of science in policymaking and debates, as scientific facts are uncertain, values are in dispute, the stakes are high and the decisions are urgent, especially in fields such as environmental science. In this framework, 'normal science', as defined by Kuhn (1962) is an inadequate mode of knowledge production as it assumes that issues can be divided into small-scale problems that can be handled without questioning the paradigm (Hessels & van Lente, 2008). Instead, there is a need for scientific practice that is capable of adapting to this plurality in addition to adapting to the variety of stakeholders and the problems at hand. This issue, according to the authors, stimulated the creation of Post Normal Science.

One of the more relevant characteristics of Post Normal Science and one that is of particular relevance to this thesis is the concept of public participation. Public participation for post normal science is about engaging stakeholders in decision making processes or in the assessment of the quality of scientific knowledge production in a process known as the extended peer community. An 'extended peer community' consists not merely of people with some form of institutional accreditation, but rather of all those with a desire to participate in 'extended peer review' processes for the resolution of the issue (Funtowicz & Ravetz, 1993). This extension requires new forms of integration and conviviality of different types of knowledge and possible justifications. On one hand the extended peer review process of knowledge scrutiny may improve the knowledge database, yet a different sort of justification can be sought - the building of a convivial society. This view of the 'integration' process considered as an interactive social process with political, as well as cognitive and scientific dimensions is, in itself, a way of generating high quality policy evaluation, decisions and outcomes (Guimarães Pereira & O'Connor, 1999). Conviviality is the opposite of technocratic production, it is the concept that recognises that *'people can do more than relinquishing the task of envisaging the future to a professional elite' (Illich, 1973, p.3).*

The similarities of Post Normal Science to Mode 2 and Triple Helix knowledge production are obvious as both theories encourage an increased level of interaction across disciplinary and institutional boundaries, allow for a greater level of reflexivity as well as additional 'quality' criteria. There is however, a difference in the scope of the theories, as Post Normal Science specifically refers to the role of science in the policy making process and does not refer to the interactions between universities and industries such as Mode 2 or the Triple Helix theories. Post normal science does, however, place a large emphasis on the ideal of contextualised research that yields 'socially robust' knowledge (Hessels & van Lente, 2008).

The theory of Strategic Science relates primarily to the role of science in policy making. Nonetheless, Strategic Science refers to basic research that is carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of a recognised current or future practical problem (Irvine & Martin, 1984).

The emphasis of Strategic Science is on basic and not applied research, a concept that distinguishes this theory from other theories that emphasise a role for industry such as, Triple Helix and Post-Normal Science or theories such as Mode 2 where the distinction between basic and applied science no longer exists. Strategic Science has internalised the pressure for relevance while maintaining the academic freedom to continuously move to the most promising line of research (Hessels & van Lente, 2008). Scientists do not operate in the 'context of application' as described by Mode 2; rather they consider the relevance of their work as a legitimate condition to be taken into account. There is still, however, a large amount of distance that exists between the practice of research and the application of this research to solutions for societal problems (Hessels & van Lente, 2008). The term 'Strategic Science' has also been used to describe the re-contextualisation of science in society that produces knowledge that combines social relevance with scientific relevance (Rip, 2004). Examples of this new regime are said to be the increased number of centres of excellence and the increasing emphasis of entrepreneurialism in universities (Rip, 2004).

The theory of Finalisation in Science first described by Bohme, van den Daele, Hohlfeld, Krohn, & Schafer (1983) attempts to explain the dynamics of science and its function in society. According to the theory, all disciplines follow a general development that can be divided into distinguishable phases known as the explorative phase, a paradigmatic phase and a post-paradigmatic phase. According to Bohme et al. (1983) the last phase is the most important as this is where 'finalisation; occurs. Finalisation is a theoretical development that is determined by external factors and, according to this theory, occurs when a discipline becomes theoretically mature and hence becomes open to orientation in accordance with external objectives. The authors (labelled 'finalists') propose that more disciplines are reaching this phase and achieving finalisation and that this implies that the relationship between science and society is changing so that society becomes an active, and not passive, partner and assuming an increasingly guiding role in the research process.

According to Weingart (1997) this theory is very similar to NPK. Its strength, unlike NPK, lies with its empirical basis. Additionally, finalisation differentiates between different scientific disciplines. Weingart (1997) stated that the tendency for other theories to refer to 'all of science' is a large claim that makes it difficult to explain individual variations that occur. Finalisation, however, allows for each discipline to progress through the academic revolution and achieve finalisation at different rates and at different times, allowing for the theory to explain for discipline differences. Finalisation is also related to the evolution of 'internal' rather than 'external' factors, another way that this theory separates itself from the others. In contrast, the driving force in the finalisation of disciplines is the increasing theoretical maturation, which facilitates social orientation whereas external factors (change in government policy, public expectations etc) drive the development of NPK. Finally, the authors of the Finalisation in Science theory provide, in addition to a description of their theory in relation to the state of science, policy recommendations calling for the 'social natural science'. That is, science in which natural norms and social interests are coordinated and scientists meet specific, societal focused conditions and aims.

Ziman's (2000) Post-Academic Science is similar to the above theories of academic revolution. Post-academic science refers to *'a radical, irreversible worldwide transformation in the way that science is organised, managed and performed'* (Ziman, 2000, p.58). In particular, post-academic science exhibits five connected elements. The first element refers to 'science being a collective entity' or that researchers and practitioners of science all share instruments and co-write articles as part of this larger collective.

Furthermore, the problems that scientists attempt to solve are transdisciplinary in nature and require the input of a number of scientists from a variety of different backgrounds. The second component refers to the exponential growth of scientific activities having reached a 'financial ceiling'. Financial resources that were once made available to science for research have now reached their upper limit and therefore are not expected to grow much further (Ziman, 2000). With the resources available for science no longer growing at the same rate as science, scientists are now required to demonstrate a greater level of accountability and efficiency with their allocated funds. This situation also, according to Ziman (2000), leads to a greater level of competition in science and between science for their share of the limited resources available. The third component is related to the limitation of resources in that there is an increased emphasis on the utility of the knowledge being produced. This is related to the greater level of accountability in science and suggests that science needs to engage with other (external) industries in order to seek extra resources. Science's record with achieving viable products from their research has been, to date, disappointing and the impatience demonstrated by the public and governments has increased the pressure on scientists to deliver more obvious 'value for money' on public funding. Next, the emergence of science and technology policy has strengthened the competition for resources. Ziman (2000) proposes that under this component, the competition for research funding has become more important than competition for scientific credibility. Finally, science has become 'industrialised', that is that the links between academic and industry have become closer. This results in a larger percentage of science funding coming from contract research, a situation that contradicts the Mertonian norms described earlier in this thesis and inspired the development of Ziman's PLACE norms also described earlier in this thesis. Despite his theory, Ziman (2000) is not enthusiastic about the introduction of his Post-Academic Science. According to him, Post-Academic Science threatens the non-instrumental roles of science i.e. the emphasis in science becomes financial that this will threaten certain functions of knowledge production such as the stimulation of rational attitudes, the production of enlightened practitioner and independent experts. These concerns, however, are not unique and are similar to the concerns expressed in the literature about how the alignment of science and business may affect the Mertonian norms of science.

A major criticism of Ziman's (2000) Post-Academic Science is the lack of empirical data used to develop the theory. This is similar to the criticisms received by NPK. Indeed both post-academic science and NPK are very similar. Hessels & van Lente (2008) believe that Ziman (2000) considers NPK as a synonym for 'Post-Academic Science'. One major difference, however, is in the emphasis of the theories. Where NPK refers to a particular way of conducting and organising research that constitutes a limited but increasing part of the science system, post-academic science is the name for this new state of the system. In addition, whereas Mode 2 can develop alongside Mode 1 (in co-evolution), Post-Academic Science is a practice that replaces the old and traditional academic science.

2.3.6 Common elements across all Academic Revolutions

While these frameworks have different 'points of departure' and definitions, they do have a great deal in common. Most importantly, there is the recognition of the need to integrate different forms of knowledge and move this integration beyond scientific production. The process of 'dialogue' outside of the scientific community is also emphasised as a necessary part of these academic revolutions. Finally, the concept of the 'quality' of research is only emphasised through scientists adoption of this dialogue (plurality of perspectives, knowledge and values according to Guimarães Pereira & O'Connor (1999). The frameworks for the production of scientific knowledge imply different relations of scientists with the overall context in which they operate. Broadly speaking, the frameworks acknowledge that those producing knowledge and their activities are bound by a more explicit relationship with society.

These ideas are important to consider when evaluating science systems, in particular scientific organisations and institutes. Although many of the theories have their own advantages and disadvantages, the majority still fail to empirically map any change in the scientific state in support of their theories. Another issue is that it is assumed that the state of Mode 2, Academic Capitalism and/or Post-Normal/Academic Science are the endpoints for science and do not predict the direction of science in the future. Excluded from this generalisation is the Triple Helix and its rejection of a larger role for the public in the production of knowledge. This statement by Leydesdorff & Etzkowitz (2003) negates any benefit of this model with which to interpret the results of this thesis. Indeed, the rationale behind the exclusion of a fourth helix representing the public is that Leydesdorff & Etkowitz (2003) believe that Mode 2 is the traditional state of scientific knowledge production as science has always been socially reflexive and maintained a partnership with the public. However, this is not the case as early science communication research has shown that prior to government reports and initiatives (discussed later), scientists were both reluctant and/or incapable of acknowledging an active role for the public in scientific research (Aikenhead, 2001; Bryant, 2003; Miller, 2003; Stocklmayer et al., 2001; van der Sanden & Meijman, 2008). As a result of this rejection of a direct role of the public in scientific research, the Triple Helix is not an appropriate model with which to interpret the results of this thesis.

As this thesis considers the ways in which five participating institutes have positioned themselves to meet both public and government expectations of greater reflexivity, the NPK

(Gibbons et al., 1994) is considered the best model with which to interpret and further understand the results presented in this thesis.

2.4 Australian Science Policy: The Rise of Public Accountability through the Commercialisation and Communication of Science

By the end of the nineteenth century, Australian science was changing. Experimental science was beginning to displace natural history as the science *de jour*. The need for a national scientific 'laboratory' had been raised in the federation debates of the 1890s but it was not until 1916 that the government appointed an Advisory Council of Science and Industry. This led to the establishment of the Institute of Science and Industry in 1921 and in 1926, the institute reformed as the Council for Scientific and Industrial Research (CSIR). After World War II the demand by scientists for renewed freedom to research saw CSIR evolve into CSIRO. By the latter half of the century, science was developing an institutional base, not just within the CSIRO but also with the establishment of universities, societies and government posts. In 1954, Australian Fellows of the Royal Society of London created The Australian Academy of Science. It was granted a royal charter establishing the academy as an independent body but with government endorsement. Modelled on the Royal Society of London, it provided Australian scientists with an academic basis and a professional fellowship that is recognisable to the rest of the world.

In January 2001, the Innovation Summit Implementation Group delivered the report 'Innovation: Unlocking the Future' that provided an interlocking series of recommendations under three headings: creating an ideas culture; generating ideas; and acting on ideas (The Department of Innovation Science and Research, 2000). The ideas required a considerable investment by government and recognised the need for a world-class research base with easy pathways for the commercialisation of new ideas and good access to the latest ideas and technology. More importantly, it expressed the need for a culture where innovation is actively pursued and encouraged in all businesses and in every research establishment.

The Chief Scientist report 'A Chance to Change' was released at the same time and outlined an integrated investment strategy based on three themes; people and culture; ideas and commercialisation (Batterham, 2000). Under '*the people and culture*' heading, the value of Australia's current scientists and the importance of encouraging students to study science was emphasised. It also expresses a need for people in science and technology to have the skills to communicate with the business world and the rest of the community. In relation to ideas, it stated that an environment needs to be created where good ideas are identified quickly and moved to experimentation and product easily. Finally, commercialisation insists that the ultimate measure of success of science is the value placed on it by consumers and the community and hence emphasises the importance of an innovation system with strong links between scientists, government and industry. In addition it outlined the need to provide incentives for scientists to make the most of their research and to challenge them to facilitate the increased transfer of knowledge to business and society, across all sectors of the economy.

As a result of these two reports described above, the Australian government introduced Backing Australia's Ability (BAA), a $3 billion, integrated package of funding for science and innovation (DISR, 2001). The initiative offered the largest and most comprehensive set of measures to support science and innovation ever in Australia. The BAA introduced a new set of government policies designed to promote research, commercialisation and skills in the science and technology sector. Amongst the many initiatives of the new policies was the expansion of the Cooperative Research Centres (CRCs), the Commercialising Emerging Technologies (COMET) Programme and the reform of current intellectual property laws. These initiatives attempted to facilitate the movement of commercial and business ideals into the science community. In addition, the BAA promoted the importance of greater awareness of science, technology and scientists in Australia through initiatives such as the National Innovation and Awareness Strategy (NIAS). NIAS supports programmes aimed at increasing the awareness of the importance of science and technology, highlighting the importance of scientists, attracting more students into scientific careers and facilitating community discussion on developments in science. As part of the package the government also committed itself to providing whole-of-government reports on science and innovation and the results achieved annually. The 2001-02 innovation report conveyed favourable results and focused on the aim of the government to strengthen the foundations of innovation in Australia. As a result, the Australian government announced first National Research Priorities in December 2002. These research priorities were seen as a tool to focus public science funding and research in the areas that will assist Australia confront its biggest economic, social and environmental challenges (Innovation, 2002).

In May 2004, the second instalment of the Backing Australia's Ability, *Backing Australia's Ability II: Building our Future through Science and Innovation* was announced (DEST, 2004). The policy included a $5.3 billion package of funding for science and innovation until 2010-11 taking the overall government contribution to $52 billion over ten years. The new policy was designed to strengthen Australia's ability to generate ideas and undertake research, accelerate the commercialisation of ideas and develop and retain scientific skills.

2.5 Commercialisation in Science and Entrepreneurial Universities

The 'second academic revolution' added entrepreneurial objectives as a third component to the mission of a university, after research had complemented education as an inherent part of a university's mission during the 19th century, the so called first academic revolution. There has been increased interest by researchers in how universities and research organisations have embraced industry interest in research. This is in response to changes in government policy and in public expectations of science, to see a tangible return on their original investment in science. Whereas the R&D focus in developed countries was once aeronautical engineering and space science, in more recent time the focus has shifted to medical research. This is particularly in relation to finding 'cures' for some of the more prevalent diseases in western society, including Cancer, Obesity and Diabetes. The profile of commercialisation within universities was helped by the implementation of government policies overseas such as the Bayh-Dole Act and the Stevenson-Wydler Act in the US (Mowery, Nelson, Sampat, & Ziedonis, 2001). These new laws gave universities ownership over their intellectual property regardless of whether it was initially publicly funded. Such policies overseas have defined the way the Australian Government views science funding, which they now consider to be an investment rather than solely a 'grant'. With this in mind, there has been a growth in the literature describing the interaction between universities and industry in a variety of different countries and contexts.

2.5.1 Business Interests in Science: The Issues with Withholding and Sharing

An opinion poll of Australian health and medical researchers conducted by Research Australia revealed that, although the excitement of discovery was identified as the most important and satisfying aspect motivating researchers, 40% of surveyed scientists would like to be involved in the commercialisation process (Bennett, 2003). This indicates an increase in the commercial activity of scientists and, although the traditional value of scientific knowledge is still a major motivator for scientists, there is a definite shift towards considering science a business where knowledge is a profitable commodity. However, despite the majority of scientists eager to profit from their research, this change is not completely welcomed by the scientific community where only 20% of researchers surveyed believe that commercialisation has a positive impact on their research (Bennett, 2003). It was clear from the results of the poll, however, that scientists had access to commercialisation procedures if they desired it as 50% of researchers indicated that they would know where to find assistance in commercialising their work. Another indication of the growing emphasis of commercialisation and IP in science is that Australia filed 103,947 patent applications in 2001 compared to 7,095 in 1985, a growth of nearly 100 000 patents in fifteen years, indicating a significant increase in the emphasis of IP in science (Bradley, 2003). This difference may be due to a number of factors including increased access for scientists to commercialisation procedures, government policy changes, and increased incentives for researchers to patent their results and, finally, the decrease in public funding forcing scientists to explore alternative funding avenues. Despite this increase in patent activity within Australian science, Australia was ranked eleventh in the world in the number of patent applications, filing only 1.7% of the world's patents and falling behind the US (38.5%), Germany (13.1%), Japan (11.4%) and Britain (6.0%) (Quinlivan, 2002). It is evident from these statistics that the increasing importance of IP to science is not restricted to Australia, indicating a worldwide change in the practice of science, a change that leads to the incorporation of business principles into scientific practices.

These business principles, and more specifically, intellectual property rights, have been a recurring source of controversy in the biomedical sciences in recent years (Rai, 1999). Various developments have contributed to the increasing importance of intellectual property in biomedical research, including growing commercial interest in the field and legal decisions that have clarified the availability of patent protection for a wide range of discoveries related to life forms (LLoyd, 2003; Eisenberg, 1996). In addition changes in federal policy encourage patenting of the results of government-sponsored research. Protection of intellectual property rights has helped researchers and institutes to attract research funding and has helped firms raise investment capital and pursue product development. But it has also periodically generated complaints and concerns about its effect on the communication between scientists. Additionally, the increased emphasis of IP results in a decrease in scientific communication and hence limits the free and open access to information and materials traditionally available in science (Hilgartner, 1997b). These concerns have been particularly pressing for scientists when intellectual property rights have threatened to restrict access to materials and techniques critical to future research (Murashige, 2002).

Several studies have investigated the relationship between intellectual property and the social relations of scientists from a sociological point of view (Mackenzie, 1990). The area most affected is in the way that scientists communicate with each other concerning their research results (Hilgartner, 1997a, 1998; Knorr Cetina, 1997). Sociological studies concentrate on the importance of the shared body of knowledge and how IP has affected this formally freely accessible pool of information and hence how scientists operate as a result (Kleinman, 1998). This change can have significant effects on science collaboration, funding, publication rates, the materials and methods used in research, the openness of scientists and negotiations about scientific exchange. It is clear from these studies that scientists view the impact of IP in science as a clash of cultures, where the noble and traditional pursuits of science are being compromised as a result of the emphasis on commercialisation (Packer, 1996). Sociological studies are concerned mainly with the 'sharing' of research results in formal scientific communication processes such as publications. However, it is clear that there are several different communication methods utilised within the scientific community that include communicating with the public so that scientists' concerns are not limited to whether to patent, maintain confidentiality or to publish.

A series of studies conducted by Blumenthal and colleagues investigated the role of withholding and secrecy in life sciences and attempted to identify the prevalence and determinants of data-withholding behaviour among academic life scientists (Blumenthal, Campbell, Anderson, Causino, & Louis, 1997; Campbell, Clarridge, Gokhale, Birenbaum, Hilgartner, Holtzman, & Blumenthal, 2002). A nationwide survey of 3394 life science academics in fifty US universities found that, although data withholding in terms of delaying publication was not widespread, where data withholding does occur, involvement in commercialisation was significantly associated with it (Blumenthal, Causino, & Campbell, 1997b). In addition, scientists reported that this tendency to withhold results had compromised the level of communication in science, slowed the rate of progress in the field and harmed the quality of relationships with their peers (Blumenthal et al., 1997). Other consequences of withholding information included the inability to replicate published results as a result of other scientists' unwillingness to share information, collaborations being dissolved, publication delays and the refusal to comply with requests from other research groups for information (Blumenthal, 1992b). It was apparent from these studies that scientists involved with highly competitive scientific fields are more likely to engage in data-withholding behaviours (Campbell et al., 2002). Indeed, several cases of data withholding behaviours have been documented in relation to the highly competitive rice and human genome projects (Rimmer, 2002). This continual secretive behaviour in the field of genetics suggests that the increased emphasis of intellectual property in scientific fields has an impact on scientists' communication with their colleagues. Reasons for withholding information vary although the majority of suggested reasons surround issues concerning intellectual property and commercialisation, including the need to honour the requirements of an industry sponsor, protecting the commercial value of results and protecting the ability to publish and profit from the information (Blumenthal, Causino, Campbell, & Louis, 1996a).

While these studies investigated the nature of secrecy in science academia, they did not, however, investigate how intellectual property in particular inhibits communication in the life sciences. Instead it identified IP involvement as only one of many factors resulting in academics withholding research results. A limitation of the study was that it only considered publication rates as an affected method of communication and failed to address other areas of communication that are used frequently in science to communicate results such as seminars, multi user database creation, collaboration, conference involvement, negotiations about scientific exchange and funding proposals.

In contrast, Zucker & Darby (1996) argued that, in terms of publication, corporate affiliations actually promote communication. They considered that the decline in communication between scientists (secrecy) was indirectly linked to commercialisation and intellectual property (Zucker & Darby, 1996). They found that researchers who were already very active in science became more productive once in a corporate environment. Those with patented discoveries were cited nine times more often as were their peers who had no patents or commercial connections (Zucker & Darby, 1996). It was suggested that the reason for this was because of the resources provided by the company, that additional funding was not required, allowing scientists to concentrate on generating research rather than raising capital. The main limitation of this study was that it failed to investigate other methods of communication other than publications. It did not investigate how academic scientists share information with other researchers or how difficult it is for non-industry academics to obtain information from industry. Rosenberg (1996b) took issue with this, pointing out that the behaviour documented by Zucker & Darby (1996) is a special case and will be short-lived and that the lack of communication in science as a result of commercialisation behaviours will escalate and impede scientific progress (Rosenberg, 1996a; Rosenberg, 1996b).

There is a traditional form of secrecy in science that is not related to commercialisation of science, in that scientists may hold back research results in order to maintain their scientific lead (Hilgartner, 2002). A question to be explored is, as a result of the increased competition due to increased emphasis of IP in science, has the general level of secrecy in science increased? Although Blumenthal and colleagues investigated secrecy as a result of high commercial involvement it was also evident from his studies that it occurred in non-commercially involved laboratories as well, for reasons such as protecting the lead or status of the researcher. Despite this, the sharing of data and information is discussed continually and commercial interests are always one of the reasons given for such secretive behaviour. But the question remains whether the level of communication has decreased as a result of increased IP involvement in science, especially in Australia where current government policy is encouraging research to become more commercially viable and to seek alternative funding avenues than the traditional government funded NHMRC/ARC grant system.

The effect of the increased emphasis on accountability within entrepreneurial universities and affiliated institutes on the publishing behaviour of scientists is therefore unsure. In particular, it is unclear whether the increased level of competition and emphasis on commercialisation and communication within organisations or research groups has induced scientists to change their publishing strategies and are now aiming to publish in higher impact journals in order to gain a higher level of visibility. There is some peripheral evidence to suggest that the academic revolution of universities and the rise of public accountability in science have affected the publishing behaviour and expectations of scientists and funding bodies alike (Glaser, Spurling et al, 2004). In particular, there are some studies that suggest that academic researchers who patent their findings generally publish at above average rates but are not the most published university scientists (Meyers, 2006). In addition, patenting may have a more durable and beneficial impact on publication rates for scientists with more than one patent (Breschi, Lissoni, & Mintobbio, 2005). Scientists boost their productivity by working on industrial technologies related to research applications (Franzoni, 2006; Franzoni & Lissoni, 2004). In addition, it has been observed that university/industry co-authored papers are cited more frequently than single university papers (Hicks & Hamilton, 1999).

2.5.2 The Evolution of the University Technology Transfer Office

Research groups have been described as 'quasi-firms' within these new entrepreneurial universities (Etzkowitz, 2003). For Etzkowitz (2003) there were only two options where this could happen. These options for universities wanting to promote more 'entrepreneurship' activities is to either separating academic and business activities; or integrating academic and business activities under common organisational missions. These options, however, lead to conflict and tension within an organization and to avoid this Etkowitz (2003) suggested four main approaches to the control or avoidance of conflicts of interest between academic and industrial science. These options were (1) prohibition of the activity, but an activity may be seen as too desirable to prohibit; (2) a requirement of disclosures, but disclosure may be too weak to be effective or does not end in controversy; (3) separation of activities; and (4) integration. An attempt, then, may be made to maintain a clear separation of activities or alternatively, the route of integration may be pursued. Etzkowitz (2003) clearly prefers the separation of activities. This is more clearly defined as the separation of the financial from the research interest by defining boundaries or creating structures that mediate between the two activities. Eztkowitz (2003) believes that a conflict of interest can be avoided by placing as much distance as possible between academic and commercial activities involved in the advancement of knowledge. This paper does outline a possible model for the 'integration approach' of combining research and commercial activities. However, the literature does heavily prefer the separation model to the integration model (Etzkowitz, 2003).

Etkowitz (2003), however, explored his 'exclusion of activities' option by analysing what he termed, 'research centres'. Research centres, exist outside the traditional university structure and were described as one of the many organisational forms that, along with incubator facilities and research parks, integrate university, industry and government into a triadic constellation that is a driving force for industrial and social innovation. The authors use a number of examples from American universities to explain what is meant by a 'centre' as opposed to a university department, institution and an organization, however no clear definition is ever made. What is made clear is the fact that, for the authors, centres enable universities to reconcile competing non-academic interests and to accommodate industrial and governmental representation that would be anathema in departments where it would be perceived as a threat to their autonomy. In this, the authors are able to describe the 'separation of activities' model that was put forward by Etzkowitz (2003). Centres that have been separated from the traditional university structures had little need for a formal technology-transfer office as companies and university researchers were free to interact within a centre. This activity could not happen, according to the authors, within a university because of the conflicts that might arise between academics and industry. Additionally, 'centres' gave companies immediate access to intellectual life within a university and companies gained a competitive advantage by cutting the usual time it took to learn about new research. Interestingly enough, there are claims that industry interaction within centres is different to that of universities because it eliminates that tension that occurs between academic autonomy and industry business.

The 'precise limits' of communication were being worked out within practice according to the authors. It is, however, the quotation from above, specifically 'you want to share with them but every time you say something you get back the answer... *'well no, I cannot tell you that'* that indicates that external 'centres' may be in need of a formal technology transfer office to help facilitate this communication whilst protecting the interests of the centre. Indeed, universities around the globe are now including the creation and commercialisation of intellectual property as one of their main objectives. This has been met with a great deal of hostility from those traditionalists that see obtaining intellectual property as contrary to the aims and purpose of the objective university sector and thereby a threat to the integrity of individual universities. Some critics believe entrepreneurialism should be resisted or at least encapsulated in a special class of institutions of higher learning, fearing that an intensive pecuniary interest will cause the university to lose its role as an independent critic of society. This thesis will show differently, however, that the creation and protection of intellectual property does not exclude a researcher's aim for public good, rather that it is a vital and recognised aim of a researcher.

The link between the establishment of internal BD and PR Offices and a change in the opinions of scientists is vague. However, it is suggested that the increasing entrepreneurialism of universities coupled with the change in government policy regarding the intellectual property of publicly funded research has stimulated proprietary activity within universities through the establishment of offices of technology transfer (Sampat, 2006; Shane, 2004). Indeed, Shane (2004) explains how central factors including the intellectual property policies of universities can be used to explain why some universities produce a relatively large number of spin-offs while others are less prolific in this area. University policies have been identified as crucial in establishing the new academic capitalism/entrepreneurial model in scientific research (Kunhardt, 2004; McSherry, 2001). There are, however, still some interesting questions to be asked, in particular to how these organisations have implemented these internal offices and how the scientists have adjusted their behaviour in response to this. From the higher education/social studies of science angle, Welsh, Glenna, Lacy, & Biscotti (2008) questioned how the universities play overlapping but different roles in society and question whether these roles might be compromised when the organisations increase interaction in particular ways. Additionally, the role these offices have in changing the culture norms and adjusting scientists' opinions towards commercialisation of science has also not been thoroughly investigated.

Finally, the question of how successful the offices are in adapting themselves to become part of the organisation is also an area of research that has received little attention. Whereas Thursby, Jensen, & Thursby (2001) found that the level of income generated by the university technology transfer offices was the direct measure of their success. This thesis, on the other hand, will identify the indirect successes of these offices in five participating medical research institutes in Australia.

2.6 Science Communication: Talking and Listening to the Public

Academia cannot accurately pinpoint the time when the awareness of science and its need for increased public communication began. However, in 1959, the problem of a 'separate science' was highlighted by the annual Reed lecture at Cambridge University by novelist and semi-retired scientist Charles Percy Snow. Snow identified an unbridgeable gap between two hostile branches of knowledge; the (natural) sciences and the humanities. He described them as two separate and even hostile cultures that 'live in different worlds and do not speak the same language'. Snow's speech of a sharply divided academic landscape and an almost unbridgeable gap gave rise to debates about poor scientific education and the lack of interest to communicate science to a general public (Snow, 1965). Snow could not have seen at the time that his 'two cultures' theory had laid the groundwork for a new, multi-disciplinary academic discipline and a change in emphasis of scientific knowledge.

Snow's description of two separate camps emphasised the need for increased communication across this 'gap', Snow argued that 'polarity and mutual ignorance led to reciprocal scorn: a profound inability to understand each other's disciplinary discourse resulted in disdain for the other's concerns'. According to Snow, increasing animosity between the two academic communities had turned literary intellectuals into natural 'Luddites'– ignorant and deeply distrustful of science and technology and hence emphasised that the main barrier facing science was not necessarily a lack of interest but a lack of understanding and therefore trust. Implied in Snow's argument for 'bridging the gap' between arts and sciences was the dire need to translate between scientific expert and lay communities (Kimball, 1994; Snow, 1965). His concern for scientific illiteracy and unbridgeable gaps was not restricted to academic communities of arts and humanities scholars but was, in effect, a much broader concern (Trilling, 1964). As long as these two groups failed to communicate on an equal footing, a professional group of translators was needed to mediate between the specialised lingo of scientists and a lay audience of virtual scientific illiterates. In short, the gap between scientists and non-scientists created a whole new government and industry-supported branch of 'translation' (Brockman, 1995; Snow, 1965). In academia, an entire field, known as Public Understanding of Science (PUS), emerged on the basis of Snow's modernist assumptions. For almost fifty years, the 'two cultures' paradigm has informed the research in science communication and still does to an extent. In a second edition of The Two Cultures, published in 1963, Snow added an essay 'The Two Cultures: A second look,' in which he optimistically suggested that a new culture, a 'third culture,' would emerge and close the communications gap between the literary intellectuals and the scientists (Brockman, 1995; Snow, 1965; Van Dijck, 2003). Aikenhead (2001) described the work of this 'third culture' as 'border crossing' where practitioners immersing themselves into this translation exercise would also be required to switch norms, switch values and switch language conceptualisations in order to communicate effectively (Aikenhead, 1996, 2001). Science communicators must be aware of the values and norms that are inherent in the conventions of science and to learn to view the results of science within this culture and interpret its consequences to a wider (mainly public) audience.

An interest in science communication and in the relationship between science and the public gained momentum with the publication of a Royal Society document in 1985, later known as the Bodmer Report. This report was named after Sir Walter Bodmer, who was the chair of a working party made up of scientists, politicians, sociologists and journalists. The Bodmer report is merited with raising the issue of the relationship between science and ordinary people and that of legitimising science communication (Pitrelli, 2003). The Bodmer report also institutionalised the Public Understanding of Science (PUS) movement and one of the outcomes was the establishment of a PUS committee known as CoPUS (Committee of the Public Understanding of Science). In addition the report stated that the reasons for promoting science communication were both individual and collective in nature as science itself would benefit from increased communication in the form of public favour new impetus and more substantial funding (Stein, 2003). However, the Bodmer report had its critics. The major criticism was that the advocates of PUS maintain that scientific knowledge is certain and fixed, and assume that science is a privileged perspective on the world and that the public is ignorant of science (Pitrelli, 2003). This view of science communication led to the construction of the 'top down' model of science communication. The 'top down' or 'deficit model' of science communication assumes that the flow of knowledge between science and the public moves one way only (Pitrelli, 2003). Communication activities, therefore, do not go by the needs or the competence of the public, but on the education and cognitive abilities they are 'alleged' to lack (Pitrelli, 2003). The PUS movement has made the mistake of paying too little attention to the importance of the sociology of science. Especially since sociology, the history of science and the philosophy of science showed that scientific establishment has turned into a social institution.

A report, the result of four focus workshops held in Europe in 2002-03 called 'who should communicate with the public and how?' examined the use of the 'deficit model' of communication in biotechnology. Participants including scientists, industrialists, government officials, ethicists, social scientists, public interest organizations and the media concluded that the 'deficit model' couldn't be successful as the particular nature; subject and circumstance of the biotechnology debate require broad dialogue (Bennet, 2003). With regard to biotechnology, there was a discrepancy between the benefits perceived and the concerns raised. This is despite information being available to the public concerning biotechnology in a variety of communication types such as seminars, workshops, flyers and websites. Despite many 'deficit model' examples of science communication, public opinion of biotechnology had not changed and the understanding of the processes remained very low. For example, to the statement 'ordinary tomatoes do not contain genes, while genetically modified tomatoes do', 35% gave the correct answer in 1996, in 2002 despite the above efforts, the percentage of people who gave the correct answer only increased by one percent. The 'deficit model' does not work as it assumes that acceptance of biotechnology is determined by the availability of information and that science communication is a one way process where the aim of communicating is to 'get the message across' rather than engaging the public with science dialogue and listening to their concerns (Bennet, 2003).

Other models emerged as a result. The 'engagement model' was based on the assumption that the 'deficit' model was based more on the interests of science than those of the public. The 'democratic model' of science communication is due to James Durant who noticed that there was a lack of public involvement in policy issues concerning science. However, in regard to the democratic model, there is a problem. Enabling the public to have the opportunity to engage continually in scientific issues requires the provision of sufficient background information, as in the cases of other political issues.

In 1993, a UK white paper 'Realising our Potential' from the Committee to Review the Contribution of Scientists and Engineers to the Public Understanding of Science, Engineering and Technology, known as the Wolfendale Report was submitted (Wolfendale, 1993). The purpose of the committee was to 'to review the steps currently being taken to equip and encourage professional scientists, engineers and research students to contribute to improved public understanding of science, engineering and technology, and to suggest how these might be improved consistent with available funding.' It recommended to build public understanding into research council grant procedures, providing training in science communication, creating incentives, including public understanding activities within the continuing education provision (Wolfendale, 1993). It suggested ways of continuing the momentum of public understanding by events and other measures, the role of COPUS, the commissioning of a 'best practice' guide by the Office of Science and Technology (Wolfendale, 1993). It also audited the current activities and recommended ways to encourage greater communication by scientists. The committee concluded that; 'In principle, all who receive grants from public funds should accept a responsibility to explain to the general public what the grant is enabling, or has enabled them, to do and why it is important and how it fits into the broader area of knowledge'(Wolfendale, 1993).

Wolfendale's (1993) main recommendation was to build public understanding of science into the Research Council's grant procedures. The five research councils, Particle Physics and Astronomy Research Council (PPARC), the Engineering and Physical Sciences Research Council (EPSRC), the Natural Environment Research Council (NERC), the

Medical Research Council (MRC) and the Biotechnology and Biological Sciences Research Council (BBSRC) have different types of public understanding of science strategies. These strategies include, communication skills training for scientists, school liaison officers, PhD students and the compulsory reporting of science communication activities by their grant holders. Unfortunately, Pearson (2001) reported that despite the increased importance of PUS for researchers in the UK, only a small percentage of research council funded scientists are involved in PUS (Pearson, 2001). This is despite research council grant applications requiring a declaration of how the research will be communicated to the public. The research council's response to the Wolfendale (1993) recommendation of making PUS an integral part of grant application and reporting has thus been limited, raising questions concerning the acceptance by scientists of the recommendations and the practicality of such expectations and procedures. Unfortunately, accurate reporting of any PUS activities within the research councils has been restricted by the inability to monitor large numbers of scientists within institutions (Pearson, 2001).

However, some scientists still argue that the Wolfendale recommendations go too far and that some science is too complex in theory and does not lend itself to public communication and that not all scientists would be proficient in PUS and that sometimes their involvement would prove counter-productive. The Wolfendale report does recognise that not all scientists will be equally skilled at communicating to a wider public, but it does emphasise the importance of making science accessible and that extreme cases of inability to provide this accessibility would likely be few. Some recommendations have suggested that, instead of making science communication activities compulsory for all, scientists with an aptitude for science communication should be identified and encouraged to participate. This would be particularly desirable especially if even after repeated training many researchers still prove ineffective communicators. Here it is important to stress that the purpose of science communication is not just about giving science a public face but to make it accessible. Different scientists may feel comfortable with different audiences and different styles of communication. Science communication must be defined according to the audience, as both traditional and modern expectations of communication are important in the scientific community.

A recent paper published in the prestigious Nature journal investigates the role of framing the scientific message and increasing the public's awareness of science (Bubela, Nibet, Borchelt, Brunger, Critchley, Einsiedel, Geller, Gupta, Hampel, Hyde-Lay, Jandciu, Jones, Kolopack, Lane, Lougheed, Nerlich, Ogbogu, O'Riordan, Ouelletter, Spear, Strauss, Thavaratnam, Willemse, & Caulfield, 2009). The authors define 'frames' as interpretative packages and storylines that help communicate why an issue might be a problem. Frames are used by lay publics as interpretive schemas to make sense of and discuss issues. Not all members of the public possess an interest in seeking scientific information and their lack of interest can frequently mean that they can avoid science media altogether, regardless of whether the information is accurately communicated or not. The paper recognises that when controversies surrounding science issues do occur that it is ignorance to blame for the public's opposition. The deficit model of science communication is ineffective as communicating through popular science outlets such as the media is too narrow and that knowledge is only one factor in an individual's decision making processes. Likewise, the deficit model also overlooks that the majority of media outlets through which science is communicated still only reach a minority of science enthusiasts who are by definition already knowledgeable and therefore an abundance of information is not likely to change their minds any further. Likewise with the engagement model of science, a variety of stakeholders can participate in a dialogue so that both points of views; public and scientific can inform research priorities and science policy. There are still advocates who argue that engagement activities happen too late and that effective engagement can only be achieved by moving it 'upstream' or to when science is in its formative stage thereby giving the public more valuable input and ownership over the science. In addition conflict can occur when the lay participant's recommendations reach collective decisions that go against the self-interests of scientists (Bubela et al., 2009).

The authors argue further that both the deficit and engagement models blame failures in science communication on inaccuracies in news coverage and the irrational beliefs of the public, but it ignores several realities about audiences and how they use the media to make sense of science. The paper divides the behaviour of the public towards information into three distinct characteristics. First, members of the public are naturally cognitive misers and therefore lack a motivation to pay close attention to science debates relying instead on mental shortcuts, values and emotions regardless of how knowledgeable they are about an issue. Second, individuals are drawn to news sources that confirm and reinforce these already held values and beliefs. This tendency is especially sensitive to slanted media outlets or sources. Finally, opinion leaders other than scientists (including politicians and religious leaders) have been successful in formulating their messages about science in a way that connects with key stakeholders and publics but at times might directly contradict scientific consensus or go against the interests of organised science. Therefore, the authors of this paper suggest that how a scientific message is framed is a more important concentration for future science communication, especially for science journalism. The public will therefore pay more attention to certain dimensions of a science debate over other depending on how a message is 'framed' (Bubela et al., 2009).

There is a growing awareness among science organisations that if they want to be more effective at using the media to communicate, they need to switch the 'frame' or interpretive lens by which they communicate about a scientific topic. How the internal PR office of a scientific organisation has not yet been investigated. Bubela et al. (2009) state that the framing on scientific information requires a delicate balance on the part of scientific organisations and that any reframing needs to remain true to the state of the underlying science. There is, currently, no research that investigates this phenomenon. The authors go further and state the current state of science communication, in particular the hype derived from errors of omission and framing, may already be leading to individual and social harm. This thesis will aim to provide the research necessary for further understanding of the role of internal PR offices in framing the message for public consumption whilst maintaining a strong relationship with the scientists within their organisation.

2.6.1 Models and Theories of Public Relations

The field of Public Relations (PR) has long been a separate consideration from science communication. Despite this there are many similarities between the models of science communication described above and the models of public relations to be described here. The models of PR share some similarities with the models of science communication and, in addition, science communication as a profession has always required practitioners to have some skills in PR. However what makes the models of public relations different is the identification of the roles of practitioners that work best under each model. The section will also explore the development of these roles and their relationship with the models of public relations and organisational change. This section will describe the background theories of public relations concentrating on discussing the models of Public Relations and research evaluating the effectiveness for different practices of public relations. In addition, this section will investigate the application of these models to different aspects of science, including, where possible, to scientific research organisations and scientists.

In most cases for Public Relations, there is a historical reason for establishing communication programs that have become entrenched in organisational structure, including the incidence of unfavourable media coverage at some point. To be successful and to be strategic, PR must ensure that everything done must be aligned with the corporate vision or mission of the organisation (Webster, 1990, p.18). PR makes organisations more effective by developing relations with stakeholders in the internal and external environment that constrain or enhance the ability of an organisation to accomplish its mission and fits squarely into the concept of strategic management. PR serves a different function to marketing and more importantly, PR cannot be excellent if it is subjugated to the marketing function. When an organisation makes public relations a marketing function, practitioners are reduced to the technician role and the organisation loses a valuable mechanism for managing its interdependence with its strategic publics (Grunig & Grunig, 1992).

Not all science communication researchers acknowledge the role of Public Relations in the public communication of science. Pitrelli (2008) warns that the combination of science communication with professional PR is runs counter to the aims of science communication. The increasing emphasis on public relations in scientific research institutes, according to Pitrelli (2008) reduces the transparency of science and scientists and therefore restricts public access and reduces the likelihood that a dialogue between science and the public will occur (Pitrelli, 2008). This conflict in particular will be investigated in this thesis.

2.6.1.1 The Four Models of Public Relations

Four models of public relations were initially identified (Grunig & Hunt, 1984). In addition two variables underlying the four models; direction and purpose were identified by Grunig & Hunt (1984). Direction described the extent to which the model is one way or two-way. One way communication disseminates information; it is a monologue. Two-way communication exchanges information and is therefore considered a dialogue. Purpose defines whether the model is asymmetrical or symmetrical. Asymmetrical communication is imbalanced; it leaves the organisation unchanged and tries to change the public. Symmetrical communication is balanced; it adjusts the relationship between the organisation and public (Grunig & Hunt, 1984).

Grunig (1976) took the idea of one-way and two-way models of communication but elaborated the idea to include the purpose of the communication as well as the direction. Thayer (1968) used concepts of synchronic and diachronic communication to describe two approaches to public relations. The purpose of synchronic communication, as Thayer (1968) explained it, is to 'synchronise' the behaviour of a public with that of the organisation so that the organisation can continue to behave in the way it wants without interference. The purpose of diachronic communication is to negotiate a state of affairs that benefits both the organisation and the public. There is concern, however, that the above models are too simplified to capture the reality of the public relations practice. Grunig & Hunt (1984) determined later that the terms synchronic and diachronic, which literally mean 'at one time' and 'at two times', did not describe accurately the difference in purpose he had in mind for the two kinds of public relations. He, instead, used the terms symmetrical and asymmetrical to describe the purpose of public relations as striving for balanced rather than unbalanced communication and effects.

The four models described in this section were initially categorised as follows:

- The Press Agentry model is a one way asymmetrical model;
- The Public Information model is a one way symmetrical model;
- The two-way asymmetrical; and
- The two way symmetrical models

The last two models were classified as their names indicate.

The Press Agentry model of PR is the most basic form of public relations, whereas the Public Information model of PR was developed as a reaction to attacks on large corporation and government agencies by journalists. Leaders of these organisations realised that they needed more than the propaganda of 'press agents' to counter the attacks on them in the media. Instead, they hired their own journalists as public relations practitioners to write press handouts explaining their actions. Although practitioners of the public information model generally chose to write only good things about their organisations, the information they did report generally was truthful and accurate. Both the press agentry and the public information models represent one-way approaches to public relations i.e. dissemination of information from organisation to public, usually through the media. The two-way symmetrical models, such as the Public Information model, were determined to be a way of manipulating the public for the benefit of the organisation. For this reason, the public information model was found to be especially strong in scientific organisations (Habbersett, 1983; Pollack, 1986).

The next stage of development of the models of public relations was based on behavioural and social sciences. This scientific approach to models of public relations revealed the two way model where practitioners both sought information from and fed information to the public and included the theories of propaganda, persuasion and the 'engineering of consent' (Olasky, 1987, 1989). This was therefore described as the first two way asymmetrical model of public relations (Grunig & Hunt, 1984). In addition, the assumptions of the two-way symmetrical model were identified by Grunig & Hunt (1984) as 'telling the truth', 'interpreting the client and public to one another,' and 'management understanding the viewpoints of employees and neighbours as well as employees and neighbours understanding the viewpoints of management.' The two-symmetrical model makes use of research and other forms of two way communication to constantly evolve within an organisation. Unlike the two-way asymmetrical model, however, it uses research to facilitate understanding and communication rather than to identify messages most likely to motivate or persuade publics. In the symmetrical model, understanding is the principal objective of public relations rather than persuasion. It is widely agreed by PR researchers that excellent PR departments employ the two-way symmetrical model.

The two-way symmetrical model of public relations argues that the purpose of public relations is not persuasion but instead is creating mutual understanding between an organisation and their publics. All symmetrical public relations provide a forum for dialogue and discussion. The two way symmetrical models additionally emphasise how both the organisation and the public eventually find ways of changing themselves in order to accommodate each other. Indeed, it was Pavlik (1989) who pointed out that organisations get the greatest reward from symmetrical public relations when opposing publics have power equal to that of the organization. Dozier (1989) took this argument further and stressed that the symmetrical model of public relations is the only model *'inherently consistent with the concept of social responsibility' (p5).*

In relation to science communication, a number of studies of scientific organisations have investigated the effectiveness of the different models of public relations in practice. A study of the Nuclear Regulatory Commission and of fundraising programs is higher education organisations found that the asymmetrical models of public relations within these organisations failed to contribute positively to either the organisation's role or the public interest (Childers, 1989; Kelly, 1989). Theus (1988) concluded that the more open and symmetrical an organisation's communication system, the less discrepancy in the news coverage as reported by journalists. Indeed, the study also found that science reporters strongly supported a set of symmetrical procedures for media relations (Habbersett, 1983). In addition, analysis of the concepts of 'knowledge of' and 'knowledge about' science in respect to the models of public relations practiced by a scientific organisation found that knowledge *of* science comes from within the science system and reinforces that system (Donohue, Tichenor, & Olien, 1973). Knowledge *about* science comes from outside the system and is more critical of it. Pollack (1986) found such correlations among these two types of knowledge and the four models of public relations. Valuing knowledge *of* science correlated with press agentry and public information whereas knowledge *about* science correlated with the two-way symmetrical model and the two-way asymmetrical model, but the latter correlation was not statistically significant.

The presence of public relations increases the effectiveness of organisations by managing the interdependence of the organisation with publics that restrict its autonomy (Grunig & Grunig, 1992). Organisations manage interdependence by building long term, stable relationships with those publics through a number of different activities. These different activities correlate with the different models of public relations. Grunig & Grunig (1992) found that the preparation of magazines and newsletters correlated positively with the public information model. In contrast, tours, open days and in-house events correlated positively with the two way symmetrical models but negatively with the Public Information and Press Agentry models. Of particular interest, marketing activities in hospitals correlated positively with the two way asymmetrical and symmetrical models but negatively with the public information model. Fundraising in hospital settings, in contrast, correlated with the two-way asymmetrical model of public relations. Despite this research, it is generally agreed that the two-way symmetrical model of public relations is the preferred model as it increases the benefit for both the organisation and its public.

2.6.2 The Roles of Public Relations Practitioners

By drawing on business and consulting literature the first descriptions of the differing roles of public relations practitioners emerged. Broom & Smith (1979) identified three separate practitioner roles. The first role, the communication facilitator role acts as the 'go-between' that facilitates communication between the organisation and their publics. Another way this role was described was as the interpreter and communication links (Newsom & Scott, 1976, p.22). This role is related to the public information model and the two-way symmetrical models of public relations of (Grunig & Hunt, 1984). The second role was labelled the 'problem solving process facilitator' and like the name suggests, plays an important role in aiding management to solve problems in a progressive manner. This role is essential in organisations that practice the two way symmetrical models of public relations (Grunig & Hunt, 1984). The final practitioner role described by Broom & Smith (1979) was that of the communication technician. This role is important for providing technical expertise related to the practice of communication from their organisations and are hence nicknamed the 'journalists in residence'. These practitioners are specifically hired away from newspapers and broadcast media as a result of their communication skills and mass media experience

(Broom & Smith, 1979). Practitioners in this role are essential in organisations where the press agentry/publicity and public information models are practiced. In addition, practitioners in organisations practicing the press agentry and public information models of public relations will engage in few activities that define the public relations manager role. Practitioners in organisations practicing the two-way asymmetric and two-way symmetric models of public relations are more likely to play the public relations manager role. This is especially true of associations and scientific organisations. Problem solving process facilitation, expert prescription or communication facilitation are of little value in organisations following a publicity/press agentry or public information model. These one-way models generate messages by organisations for distribution to publics. Publicity/press agentry model organisations spread favourable propaganda about the organisation with only moderate regard for information accuracy. Public information model organisations disseminate information with traditional journalistic concerns for objectivity and accuracy and do not require practitioners to enact the manager role but instead emphasises the need for technicians.

In contrast, Ferguson (1979) identified several more roles in the public relations office within organisations. These roles were drawn not from organisational behaviour but from the concept of role norms. By surveying members of the professional organisations for public relations in the US, Ferguson (1979) identified eight role norm factors which included the problem solver manager, the journalist-technical communicator, the researcher, the staff manager, the good-will ambassador, the meeting organiser, the personnel-industrial relations and the public community relations role norms. These factors were determined to be too complex by Dozier (1984) and the common elements were reduced to reveal four common factors that differed immensely from Broom & Smith (1979) original three practitioner roles. Dozier (1984) public relations manager; public relations technician; and the minor roles media relations specialist; and communication liaison were developed using factor analysis and are currently the main roles described in modern public relations. The public relations managers are held accountable for the outcomes of the organisation's public relations program. Their other main role is to facilitate communication between management and the organisations' publics. The other major role, that of the public relations technician does not participate in management decision making but is important in generating the products of public relations and implementing the policy decisions made by other Media relations specialists, the first of the minor roles, specialise in external media relations rather than internal communication production. The final role, that of communication liaison, specialises in linking communications between management and key publics but is not involved in management decisions or policy making. Finally, all roles can be further divided into two major roles, the communication managers and the technicians.

This thesis provides evidence of a link between these models of public relations and science communication that may be useful for organisations wishing to establish excellent and effective internal PR Offices that consider modern science communication principles. Such a link has not been made previously, despite the PR models being used to describe government, private and industrial scientific organisations.

2.7 Changes in Publishing Behaviour: JIF Prediction and Gaining Attention in Science

Bibliometrics has recently become a more sophisticated avenue of investigation. Of particular interest for this thesis is the area of bibliometric research that is attempting to characterise the publishing behaviour of scientists and research groups. Additionally, bibliometric researchers are interested in examining how manipulating these behaviours, can result in higher citation rates and a higher level of impact for scientific research through publication in academic journals.

The intended effect of politicising research metrics in national evaluation frameworks is to create competition amongst organisations of higher learning and research thereby increasing their efficiency. This aim can have inadvertent consequences on the science system itself (Weingart, 2005); however, there is little empirical evidence supporting any negative effects on the behaviour of scientists but there are still a large number of scientists who warn against the evaluative culture of science. Furthermore, too little is known about the nature of citations either positive, negative or perfunctory (Case & Higgins, 2000; Cronin & Pearson, 1990). The application of citation indicators has to be based on the conviction emerging from a number of studies that, given sufficiently large numbers, different motives for citing an article will neutralise each other. The effects of this growing evaluative culture within science was investigated by Weingart (2005) who stressed that concerns about the validity and reliability of bibliometric measures are all negligible as long as they remain research tools. They become of high political significance once these measures are implemented as indicators on which distributive decisions are based, that is, if they obtain a status as tools of policy making. He stated that as soon as these bibliometric tools are incorporated into the decision making about grants allocation, scientists will react by altering their behaviours. This change in behaviour is intentional by government funding bodies. For example, the link between citation measures to the allocation of funds is supposed to encourage a researcher to engage in more competitive publication routines to increase their publication activities and publish their papers in high impact factor journals

(Weingart, 2005). Accordingly, scientists are adjusting their behaviour in order to best position themselves to obtain this desirable, high impact publishing. Ethnographic studies show that scientists do react to non-epistemic influences (Glaser et al., 2004, p.16) and what is true for individuals is also true for institutes. Institutes can implement strategies that will guide their scientists to high impact publishing, increased research funding and therefore increased prestige for the institute.

One Australian study investigated how government funding policies based on the number of publications affected the research output of universities. A financial incentive from the government was allocated to universities to reward high impact publication. However, though the number of publications increased, the quality (as measured by the JIF) decreased and this, in turn, negatively affected Australia's overall publication output. The authors of the paper stated that *'with no attempt made to differentiate between quality, visibility or impact of the different journal when funding is allocated, there is little incentive to strive for publication in a prestigious journal'* (Butler, 2003, p.41).

With this in mind, it can be assumed that if the funding culture of science rewards quality of publishing output, then scientists will aim to meet these measures by changing their publishing aims and behaviours. The basis of this study's quantitative research is the reward maximisation model of publishing. The reward maximisation model is based on an assumption that scientists have a rational and self-seeking behaviour; when reporting the findings of their research, scientists seek to maximise the benefits to be accrued from publishing (Luukkonen, 1992). Ravetz (1971) outlined that a paper appearing in a journal of high prestige has a much better chance of attracting attention than one in a journal of low prestige. The 'better' journal will be more widely distributed, it will be scanned more carefully by active scientists and a paper in the 'better' journal will be given a greater initial credit for quality. The reward maximisation model assumes that 'reward' or the recognition by qualified peers as the basis of extrinsic reward is the primary consideration of scientists when choosing where to publish their research (Luukkonen, 1992). This model, however, can be in some cases considered problematic as a scientist's publishing behaviour is motivated by a combination of different factors of which 'reward maximisation' is only one. Gordon (1984) tested this theory using surveys of biochemists and found that journals were primarily selected in the basis of what they offered in terms of 'communication' maximisation rather than the reward. Little support was found for the suggestion that rejected authors work their way down a pecking order of journals in their discipline until acceptance is secured. Instead, studies have shown that both the prestige and visibility of the journal, and whether the journal covers a large section of the intended readership are equally important publishing criteria irrespective of the field of research. However, there are some issues with this conclusion; first, when Gordon (1984) paper was published, science wasn't as competitive and funds were not based as strongly on the basis of a publication's 'visibility' and 'quality' as it is currently within the 'evaluative state' described in Glaser et al. (2004). In addition, reward maximisation has different meanings when the question is considered in quantitative and qualitative terms. The slogan 'publish or perish' assumes that the quantity of publications is decisive for a successful publication performance. Despite this, however, a number of studies attempting to create a mathematical guide for scientists to use when deciding where to publish have been quite successful in the economics field (Oster, 1980). Oster (1980) devised the optimal strategy for submitting manuscripts in economics that was, like this study, based on the reward maximisation model. In addition some researchers have suggested that such a model would be advantageous for scientists who are unsure of the best channel to publish and called for a service, based on the reward maximisation model of scientific publishing, to help authors select journals for publications (Kochen & Tagliacozzo, 1974).

There are a number of methods that can be used by scientists to gain more attention towards their research. One basic method is to publish in high impact journals. Publishing in high impact journals has been associated with a number of specific scientific behaviours of which, when understood can help scientists achieve higher impact publishing. One of the more significant observations has been in relation to collaboration with the number of authors per paper and the incidence of group authorship significantly rising in specific disciplines over the last 80 years (Weeks, Wallace, & Surott Kimberley, 2004). Indeed, a study of journal articles published in the Lancet, found that highly cited articles had 15-20 times the average number of authors per article when compared to lowly cited articles in the same journal (Kostoff, 2007).

A high level of collaboration can also reflect the level of interdisciplinary of a particular article, thereby allowing the paper to be distributed further through more distinct academic communities, potentially gathering more citations. Multidisciplinary science has been found to be more highly cited and found in higher impact journals (Levitt & Thelwall, 2008a). In addition, there is evidence that applied fields of research are increasing more rapidly than basic or 'pure' fields of research (Zsindely, 2008). Further, the more research fields being incorporated in a paper, the larger the data and research displayed. Certainly Yitzhaki (1994) observed a significant interaction between the JIF and the length of the title of a paper and multi-authored and multi institutional papers have been found to gain higher citations in Molecular Biology (Yitzhaki, 1994, 2002).

Within this topic of higher levels of collaboration, a number of papers that have investigated the changing trends of multiple authorship of publications (Gordon, 1980). It has been found that collaboration or 'teamwork in science' spans university and national boundaries and, in fact, collaborating with an author from a top university is associated with a larger number of citations (Jones, Wuchty, & Uzzi, 2008). This investigation of 4.2 million papers over 30 years, found that not only are multi-university collaborations the fastest growing type of authorship structure but also produce the highest impact papers when they include a top-tier university. Within the science and engineering fields it was found that single author papers are in decline over the period 1975-2005 with an increase in 'between-university' collaborations. Interestingly enough, such collaborations were found to have a citation advantage, with a higher probability that a paper with multi university collaborations receives above average citations (Jones et al., 2008). In addition, when the US universities participating in these multi university collaborations were divided into Tiers, with Tier 1 being the highest performing university, it was found that cross tier collaboration may follow a 'strongest partner' rather than a 'weakest partner' model. That is, collaboration between Tier 1 universities will help the performance of Tier 4 universities more than association with Tier 4 will bring down the Tier 1 universities (Jones et al., 2008). Kulkarni et al. (2007) found that group authorship on a paper increased that paper's annual citations by 11.1 cites.

Papers declaring industry funding with industry-favouring results was also associated with higher annual rates of citations (Kulkarni et al., 2007). Indeed, declaring industry funding was found to increase citations by an average of 21.7. The field of research can also have an effect on the total number of citations a paper attracts and the JIF of the publishing journal. Journal articles published on cardiovascular medicine or oncology were found to achieve on average 12.6-13.3 more citations when compared to other medical fields. This was confirmed by a study by Kostoff (2007) which investigated the differences between lowly and highly cited articles that appear in the Lancet. Over a three year period it was found that these highly cited articles shared a number of similar characteristics, including a large number of authors, references, abstract words and journal pages. Achieving a greater number of citations was found for articles published in the fields of breast cancer, diabetes, coronary circulations and HIV immune system properties (Kostoff, 2007). Larger sample sizes were also found to be associated with higher levels of annual citations. Kulkarni et al. (2007) also stated at the end of this study that the results outlined in his paper should be made available to the medical community so that scientists could use the results to ensure that their papers had a greater impact. In addition, Aksnes (2003) found that big teams, international collaboration, reviews, higher impact journals and papers that age slowly all contribute to bigger citation rates.

Another, more recently controversial method of increasing the citations of an article is by encouraging authors and their institutes to publish in an open access journal (Norris, Oppenheim, & Rowland, 2008). Open access articles achieved a significantly higher mean number of citations when compared to toll-access articles. Apparently, this is because it is common practice for scientists to self-archive their better work and because some articles are made available as preprints before publication, they have a longer period in which to attract citations (Norris et al., 2008). In addition, a strong association was found between single authored papers being toll-access, (over 60% were toll access articles) lending further evidence to the citation advantages of large collaborations and open access publishing. Furthermore, Piwowar, Day, & Fridsma (2007) found that cancer clinical trials which share data, through publishing in open access journals, were cited about 70% more frequently than clinical trials that do not. This result also held for articles published in lower impact journals and is thus relevant to authors of all trials. While altruism was postulated to play a part in the motivation of authors, studies have found that an additional reason authors choose to publish in open-access journals is that they do believe their articles will be cited more frequently (Eysenbach, 2007; Swan & Brown, 2004). This finding also suggests that scientists are both capable and willing to manipulate their behaviour in order to achieve a higher impact publishing and a greater number of citations. Finally, factors such as the reputation of the author and journal have also been associated with higher level of visibility in science. These two factors, combined with the 'state of un-citedness' of an article, as an indication of the assessment by the scientific community of an idea, were found to play an important role in an article's recognition. However, out of these three factors, the reputation of the publishing journal played the most important role in increasing the citations an article receives. In particular, articles published in core journals receive considerably more citations than articles in second-tier journals. The speed with which knowledge disseminated lies far higher in the core journals than in the journals with less visibility and less reputations (van Dalen & Henkens, 2005).

In summary, there are a number of different scientific behaviours associated with high impact publishing and achieving a large number of citations. The next section will outline how the JIF will be used as a measure of the visibility of a scientist and their research for the purpose of my study.

2.7.1 JIF as a Measure of Scientific Visibility

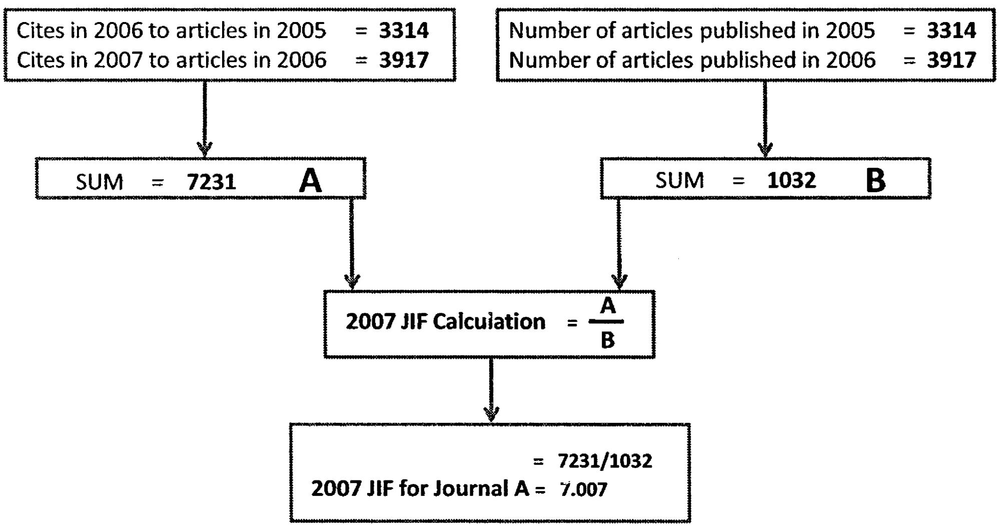
Citations reflect the 'quality' of the paper, the visibility of the journal with which the article appears and, in some cases, the researchers themselves. How a scientist behaves towards achieving the elusive high impact factor journal publication is largely unexplored and is centred on proving or disproving the reward maximization model. Previous research, despite providing valuable information about the characteristics of highly cited research and researchers, has still not provided evidence about how scientists manipulate their behaviour in order to achieve higher impact publishing and therefore become more competitive in an increasingly competitive funding environment. This thesis will provide some evidence in order to better understand this question and will also attempt to relate such behaviour to the increased need for public accountability and the presence of the internal offices at their affiliated research institutes.

Impact is not the same as importance or significance. However this section will make a case for using the JIF as a reliable measure of the *visibility* of a scientist and their research. There is no specific correlation between the numbers of papers published by an individual and the quality or importance of his work, though Price (1963) has indicated that scientists who produce work of high quality usually have a high publication rate (De Solla Price, 1963). Indeed Garfield (1963) maintained that citation counts were adequate for measuring the impact of a scientist's work. For example, he showed that using the SCI, the 1962 and the 1963 Nobel Prize laureates in science received more citations to the work they published prior to receipt of the prize than the average cited author (Bayer, 1966; Garfield, 1963).

The SCI does still have its fair share of critics particularly among scientists who were sceptical about the use of bibliometrics measures of impact or quality. Many critics could highlight examples of highly cited papers or individuals who received a large number of citations for new methods or techniques that everyone in the scientific area would reference regardless of whether it had a significant impact on their work (Hansson, 2002). Other examples included the Nobel laureate who had relatively few citations compared to less eminent scientific authors, the fact that in most scientific papers he is the most 'important' author in a collaborative work was usually mentioned at the end of an author sequence (Sparkes, 1972). In addition the existence of 'negative citations', where a scientist's work is referenced in order to criticise it, is also used to downplay the value of bibliometrics and the impact factor in evaluating scientific research. Franck (1999) stated that scientists with the largest bibliometric scores would not always be the best scientists as there are always ways to accumulate citations that have little to do with scientific value (Franck, 1999).

Despite the controversy, the calculation of the Journal Impact Factor (JIF) is actually valid. Figure 2.2 demonstrates how to calculate the 2007 JIF for an imagined journal. The JIF is calculated by dividing the number of citations in a given year (eg, 2007) to all articles published in the preceding 2 years (2005-2006) by the number of 'source' articles published in the same 2 years (Cartwright & McGhee, 2005). The JIF is, therefore, a calculation of the number of times an average article in a specific journal will be sited within the 2-year time period.

Figure 2.2 Calculation of the Journal Impact Factor (JIF) for Journal A



I argue in this study that the JIF is also a tool for analysing the level of visibility achieved by a scientist and their institute. Unfortunately, the misuse of the JIF has resulted in distrust from the scientific community. However, when used properly, JIF can be a reliable tool to describe the spread of scientific information within the scientific community, especially in relation to the visibility of scientists and their institutes to which they belong. Garfield (2005) himself explained the meaning of 'impact', emphasising that a citation indicates an article has influenced someone and therefore, the more often an article is cited, the greater its influence on the scientific community. In this thesis, the JIF is used not to compare quality of science but rather in comparing knowledge that has been distributed amongst the scientific community with higher JIF achieving a greater level of visibility in the scientific community. It is not unreasonable to assume that scientists themselves would aim to publish in the highest impact journals possible considering recent changes in the funding allocation guidelines of the Australian Government. With this in mind by comparing *Nature* to the

Journal of Biological Chemistry (JBC), since *Nature* has a higher JIF than JBC we conclude that an article in Nature not only has a higher probability of high visibility of research but that a scientist will aim to publish in *Nature* first, only settling on JBC after rejection from *Nature.* This assumption is in line with the reward maximisation theory of scientific publishing.

Therefore, many of the criticisms of the use of JIF do not apply when used for the analysis of the visibility of a scientist, their research or their institute. Many factors that are said to bias the Impact Factor, such as language preference of the SCI database, negative citations, citing behaviour across subjects, possibility of exertion of influence from journal editors and online availability of journals, are not relevant when investigating visibility in science as each bias still means that the author of that paper and the editor of that journal has read and used that paper and has cited it accordingly.

Unfortunately the citation index and its list of journals is not normalised for fields of science and significant differences in the JIF of different fields of research are commonly observed. Citation rates in medical research fields, such as immunology, are influenced by the number of people working in it and the speed in which the field progresses. It is therefore a field that receives more citations per article and the field specific journals generally have a higher impact factor than astronomy. More 'trendy' or popular fields of study such as Genetics and Immunology are generally cited more and published in higher impact journals than, for example, Neuroscience. This bias was acknowledged in all bibliometric analyses presented in this thesis by controlling for the field of research (See Chapter 3: General Methods for more information).

Finally, research metrics and in particular the JIF are increasingly being used by government and other funding agencies to evaluate individual scientists, institutes and fields to determine the allocation of funding. In Australia, research metrics and the JIF have formed the basis of a number of different attempts of establishing a national framework with which to evaluate publicly funded research and researchers. These aim to ensure that the resources provided to carry out research are directed to areas of research excellence and the impacts and benefits that result from the public's investment in that research. The Australian Government, aims to create a clear rationale for examining the quality and impact of publically funded research in order to direct funds to the areas with the highest potential for success in a global market and further develop Australia's innovation base.

With the competition for research funding increasing, it makes sense for scientists and their affiliated institutes to aim to maximise their competitiveness and potential to receive grant funding by increasingly publishing in higher impact journals. By doing this, scientists and institutes are able to gain a higher level of visibility of their research.

2.8 Summary and Unresolved Issues

Science is a culture. It operates with its own set of rules and norms that are inherent to science and the scientists. A scientist is a product of the environment in which he works and likewise his environment affects his work, but what if that environment changes? What if external pressures alter the way in which a scientist is expected to operate? What structures are put in place by the institutes in order to assist scientists to operate in an often competitive academic environment and how successful are these structures? These questions will be the focus of this thesis. The culture of science has been bombarded with new pressures that will affect the way it operates. In particular, the rise in public accountability in science and how it manifests itself through increased pressure to communicate and commercialise research. Scientific research institutes have attempted to adapt their structures in order to position their scientists best to address these new public accountability pressures. This chapter has outlined a number of important points with which to frame this thesis, the most important of which will be summarised here.

The pressure for science to adapt to these new expectations has also contributed to the development of new scientific movements and academic disciplines. All this suggests that science has the ability to adapt to a change in the environment in which it works. This study will concentrate on two of these environmental changes; the need to communicate and the increased emphasis on commercial application of research, and will analyse how the scientists and the scientific research institutes have adapted themselves to accommodate this new and important social contract for science. Science may have its own norms but on an institute level the effect of external influences on changing the motivations of the scientists is largely unknown.

The models of public relations are similar in structure to those of science communication; however they have not yet been combined in order to study its infiltration scientific research organisations. Pitrelli (2008) stated that the combination of science communication with professional public relations is detrimental to the goal of greater transparency and accessibility of science and scientists. He labels the increasing reliance of scientists on public relations to formulate and frame the scientific message as the privatisation of science communication and therefore against the aims of engagement between science and the community. However, recent changes in the funding structure and the sometimes hostile reception from the public towards science means that the presence of public relations practitioners is becoming increasingly important for scientists and their institutes. How these offices have evolved to accommodate the needs of scientists has not previously been investigated. In addition, how scientists view and interact with these professional offices and through them, the public, is also largely unknown.

The internal BD Office through commercialisation is also a component of public accountability that will be explored in this thesis. Previous research has stated that combining the commercial interests with the academic interests of science will emphasise tensions between the scientific and commercial interests of science. It is therefore recommended that these two aspects of scientific research be kept separate in order to avoid tension (Etzkowitz, 2003). The participating institutes in this study support a combination of the integration and separation models with which to compare their effectiveness and scientific level. There have been a number of investigations of the effects of external pressures such as commercialisation on the progress and practice of science but there has been no attempt to examine the effects of such pressures on the scientific organisations and on scientific publishing output. Most studies about academic capitalism have focused on analysing the whole university or the smaller, individual research groups. However, none have studied the semi-private/public research institute and how they have adapted to the rise in public accountability in science such as the scientific institute. Scientific research institutes are different from universities as they are significantly smaller and grouped around a common discipline and business goal. Institutes balance the academic/business divide and never fully integrate with either side. In addition, as neither solely research or business organisations, maintaining a positive public 'image' is still particularly important to research institutes. The evolution and current effectiveness of PR and BD under these unique institutional structures has also not previously been investigated in studies of academic revolutions.

In addition and in addendum to the main argument of this thesis, I will present supplementary quantitative data to investigate how the presence of these offices, combined with the increasing competition in science, has changed the publishing behaviour of scientists within our five medical research institutes. The JIF is used in this study as a measure of visibility, where achieving publication in high impact journals also means achieving a higher level of visibility for the scientist, their research and their affiliated institute. High impact publishing is made even more desirable by the use of the JIF and other associated metrics for the determination of the allocation of government research funding. Despite the increased pressure on scientists to achieve high impact publishing and therefore a higher level of visibility of their research, there is currently no empirical study investigating how external influences has affected scientific publishing output. It is important to mention here that this study does not reject the problems with the JIF but also recognises that a JIF number is inappropriate for judging the quality of a piece of research. It is however, a measure that scientists eagerly take into account in relation to their research funding and promotion. By using the JIF as a dependant variable in this study, I am not evaluating researchers or institutes in relation to their publishing output. I do, however, use the JIF to acknowledge that the increasing use of quantitative indicators to influence funding and promotion has changed the way that researchers and institutes view scientific publishing. In addition, I use the JIF to measure how scientists have changed their publishing objectives in response to an ever increasingly competitive environment for research funding - especially considering that government funding is increasingly determined by metrics including the JIF.

My task is therefore to analyse the extent to which these external pressures have changed the publishing behaviour of the scientists within our five medical research institutes in relation to where they publish their research. As a result of the increase in the evaluative culture of science, I assume that scientists follow the reward maximisation model of scientific publishing and aim for higher impact journals in which to publish their research.

The current state of science and technology policy in Australia provides an ideal environment in which to study these phenomena. The time period studied in this thesis, 1999-2005, is particularly important for studying the effects of commercialisation and communication on scientific research institutes as the first BAA policy program was implemented in 1999 and renewed in 2004. This policy provided, for the first time, government pressure on scientists to communicate and commercialise their work as part of science's contract with society. No study, however, has investigated how the implementation of this policy has changed the way in which scientists and scientific research institutes operate.

Although comparisons of NPK in the Australian context has not been previously examined, from the information presented in this section as well as the description of characteristics of Mode 2, a number of parallels can be drawn. In particular, the characteristics of reflexivity and context of application are important in reference to the introduction of BAA in 1999 and its re-introduction in 2004. On both occasions, the research environment changed to reflect and incorporate these two characteristics by the government policy's new emphasis on the accountability of research. Though it can be argued that some scientists and fields, were never in Mode 1, this change in government policy and, ultimately, funding allocation (Glaser & Spurling, 2004), stimulated changes in the research environment would have been felt acutely by scientists and by institutes. The aim of this thesis is to analyse how research institutes have evolved to adapt to the requirements of this new environment which incorporate at least two of the characteristics of Gibbons et al (1999) and Nowotny et al (2001) Mode 2 theory of knowledge production.

In this thesis, I combine research concerning science communication, public relations, entrepreneurialism and the academic revolutions to present one of the first empirical investigations of how changes in the academic landscape have changed the nature and function of Australian Medical Research Institutes. In addition, by using a combination of interview data and bibliometrics, I analyse changes that scientists have made to their behaviour under these organisational structures. Finally, I attempt to provide a comprehensive picture of how medical research institutes have undergone a structural evolution in order to accommodate the recent increased emphasis in public accountability.

Chapter 3: General Methods

3.1 Introduction

This Chapter outlines and discusses the methodology used in this study. As has been outlined in Chapter 1 and 2 of this thesis, there has been a limited amount of empirical studies investigating the influence of communication and commercialisation on the practice of science. There is even less evidence about the effect of the increase level in public accountability on scientific output.

The object of the methodology described in this chapter was to collect information regarding the relationship between the scientists and the internal and external PR and BD offices in the five participating medical research institutes. In order to investigate this further, qualitative methodology was employed by conducting interviews with the internal office staff and the institute's scientists. These methods were used to answer the following two main research questions outlined below.

The third, and separate, research question refers to the quantitative bibliometric techniques used to investigate how the public demand for scientific accountability, competition and the presence of the internal offices may affect publishing behaviour. These methods are described, along with the results, in Appendix III.

Research Question 1

What are the responsibilities and communication strategies of the internal PR and BD Offices within Australian Medical Research Institutes?

Research Question 2

How do the scientists in these institutes view the role of these Offices and more broadly, communication and commercialisation, in their research?

The third research question refers to the quantitative analysis presented in Appendix III. This appendix is separate from the main argument in the thesis and aimed to validate the assertions by the interviewees in Chapters 4 and 5.

Research Question 3

Has there been any change in scientists' publishing behaviour as a result of the increased level of public accountability in science and/or the introduction of these internal Offices?

To fully understand the aims of the management, office staff and scientists, a short history of each institute is included in this chapter. In particular, these histories outline the motivations behind establishing the internal BD and PR offices.

This study aims to separately understand the structures and processes within each institute in relation to communication and commercialisation in science. The general aim of the methodological design was to be able to translate the results of the study for an interested lay communication audience as well as a professional scientific audience.

3.2 Participating Institutes

Eight institutions were contacted and invited to participate in this study. Letters were initially sent to the Directors of each institute requesting their participation in the study. Unfortunately, simply sending letters to the directors of the institutions was not sufficient to attract their involvement. If the initial letters received no reply, the second option was to contact the internal Public Relations and/or Communications Office of each institute in order to attract their support for the aims of the project. This method proved more successful with 5 of the 10 contacted institutes agreeing to take part in the project. The final lists of the participating institutes are;

- The John Curtin School of Medical Research (JCSMR);
- The Walter and Eliza Hall Institute (WEHI)
- The Garvan Institute of Medical Research (GARVAN);
- The Prince of Wales Medical Research Institute (POWMRI); and
- The Queensland Institute of Medical Research (QIMR)

The histories of the participating medical research institutes are included below to help frame the interview data collected from the institute's internal office staff and scientists.

3.2.1 The John Curtin School of Medical Research

The Australian National University was created by an act of Parliament in 1946. It was to be a research only university and consist of four research schools including The John Curtin School of Medical Research (Porter, 1985).

The origins of the John Curtin School of Medical Research are associated with one main event in Australian history; the aim of the wartime Commonwealth government to establish a national research university that would encourage talented scholars to remain in Australia. 'The idea of a national medical research school was the joint idea of the then Prime Minister of Australia, Mr John Curtin, and Nobel Prize winning Australian expatriate, Professor Howard Florey, who eventually became the first unofficial Director of the John Curtin School of Medical Research.'. Unfortunately, due to the delay in completion of the building and his reluctance to leave his position at Oxford University, Florey resigned as Advisor in 1955. He did however, oversee the recruitment of the first professors; Arnold Hughes Ennor (Biochemistry), Adrien Albert (Medicinal Chemistry), Frank Fenner (Microbiology) and John Eccles (Physiology and one of the founding fathers of The Australian Academy of Science in 1954) (Porter, 1985). Research in the school continued in temporary buildings before moving into the new building in 1957 (Fenner, 1971).

The school has received many honours including three Nobel Prizes. Howard Florey was awarded the 1945 Nobel Prize for Physiology or Medicine for his discovery and production of penicillin. In 1963, one of JCSMR's original Professors, Professor John Eccles, Professor of Physiology, won the Nobel Prize for Physiology or Medicine for his investigation of the ionic mechanisms underlying excitation and inhibition in the mammalian spinal cord. More recently, in 1996 scientists Peter Doherty and Rolf Zinkernagel were awarded the Nobel Prize for Physiology or Medicine for their work on MHC restriction. Other notable scientists associated with the JCSMR include; Professor Frank Fenner, past Director, who led the World Health Organization in the eradication of small-pox and Professor Gordon Ada, who was then the Head of the Department and Microbiology and a renowned immunologist and vaccinologist (Lafferty, 1995). Both professors remain as visiting fellows at the JCSMR today.

The John Curtin School of Medical Research remained block-funded until 2001. Under the block-funded scheme, JCSMR researchers were unable to compete for grants from the country's two main science funding agencies, the National Health and Medical Research Council (NHMRC) and the Australian Research Council (ARC). Block-funding was seen as an impediment to growth and was also said to inhibit collaboration between scientists, since institute researchers could not hold grants with investigators from outside their institution. In 1998 the Commonwealth Government White Paper of Tertiary Education and the Health and Medical Research Strategic Review titled "The Virtuous Cycle" were produced. These reviews recommended changes that included a more centralised control of research funds and the effect on JCSMR was substantial with the scientists in the school having to compete against other Australian medical researchers for NHMRC and ARC funding. In order to have access to NHMRC and ARC competitive funding schemes however, the school lost 20% of its block funds, which were divided between NHMRC schemes and Department of Education, Science and Training's (DEST now DIISR) infrastructure development pool. In 1992, the school opposed the idea of separating the JCSMR from the ANU and establishing it as an independent medical research institute (Lafferty, 1995).

Public relations at JCSMR began in 1980 when Professor Robert Porter was appointed as the Director of the school. One of the main innovations that Porter introduced was the production of comprehensive annual reports. These annual reports were to contain information concerning JCSMR's research and scientific work, publications, support staff and a report by the Director reflecting on the achievements of the school during the last 12 months. Porter also highlighted the need for public relations with the establishment of the Florey Museum in the school, which allowed the public to view the work that the JCSMR had done and was conducting and the introduction of school Open Days (Lafferty, 1995).

In charge of editing the report was Peter Jeffery, a scientist in the Department of Physical Biochemistry. Jeffery continued to edit the annual reports until 1992, when he assumed the more formal position of Academic Assistant to the Director and acted as chairman of the public relations committee of the school. In 1992 Jeffery's responsibilities were extended to include writing and editing, publicizing the achievements of the school and facilitating relationships with the community (Lafferty, 1995).

3.2.2 The Walter and Eliza Hall Institute

The Walter and Eliza Hall Institute was Australia's first Medical Research Institute established in 1916 from a trust established by the family of Eliza and Walter Russel Hall (Nossal, 1985b). After Walter Hall's death, his widow, Eliza Hall, established the 'Walter and Eliza Hall Trust' stipulating that the income from the trust would be used for *'the relief of poverty, the advancement of education, the advancement of religion in accordance with the tenets of the Church of England and the general benefit of the community'*. Dr Harry Allen first suggested that the trust money should be used to create the Walter and Eliza Hall Institute for the Melbourne Hospital. It was proposed that the Trust would provide 2,500 pounds per year to the institute and would be controlled by a board comprising representatives of the trust, University and the Hospital. It was agreed that for the institute to be successful it needed to be 'intimately associated' with the work of a large hospital (Nossal, 1985b).

World War I significantly delayed the establishment of the WEHI. Two days after a board meeting to appoint the Institute's first director, Dr Gordon C. Mathison, the ANZACs landed at Gallipoli and the proposed Director was fatally wounded (Nossal, 1985a). It was considered unwise to appoint a permanent staff during World War I as many servicemen were overseas but in 1916 Sir Harry Allen, as the Dean of the Melbourne University Medical School, was installed as Honorary Director of the Institute. Dr Allen worked closely with Casey to ensure that a small portion of the Trust's income (2500 pounds) would be used to fund the Institute. In 1919, Dr S.W Patterson became the first full time Director of the Walter and Eliza Hall Institute and started appointing staff to equip the laboratories. In 1923, Dr Patterson retired and was replaced by Dr C.H. Kellaway (Hobbins & Winkel, 2007; Marchalonis, 1994; Metcalf, 1996; Nossal, 1985b).

The 'Kellaway era' was critical in establishing the Hall Institute as a focal point of Australian Medical research by establishing an endowment fund for the Institute. He also established the first three departments in the WEHI: the Departments for Physiology, Pharmacology, Biochemistry and Bacteriology. He launched the Institute as the main focus for research in virology and immunology (Hobbins & Winkel, 2007). With the establishment of the National Health and Medical Research Council in 1937, the Institute was well placed as being the best Medical Research Institute in the country and therefore able to take advantage of the new funding body with a higher proportion of its grants being awarded to the Institute than any other organization in Australia (Silverstein, 2008). Kellaway was not only a renowned scientist but also was supported by one Australia's most famous scientists, Frank Macfarlane Burnett (Hobbins & Winkel, 2007).

Burnet became the Director of the Institute in 1944. At that time, WEHI moved with the Hospital to its present premises in Parkville, opposite the University of Melbourne. Burnet also appointed Ian. J. Wood to head a Clinical Research Institute. This brought the Institute fully into the world of clinical research and allowed it to span the full spectrum of fundamental to applied science (Marchalonis, 1994).

Unlike Kellaway, Burnet held the opinion that if Australia were to make a significant contribution to the world scene, heavy concentration on and around a particular theme was required. During his directorship therefore, the Institute focused mainly on studying viruses, in particular, influenza. In the late 1950's the field of virology was moving towards a more molecular biological orientation and in response to this Burnet increased the Institute's involvement in immunology. In 1957, Burnet formulated his famous Clonal Selection Theory for Antibody Formation which would eventually win him The Nobel Prize for Medicine and Physiology in 1960 (Marchalonis, 1994).

When Gustav Nossal was appointed Director in 1965, he faced two major challenges. First, the Institute was badly under-equipped and under-financed and second, its staff had a narrow skills base. There was no immunochemistry, no molecular biology, very little cell biology, virtually no modern tissue culture facilities and no embryology apart from chicken studies. The Director's tasks, therefore was to raise more money and to broaden the skills and techniques of personnel available in the Institute so that the research questions could be explored in greater depth. In response to this, a cancer unit was established (Nossal, 1995). In 1965, 81 people worked at the Institute with an expenditure of $360 000 per year and an endowment of $400 000. Twenty years later, the Institute had grown to employ 220 people with an annual expenditure of $8.5 million and an endowment of over $10 million

(Marchalonis, 1994). In 1996 Professor Suzanne Cory succeeded Prof Gustav Nossal as Director of the Institute.

Like the John Curtin School of Medical Research, the Walter and Eliza Hall Institute was block-funded until 2001. The introduction of these changes enabled the Institute to compete for ARC and NHMRC grants against the other scientific research institutes in Australia.

The WEHI and the JCSMR share a unique relationship where the WEHI provided many distinguished scientists to JCSMR including Professor Frank Fenner, Norma McArthur and Professor Gordon Ada. In addition, when the JCSMR was being built, the WEHI provided hospitality to the ANU's new Institute while the JCSMR building was constructed. However, when the plan for the JCSMR was proposed there was concern that JCSMR's establishment would be detrimental to smaller institutes like the WEHI. The eradication of the government's block-funding program changed that with scientists at each institute being judged by their scientific success rather than their affiliation. However, since the establishment of JCSMR, the two institutes have maintained an informal relationship.

3.2.3 The Garvan Institute of Medical Research

The Garvan Institute for Medical Research (Garvan) is the result of funds raised in the 1957 Centenary Appeal of St Vincent's Hospital. The aim was to establish a St Vincent's Medical Research Institute but the name Garvan was chosen after the brothers James Patrick Garvan, a former treasurer in the New South Wales Parliament in the 1880s and the founder of the MLC insurance company and Sir Jospeh Garvan, the first Chairman of the Board of the Commonwealth Bank (Shine, 1996).

The Institute initially functioned as a hospital research department becoming a centre of excellence for endocrine research under the direction of Professor Leslie Lazarus. The Garvan Research Foundation was established in 1981 as a fundraising and public relations arm of the Institute (Shine, 1996).

In 1984, the NSW Parliament passed the Garvan Institute of Medical Research Act, a special Act that incorporated the Garvan Institute as an individual entity with affiliation with the St Vincent's Hospital and the University of New South Wales. Like many institutes in Australia at that time, the Garvan had to struggle with limited resources. Being new and relatively small, it was absolutely dependent on NHMRC funding, clinical service activity and community donations. However, in 1996, after an international review, the Garvan was awarded a National Health and Medical Research Council (NHMRC) block grant (Shine, 1996).

From the beginning, Garvan has had a strong corporate focus. The members of the Board were particularly influential in providing the Garvan with access to the corporate world even when the culture of corporate support for medical research was not very well established. However, through the work of its board members, Garvan became recognised as a valuable medical research asset for NSW and Sydney, a recognition that would prove valuable for ongoing community, corporate and government support (Fleming, Vitale, & West, 2006).

At the beginning of the 1990's, Garvan's research included programs in diabetes and metabolism, breast cancer, osteoporosis and neurobiology (Shine, 1996). One of the biggest catalysts in the history of the Garvan Institute was the appointment of Professor John Shine as Director of the Institute. Professor Shine came from a strong traditional science background at the Australian National University but also a strong background in commercialisation of science having previously directed a biotechnology company, California Biotechnology Inc, now Scios. Under his direction, the Garvan has been involved with some major industry initiatives including the Co-operative Research Centre for Biopharmaceutical Research, the development of a joint venture (Aza Pty Ltd) with Eli Lilly Australia to foster research in diabetes and osteoporosis and a partnership in obesity research with Bristol-Myers Squibb (Fleming et al., 2006).

The current Garvan building was made possible by a large infrastructure grant from the NSW government in 1994. The building was completed in 1997 and it was hoped that it would facilitate interaction between different projects and foster collaboration and a feeling of belonging to a large institute (Shine, 1996).

Throughout its development, the Garvan has maintained a close relationship with St Vincent's Hospital. Presently, Garvan research is divided into three themes; Genes and Diseases, Fundamental Body Systems and Clinical Contributions. The Victor Chang Cardiac Research Institute, another institute that emerged from the hospital, occupies a floor in the Garvan Building. Several other St Vincent Hospital research groups also occupy space within the Garvan building. This arrangement not only ensures the effectiveness of smaller research groups but also reinforces the relationship of Garvan research and clinical applications (*The Garvan Institute for Medical Research www.garvan.org.au*, 2009).

3.2.4 The Prince of Wales Medical Research Institute

The Prince of Wales Medical Research Institute (POWMRI) is located in the grounds of The Prince of Wales Hospital in Randwick in the former Randwick Chest Hospital. The

Randwick Chest Hospital was an independently run facility operated by the NSW Department of Public Health primarily for the screening and treatment of tuberculosis. As the tuberculosis epidemic subsided, the building's original purpose was no longer relevant and in 1991, the Prince of Wales Medical Research Institute was established (Fenner, 1985; POWMRI, 2009).

Professor Ian McCloskey, Professor David Burke, Professor Simon Gandevia and Professor Erica Potter established POWMRI. Professor Ian McCloskey became the Institute's first Director with Professor Gandevia as Deputy Director (POWMRI, 2009).

POWMRI is a specialised institution for Neuroscience, a centre for excellence in research into the functions and disorders of the brain and nervous system. The original hospital wards were converted into specialised laboratories using funds supplied by the NSW and Federal governments. The Institute was officially opened by the Commonwealth Minister for Health, Senator Graham Richardson and the NSW Minister for Health, The Honourable Ron Phillips on the 8th November 1993. POWMRI Limited was registered as a public company limited by guarantee under the Corporations Law of NSW on 4th August 1993. POWMRI is an independent non-profit company that recruits researchers who bring their own salaries as components of peer reviewed research grants and other funding types including Cooperative Research Centres (POWMRI, 2009). The Institute grew rapidly to include a unique Spinal Injuries Research Centre which was opened in November 2000.

A relatively new institute, POWMRI has strong formal affiliations with the South Eastern Sydney Area Health Service and the University of New South Wales and is involved in the training the University's postgraduate medical science students. Both organizations are represented on the POWMRI board of directors (POWMRI, 2009).

All research work is conducted on the premises and includes work on nerve regeneration, neuropathology and human autonomic and sensi-motor function. The Institute has a strong clinical focus with collaborations and consulting conducted at the spinal injuries centres at both the Prince Henry and Royal North Shore Hospitals. The Institute is also home to Australia's largest brain bank. It is one of the world's largest brain banks where invaluable resources of bequeathed brains of patients with a range of conditions under study are held, together with complete clinical records of the patients themselves. The Institute is now considered the largest institute specialising in research on the functions and disorders of the brain and nervous system.

A significant change in the history of POWMRI was the appointment of its second Director, Professor Peter Schofield, on 5th July 2004. Professor Schofield is an eminent academic neuroscientist with experience with working with the biotechnology industry in the US and in Germany (POWMRI, 2009).

3.2.5 The Queensland Institute of Medical Research

The Queensland Institute of Medical Research was established in 1945 by Dr Edward Holbrook Derrick who was an early Director of the Queensland State Health Department Laboratory of Microbiology and Pathology. The *Queensland Institute of Medical Research Act* was passed by the Queensland Government in 1945 (Derrick, 1972). It was intended that the research at the Institute would be devoted to basic research as the most effective way of tackling a range of diseases prevalent in Queensland at the time (Derrick, 1972). The QIMR Act of 1945 listed the following areas of research (Table 3.2.5)

Table 3.2.5:
Description of research areas as outlined in the QIMR Act (1945)

	AREA DESCRIPTION
1	Queensland fevers, including 'Q' fever, scrub typhus and leptospirosis
2	Lead poisoning, problems of diagnosis and after effects, and particularly as affecting the health and well being of children of the State
3	Virus diseases, presence of pathogenic viruses, particularly in relation to children
4	The effect on health of industrial processes and industrial diseases generally
5	The incidence of disease in relation to social and nutritional status
6	The incidence of disease in relation to geographical districts and climatic influences in Queensland
7	Certain tropical diseases in North Queensland

The original QIMR building was located in a temporary hut in Victoria Park, Brisbane. The Institute remained in these buildings for 30 years. In 1977, the Institute moved to its permanent buildings at the Royal Brisbane Hospital (Kidson, 1985).

The first director of this new Institute was Dr Ian M Mackerras, an entomologist who during the First World War was largely responsible for the malaria control work of the Australian Army. Edward Derrick succeeded Ian Mackerras as Director in 1961. It was the combined aims of these two directors that shaped the direction of research at QIMR for its first 30 years, cementing its international reputation as a leading institute for research into tropical infectious diseases, especially Q fever, scrub typhus, Ross river virus and the biology of the Epstein-Barr virus (Powell, 1996).

In 1977, the QIMR moved to a new building on the campus of the Royal Brisbane Hospital. The following year the Institute had a change of directorship and Professor Chev Kidson assumed the role. This was fortunate as science was expanding and Prof Kidson brought experience of his background in Biochemistry and Molecular Biology which saw an important reorientation of research objectives and new initiatives. These initiatives, while building on the strengths of QIMR's history focused the available expertise more sharply on cancer and infectious disease. Kidson had a pronounced effect on QIMR, doubling the staff size. He made appointments in epidemiology and molecular parasitology in order to build more diverse research areas and developing a sharper relationship with the University of Queensland and the Queensland University of Technology (Kidson, 1985).

In late 1985, a federal review of research and education requirements for public and tropical health in Australia prompted the establishment of a Public Health Education and Research Program at the Institute. The institute was one of nine in Australia to participate in this program. It resulted in the outcome of five new research programs established as joint initiatives of QIMR and The University of Queensland. In 1988, amendments to the QIMR Act converted the Institute to a statutory authority and as a result QIMR became highly competitive with other academic institutions in attracting world-class researchers (Powell, 1996). By this time the Institute had moved again into a new purpose built building on the Hospital campus called the Bancroft Centre (Boreham, 1991).

In 1993, the Institute was appointed coordinating partner for the Cooperative Research Centre (CRC) for Vaccine Technology. What followed was the QIMR's involvement in a variety of government initiatives including the CRC for Diagnostic Technologies, the CRC for Human Gene Discovery, the CRC for Aboriginal Health and the Australian Centre for International and Tropical Health (QIMR, 2009).

The Public Relations office was established in 1994 to increase the awareness and heighten the profile of QIMR and to raise vital funds for ongoing research, which has been extremely successful. In 2000, the size of the Institute has grown to over 400 and under the leadership of their new Director, Prof Michael Good, expanded into a new building, the Clive Berghofer Cancer Research Centre (CBCRC). The CBCRC was purpose built to enable the Institute to perform early stage clinical trials alongside molecular biology and epidemiological research (QIMR, 2009).

A Business Development Executive was appointed in 2001 to lead the Institute's commercial agenda. In 2002, Q Pharm Pty Ltd, a joint venture between QIMR and the University of Queensland designed a Phase 1 Clinical Trials Facility to test potential new human therapeutic products. The QIMR also hosts an Indigenous Health Program along with holding equity in the spin off companies, Q-Gen Pty Ltd, Vaccine Solutions, Replikun Biotech Pty Ltd and Adipogen Pty Ltd (QIMR, 2009).

3.3 Ethics

Any research involving humans is required to be approved by a Human Research Ethics Committee under The National Statement on Ethical Conduct in Human Research (2007). The ANU Human Research Ethics Committee approved this study under protocol number

2005/144. In accordance with the ethics protocol, all participants interviewed completed a consent form and was provided with an information sheet about the research. All interview data was de-identified with participants only identified by their affiliated institute, field of research and a reference number.

3.4 Interviews

This qualitative aspect of the research was concerned with personal accounts of attitudes, beliefs, interpretations, motivations and behaviour of the office professionals and the scientists within each participating institute. More importantly, it was concerned with how scientists and the staff of the internal PR and BD offices interact with each other and how the two groups of professionals interact to further the aims and missions on the institute. The reliability of qualitative data is sometimes flawed because of the difficulty of replicating the research. In order to assess the reliability, it is necessary to document the research procedure so that the reader can find details on how and why decisions were made in the research procedure and how the information was collected and analysed (Minichiello, Aroni, Timewell, & Alexander, 1990, p.212). The following sections will outline the strategies used by the researcher to analyse the data and will outline the triangulation method used during the interviews with the internal BD and PR office professionals, the scientists and the bibliometric analysis, presented separately in Appendix III.

For this study, semi-structured interviews were used as the main type of qualitative data and employed specific interviewing techniques. Formal interviewing is more discernable from participant observations as it represents a distinct setting and this helps the interviewer to remain in control of the interview's progress. Another method an interviewer can use to remain in control of the interview is to enter the interview fully prepared and briefed about their participant. In order to achieve this, a copy of the participants' curriculum vitae (C.V) was requested. This information not only provided the interviewer with valuable information to prepare for the interview including the type of research in which the participants were involved and if they had engaged in any commercialisation. Information regarding their involvement in commercialisation was essential in order to structure each interview according to the participant's experience. The C.V of each participant also provided information about the participants' work history, education, community activities and most importantly, their publication record. Scientists use their C.V as a marketing tool in order to attract funding and career advancement opportunities. The C.V was particularly useful is classifying the participating scientist's research and by also listing involvement in all types of communication activities. It was therefore an excellent tool for collecting and classifying information about a scientist's career. The aim of conducting the interviews was therefore two-fold. Scientists rarely consider science communication as an item worthy of listing on their C.V and the definition of what constitutes science communication can differ between scientists and between the scientist and the interviewer. With this in mind, an interview with a set of questions about science communication involvement as determined by the interviewer was advantageous as the information would be compared between participants.

The interviews of the scientists were semi-structured and were framed around the main concerns described in the literature about the role of communication and commercialisation in science. The structure of the interview is represented in the flow chart in Figure 3.1A. Despite the interview plan outlined in Figure 3.1B, participants were allowed to continue with a thought and allowed to take control of the interview as they wished. This allowed the discussion to flow in a way that seemed natural for the participants. Additionally, this natural flow of the interview allowed the interview, like any other social interaction, to be structured by both the participant and myself and this is an essential aspect of interviewing (Hammersley & Atkinson, 2007).

Figure 3.1A
Flowchart of the interview questions. The interviews were not required to follow this chart however the chart was used to ensure that all points of interest were covered during the interviews as well as to help during the transcription and analysis.

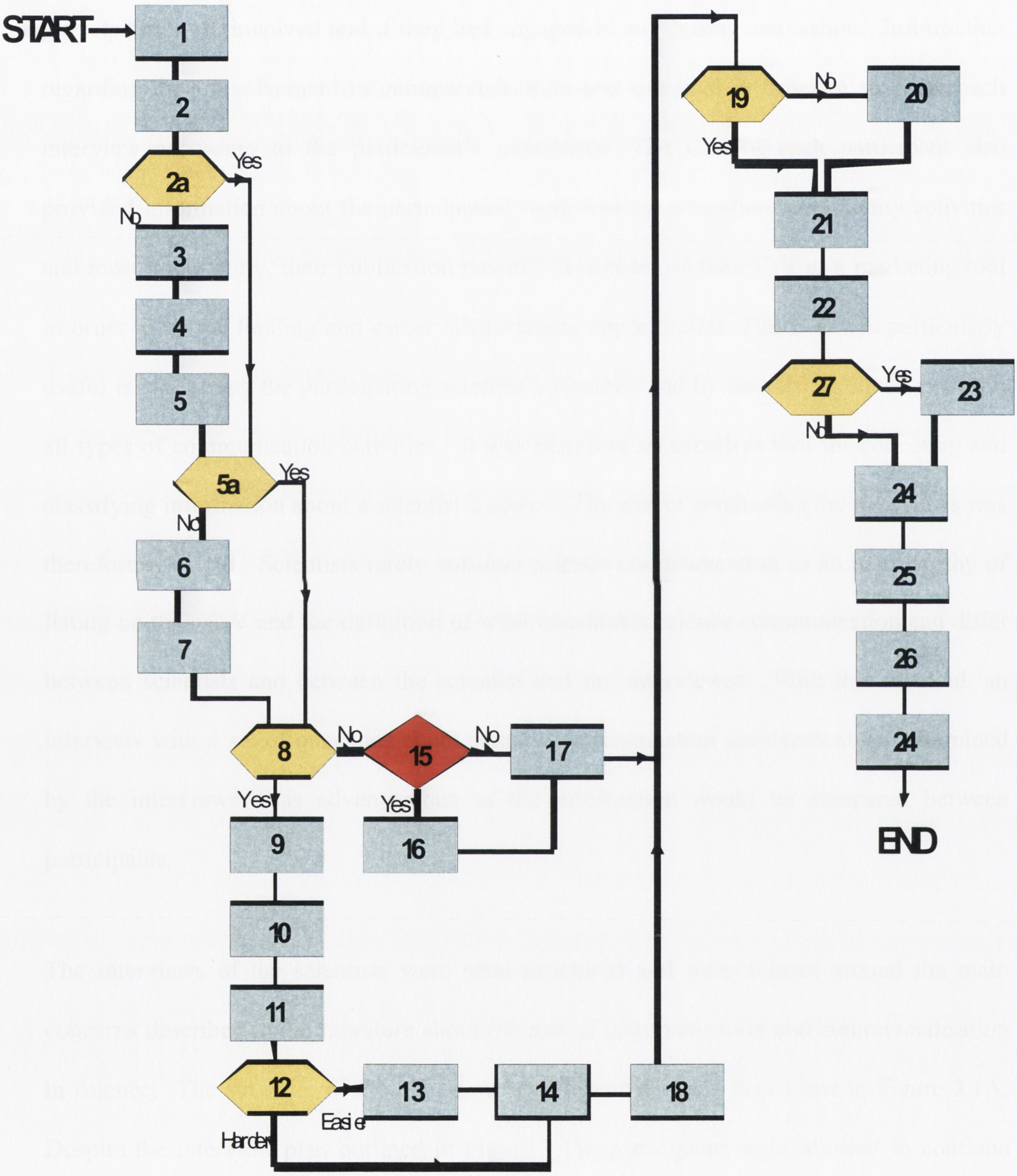


Figure 3.1B
List of interview questions and corresponding flowchart numbers in order for the questions to be identified within the flowchart illustrated in

Number	Question
1	Tell me about your science career. Why did you become a scientist?
2	How do you think the nature of science and scientific practice has changed since you started you career?
2a	Did you think when you started your career that Science Communication would play a large part?
4	In what ways has Science Communication been an important aspect of your career?
5	What do you think is the role of Science Communication in the future?
5a	Did you think when you started your career that Commercialisation would play a large part?
6	Do you think there has been an increased emphasis in commercialisation in science? How?
7	What do you think is the role of commercialisation of science for the future?
8	Have you had experience with commercialisation?
9	Tell me about you experience with commercialisation of your research. What were the high and the low points?
10	Did you encounter any barriers to communicating your research? What were they? How did they restrict your communication?
11	Did communication resulting from your commercialised research promote your research and you as a scientist?
12	Was it easier or harder to communicate your research that head been commercialised?

13	How?
14	How do your commercial partners view your need to communicate?
15	Would you ever consider a commercial application to your work?
16	What would you hope to gain from the commercialisation?
17	What do you think are the disadvantages of commercialisation?
18	What did you hope to gain from commercialisation?
19	Do you think that commercial involvement in science affects how scientists communicate? Examples?
20	Why/Why not?
21	Have you ever experienced restricted access to information or methodology due to commercial or competitive reasons? Examples?
22	Have you ever withheld information or access to methodology for commercial or competitive reasons? Why is this? Use examples.
23	Do you think that student's expectation of what a science career will bring them is different to how you pictured your career at that stage? How?
25	What, in your opinion, is the 'ideal' model for science communication in the future?
26	How successful do you see your institution in communicating your research? What works and needs to be done?
27	Are you involved in a lot of postgraduate research?
24	Please describe what you consider to be the main successes of your research?

Despite the obvious advantages of interviews progressing like conversations, Hammersley & Atkinson (1983) warn against the interview becoming too much like conversations and warn the researcher of being unprepared. The way in which I addressed this concern of ill-preparation has been described earlier in relation to the structure of the questions and the collection of the participant's C.V.

There is also an acknowledged problem about relating perspectives elicited in interviews to actions in other settings (Hargreaves, 1977). However, Hammersley & Atkinson (1983) suggest that the distinctiveness of the interview setting can be viewed as a resource rather than a problem. For this reason, all interviews were conducted in person, within the scientists' affiliated institute. Interviewing participants on their own territory and allowing them to organise the context the way they wish is the best strategy for ethnographical interviewing. It allows them to relax more that they would in less familiar surroundings and it may also provide insight into their sense of themselves and of their world and social setting (Herzog, 2005).

The interviewer will often need to work at building rapport with the interviewee. Measor (1985) outlines the importance of sharing interests and experiences as a tool to building rapport and facilitating the interview process. In addition, Ryan (2006) discusses the disclosure of personal information about the interviewer as an important method to use to build rapport. The necessary level of disclosure creates a relationship that facilitated open and honest dialogue between the participant and the researcher. These were some of the techniques used during the interviews and at sites of participant observations that were employed in an attempt to build this rapport with the participants.

Knorr-Cetina (1999) stated that conducting interviews within the scientist's environment was particularly important. In her study and in other ethnographical accounts of science the scientific laboratory is seen as a social construct where science and knowledge is formed (Latour & Woolgar, 1979). Different settings are likely to induce or constrain talk of particular kinds of information (Hammersley & Atkinson, 1983, p.125) and it is therefore important to consider this when considering the location of the interview. In addition interview data, like any other, must be interpreted against the background of the context in which they were produced (Hammersley & Atkinson, 1983, p.126). In relation to this thesis, all interviews were conducted in person, within the scientist's home institute. This was additionally advantageous as face-to-face interviews generally result in higher response rates and better quality data than telephone interviews (Aquillo, 1992). It also affirmed that the interview would be confidential and allowed the interviewee to feel comfortable and refer to particular examples within the institute's environment with which to frame their responses to certain themes of questions. In addition, the time I spent around the institute by participating in institute activities, helped further frame the structure of the interviews and their analysis as well as build rapport with the institute staff and scientists. The major advantages of conducting interviews in person and whilst being present within the institute, was their adaptability and the opportunity to obtain more information and clarify vague statements.

All interviews were recorded so that they may be transcribed and then reviewed at a later date. A sample interview is provided at the end of this thesis in Appendix II. I took handwritten notes during and after every interview in order to identify common and important themes between interviews and institutes. In addition, I kept a fieldwork journal with thoughts and reflections on the actions within each institute were kept. This fieldwork journal proved invaluable when conducting and analysing the interview data. All transcribed interviews were then hand-coded using the handwritten notes as a basis for the coding themes that were used during this part of the interview analysis.

Each institute was initially analysed separately in relation to the interview data from the Office professionals and scientists in order to further understand the institute-specific themes. The themes identified in the interviews were then compared across fields independent of institute-affiliation of the scientists. Strong and reoccurring themes that had been identified in the previous stages of analysis were then analysed further to test their levels of validity and reliability. In all scientific studies, the reliability and validity of the study is particularly important. This is difficult to do in qualitative studies, especially interviews. However, if the interviewer wishes to claim that these are the respondent's true opinions, they should collect evidence that all similar respondents share the same understanding of the topic. This is known as a construct validity claim. The construct validity claim for this study was to ask a set of similar questions of both the Scientists and the Officers; by achieving this, the researcher was able to gain different perspectives on the similar experiences and opinions of both the scientists and office staff. In addition, the interviewer can also establish whether the respondents are stating their true opinion by determining whether they express similar opinions on other measures of the same content (Gall, Borg, & Gall, 1996). Both these techniques for ensuring reliability and validity were implemented when designing and undertaking the interviews. Similarly the introduction remarks, basic interview questions and concluding remarks were kept similar so to expose all respondents to similarly themed questions.

3.4.1 Office Professionals

In total, 12 office professionals were interviewed from the five participating institutes. Each Office professional was contacted requesting an interview. All interviews were conducted in person and during my visit to the particular institute. This also meant that the interviews of the office professionals were done at the same time as the interviews of the scientists which allowed me to explore institutional policy issues as they arose. Unfortunately, not every institution had the same number of professionals in each Office. JCSMR, in particular, does not support an internal commercialisation (BD) Office and this was taken into consideration when analysing the results. Similarly, the internal PR Office at QIMR is considerable larger than at other institutes, this too was taken into account when analysing the results. Particular care, however, was taken to conduct interviews with a number of support staff in order to understand completely the function of each individual Office.

The interview questions for the office professionals differed from the set of questions prepared for the scientists; however there were many similarities in the topics covered during these interviews. By combining these topics, particular themes identified in the interviews with the scientists could be checked with the office professionals and explored further. Despite these similar themes, the interviews with the office professionals were less structured than the Scientists interviews and this therefore allowed the interview to progress more like a conversation with a particular research agenda to be covered and in such a way that remains true to the original aims of the thesis.

3.4.2 Scientists

The 82 participating scientists for this study were selected by initially contacting the PR Office of each particular institute and asking them to nominate scientists they thought would be most appropriate for the aims and objectives of the study. Once the names and contact details of the interested scientists were received from the internal PR Office, I proceeded to contact each participant and arrange an interview as well as receiving a copy of their C.V (explained above). All participating scientists were Laboratory heads, which ensured that every participant had managerial level experience. In addition, all were recipients of at least one government funded grant from the ARC or NHMRC and had, at some time, completed their PhDs and at least their first post doctoral positions. The number of grants and amount of experience varied with each scientist but all participants satisfied the above criteria and belonged to one of the participating institutes described above. All scientists were then classified into one of thirteen different fields (described below) in order to aid comparison of opinions between different fields.

For the purposes of the interviews with scientists, communication was defined as any activity undertaken by a scientist to impart their research to another body and is not restricted to communication to non-scientific bodies. In addition, commercialisation was defined as any activity undertaken by a scientist in collaboration with industry, business and/or any other active non-scientific research partner. Scientists were also allowed to alter the definition of both terms as it related to their research, role, experience and opinion. During the analysis of the interview data, I remained aware that individual meanings could vary and was careful to ensure that the individual (scientist) meaning of communication and commercialisation was not lost during this stage.

3.4.2.1 Field Classification

Each scientist has been codified by a notation that relates to their affiliated institute and a identification number. In addition, scientists were further classified into their field of research in order to draw comparisons within and between research fields. Each scientist's field classification is provided after their quote, next to the identification number in brackets. A list of the different fields of research classifications is given below in Table.5.2.2.

Table 3.4.2.1
Field Classification and Definitions used in the Interview Data Presented in Chapter 5

Abbreviation	Field Classification Definition
CHD	Cancer and Haematology (Including Cancer Research)
DNG	Neurobiology (Neuroscience)
IMM	Immunology (Basic Immunology)
MBD	Molecular Biology (Basic Moloecular Biology)
EPI	Epidemiology
INF	Infection and Immunity (Infectious Diseases, Vaccines)
GBI	Genetics and Bioinformatics (Basic Genetics and Bioinformatics)
ATD	Autoimmunity and Transplantation (Asthma, Diabetes)
JPS	Joint Proteomics (WEHI Specific)
HBP	High Blood Pressure
MGC	Molecular Genetics of Cancer (Including Applied Genetics)
SBD	Structural Biology
OTHER	Other Miscellaneous Research Areas

3.6 Triangulation

Triangulation is defined as the checking of inferences drawn from one set of data sources by collecting data from others (Campbell & Fiske, 1959; Webb, Campbell, Schwartz, & Sechrest, 1966). Two methods of triangulation were used in this study. The first was in regards to respondent triangulation, or data source triangulation, which involves the comparison of data relating to the same phenomenon but deriving from different phases of the fieldwork, different points in time or account of different participants differentially located in the setting. This type of triangulation was employed in the current study by the comparison of the themes discussed in the interviews of the Office professionals with the Scientist interviews. Besides providing a validity check, these comparisons gave added depth to the description of the social meaning involved in a setting. Finally, it allowed the collection of data surrounding the opinion of certain Institutional policies in regards to publishing, competition, commercialisation and communication in science from different sources. These comparisons helped identify the major themes that are investigated in this thesis.

Method source triangulation, when the data produced by different data collection techniques are compared, was employed in an analysis adjacent to the main argument of this research (Hammersley & Atkinson, 1983). In particular, many of the issues explored in the interviews are investigated further using a bibliometric analysis of the publication output from each institute and across fields. This data is presented as supplementary information in Appendix III. The aim of this supplementary information was to investigate the validity of the issues described by the scientists and office professionals about changes in scientific publishing behaviour by triangulating the interview data with a bibliometric analysis.

The main concern is that there are different methods and sources of information involved and discrepant epistemological or ontological assumptions, so the data they produce is difficult to be compared fairly. However, the nature of the different sources of data should always be kept in mind so as not to assume validity and that a healthy level of scientific scepticism is essential for the accurate and fair analysis of data.

3.7 Limitations of Study Design

A number of limitations must be acknowledged due to the unique combination of qualitative and quantitative methods employed in the current study. The first limitation relates to the selection of informants. Achieving a representative sample is not the primary concern in this research, especially when the primary concern is with eliciting information rather than with documenting perspectives. The aim is therefore focused on targeting people who have the knowledge desired and who will be willing to divulge it to me. For this reason, in this study, only laboratory heads and senior scientists were interviewed formally. The study would have benefitted from interviewing PhD students and laboratory assistants as well as more time spent at the participating institute. However, since the research questions focused on changes over time in science in regards to communication and commercialisation, the choice of senior scientists and laboratory heads was justified. It was therefore decided that PhD students and other related scientific personnel might not have enough experience to drawn upon in answer to the interview questions and themes surrounding the role of communication and commercialisation in science.

Only three out of the five participating institutes supported internal BD Offices. This study would have benefitted from including data from representatives from the external BD Offices of the remaining two institutes. This would have no doubt benefitted the investigation of the research questions and unearthed further boundaries worthy of discussion. However, the original research aims were to investigate the evolution of public accountability within the research institutes. Therefore investigating influences external to the central organisational culture would have compromised the results.

This thesis would also have benefitted from the employment of a full ethnographic research framework. There were significant time constraints, however, related to a full ethnographic investigation of all five participating institutes and so this method was not pursued. In addition, the risk of *'going native'* considering my medical science background and my relationship with the participating institutes, was considered too great and would have compromised my ability to evaluate each institute fairly.

In relation to the analysis of the publications output of each institute presented as supplementary information for this thesis in Appendix III, there was a small minority of publications (<1%) that were not included in the analysis as the journals were not listed by Thomson Scientific (ISI). However as focus of the publication analysis was the *'visibility'* of the research as determined by the reward maximisation model, journals not listed by Thomson Scientific were assumed not to have reached the desirable level of visibility. Any resulting effect from this small minority of journals would be negligible.

Finally, the choice of participating institutes was a recognised limitation of this study. There are several Medical Research Institutes in Australia, of which only five agreed to participate in this study. However, final five participating institutes did reflect a broad comparison between different Institutional structures and field concentrations that was necessary for this study. Any further study in this area would benefit from taking a broader approach to the institutes chosen, however this could only be used in confirming the results of the current study.

3.8 Methodological Guide to this Thesis

The specific methodologies used for each set of results will be outlined again at the beginning of each corresponding results chapter.

Chapter 4: Results

Bo'sun:	**Still the guns and stow 'em, Signal the men, set the flags and make good to clear port.**
Elizabeth:	**Wait! You have to take me to shore. According to the Code of the Order of the Brethren .**
Barbossa:	**First, your return to shore was not part of our negotiations nor our agreement so I must do nothing. And secondly, you must be a pirate for the pirate's code to apply and you're not. And thirdly, the code is more what you'd call "guidelines" than actual rules. Welcome aboard the Black Pearl, Miss Turner.**

4.1 Introduction

The internal Commercialisation Office (BD Office) and the Communication Office (PR Office) in each of the participating institutes were run in different manners. The aims and objectives of each institute's office differed and this had different effects on how those offices were viewed and valued by their scientists. Like Elizabeth Swan in the above quote from "Pirates of the Caribbean", it is sometimes difficult for the BD and PR Offices to understand the rules that exist within the scientific community. How successful these offices are in earning the respect of their fellow scientists affects the institute's culture and the extent to which the scientists openly accept the introduction of BD and PR into scientific practice.

This chapter attempts to identify and describe the different ways in which the internal BD and PR Offices in each institute operate. Understanding how successful an office views itself and how successful the office is viewed to be by the scientists is an important perspective that can be used to evaluate the success of that office.

In addition, the way that the BD and PR office works can affect how scientists view commercialisation and communication as aspects of science. The assumption is that a successful office will result in scientists being receptive towards communication and commercialisation in science. In short, a scientist's actions and motivations towards these issues will be reflective of how successfully the BD and PR offices engage their scientists. This chapter also attempts to compare the different offices by highlighting key aspects over all participating institutes.

4.2 Methods

See also General Methods.

Interviews were scheduled with the Communication (PR) and Commercialisation (BD) Officers at each institute whilst the researcher was visiting each institute. The interviews with the Office professionals and interviews with the scientists were conducted during the same visit to the institute. This allowed for the cross comparison of themes highlighted by the scientist interviews with themes in the internal BD and PR Office interviews. Interviews lasted for approximately 40-60 minutes each. All interviews were semi-structured with a list of themes to be covered. This purposeful lack of structure also allowed the interview to progress more like a conversation with a particular research agenda to be covered.

4.2.1 Analysis

All interviews were fully transcribed and then hand-coded for analysis. In conjunction with the interview notes taken at the time of the visit to the institute, the interviews were then analysed for common themes between the BD and PR Officers between institutes. In particular, the tools an Officer will use to engage the institute's scientists were identified and compared between the internal BD and PR Officers. In addition, the perceived success of the Officers of engaging the scientists in communication and/or commercialisation was triangulated with the scientists' opinions of that office.

4.3 Results

4.3.1 Communication Within an Institute

This section of this chapter is primarily concerned with investigating how the internal PR Office operates within each Medical Research Institute (MRI). It examines the roles assumed by each Office within each participating MRI and the specific techniques used to communicate scientific research and promote the institute. In addition, this section will investigate and outline different methods used by the communication office to interact with the scientists and in particular will investigate the relationship between science communication and fundraising within the PR Office.

4.3.1.1 Responsibilities of Communication Staff Vary Between Institutes

All interviews began with a general question about the main responsibilities of the interviewee. The results ranged from general "promoting science to the public" to more specific tasks unique to that particular institution. For example, at the GARVAN and JCSMR the tasks of the communication office were more general:

> *'My primary responsibilities are raising the profile of the Institute; and that is to a number of stakeholders such as the public to government through to corporate, and insuring consistency and accuracy in all the publications that come out of the Garvan Institute.'* *GARVANSC01*

GARVAN SC01 then explained the avenues she used to promote the Garvan Institute used to channel these communication methods

> *'... the way I communicate with these stakeholders is the four main communication channels: the media, face to face, internet and publications.'*
>
> GARVANSCO1

The Communications Manager at the JCSMR also describes her responsibility of promoting the research of the institute through a number of different channels.

> *'My absolute major role is to promote the John Curtin School to the local community and to the scientific community as well as to the general public.'*
>
> JCSMRSC01

She also mentions that the main method of promoting the institute is by speaking directly to the Canberra community about JCSMR;

> *'So I spend a lot of my time out speaking to people about what we do within the school, why medical research is important to the community and why it continues to need funding and all of those kinds of things.'*
>
> JCSMRSC01

Both the GARVAN and JCSMR have a small number of personnel in each Office. JCSMR has only one full-time communications officer for the entire institute. Garvan has one full-time communications manager and one part-time communications officer who work two days a week. However, what is described above is a more general description of the responsibilities of a Communication Officer within a Medical Research Institute. The specific tasks that must be completed in order to promote each institution are numerous and are completed despite the small size of the communication office.

Responsibilities include organising conferences both outside the school and also attracting scientific speakers and conferences to be held within the school. At JCSMR the role of the Communication Manager also involves maintaining contact with alumni and community supporters of the school. This combines the role of the general promoter of the institute with a discreet fundraising role. This discreet fundraising role is in contrast to the fundraising role of other institutes and the Communication Manager of the institute allows the good reputation of the JCSMR in the local community to attract fundraising dollars.

> *'We also make sure that our database is updated so that we can continue to make sure that scientists in Australia and worldwide hear about what we are doing in the John Curtin School of Medical Research.'*
>
> JCSMRSC01

This is done through a number of different strategies including through the hosting of special events within the school;

> *'Things like the counting down events that we hold each year where we bring in the local business community and the politicians as well as the local academic community. So we run special events that would be called largely social and promotional events but I do also run scientific conferences and seminars'*
>
> JCSMRSC01

In addition, the Communication Manager oversees the production of JCSMR specific publications to send out to members of the scientific and local community;

'I am involved in writing and editing all of the promotional publications that come out of the school so that involves the annual report, any promotional brochures that come out the JC which are either to do with fundraising or student recruitment or just information brochures that come out about the school'

JCSMRSC01

One of the more unique roles for the JCSMR Communication Manager is the organisation of the annual JCSMR retreat. The retreat is a 1-3 day event attended by JCSMR staff and students to discuss the strategic direction of the institute. This allows the staff and students to voice their opinion about various aspects of the school governance.

'Major events like the annual retreat I completely organise it from within my office so that involves not only organising the housing scene, 180 guests. It also involves putting together a scientific program and the social program that engage our school guests, our visitors, people from our strategic advisory committee for research advisory who actually attend our retreat as well. Every year we have a theme, so I have to get together a theme to program.'

JCSMRSC01

JCSMR, although maintaining an independent public profile, differs from the other participating institutes in that its governance falls under the corporate banner of a university, The Australian National University (ANU). In 1992 when the school rejected the idea of establishing themselves as an independent research institute from the ANU, this also meant that all external communications from the JCSMR would be promoted under the auspices of the ANU. This partnership between the ANU and JCSMR also means that the communication (PR) office can share its workload with the main ANU communication office. For the day-to-day responsibilities of the JCSMR Communications Manager, however, this means sitting on a lot of ANU committees;

'In terms of involvement with ANU, I'm on a number of ANU committees so I'm on board of National Institute of Health and Human Sciences. I'm on the Board of the National Institute of Bioscience so I represent the John Curtin School on those. I'm our marketing committee representative so I maintain very close links with the marketing people at ANU. Plus, I'm the John Curtin School representative. I get invited to sit in on strategic advisory committee and I'm an ex-officio member of the faculty board. So there are meetings and things to attend.'

JCSMRSC01

Through this myriad of communication activities, the JCSMR PR Office still develops a good working relationship with the local community and business groups. This is achieved by conducting laboratory tours and by giving presentations to these groups. These activities demonstrate the importance of the research being conducted at JCSMR and are particularly essential in maintaining a good reputation with the local community.

'As part of my brief to communicate to the local community I get up and speak to community groups and to local schools, and in a busy month that can involve eight outside talks in a month. I also conduct tours of the John Curtin School and I invite members of the local community to come in and see what goes on in our laboratories and I'm responsible for organising and running those as well. Um, I don't sleep! (Laughs)'

JCSMRSC01

Despite having a similar number of communication personnel, the GARVAN has one advantage and that is the GARVAN Foundation. The GARVAN Foundation was established in 1981 to provide fundraising support to the Institute's medical research community. Over time the Foundation has grown to support the PACE initiative (Public Awareness and Community Education Program) that aims to increase "understanding" across the broader community of the medical research taking place at GARVAN.

'We have a foundation which is a separate body headed and they see themselves as marketing and fundraising for the Garvan but then a lot of the communication and marketing is actually what I do. For example, publicising seminars both internally and externally, I do that. And I can call on them to do things and they can call on me – so that is pretty much how it works.'

GARVANSC01

Although the Communication department at JCSMR has a fundraising element, it is only one informal task of the larger responsibilities described above. For GARVAN, the Communication Department and the fundraising and marketing elements of the Garvan Foundation are separate.

'... and they [the Foundation] handle the high network corporate bonuses so they are liaising with them making sure that they know what research their money is going to.'

GARVANSC01

There are however aspects of the fundraising role of the Garvan Foundation that require the expertise of the internal PR Office. As described below, the Foundation uses the Communications Manager as a liaison point between the aims of the foundation and the research being conducted at the institute. This is particularly important when producing publications about the Garvan's scientific research which require the Communications Manager expertise in interpreting the science;

'... I do interpret some of the science for them and obviously "Breakthrough" which is marketing and fundraising publication that is being looked after by me. So I break up my time.'

GARVANSC01

This tentative link is important as it allows the GARVAN Communication Office to dedicate its time to communicating the science through more formal means. As seen in the JCSMR example there is no time for a formal fundraising role as the time of their one employee is taken up with other Communication tasks. It should also be noted that JCSMR is formally part of the Australian National University (ANU) as one of its founding research schools (see General Methods) and although there is one person within the school dedicated to PR and Communication tasks, many of the formal fundraising would take place at the University level in much the same way that the Garvan Foundation works with the Garvan Communication department. This issue regarding the time and the number of tasks for which an internal PR department is responsible as highlighted in an interview with a member of the Communication team at POWMRI.

> *'My job initially was public relations/fundraising/marketing and events so it was the whole thing up until about 18 months ago when it was just getting too big. I mean, I can do the small things, I couldn't do them properly. I could only really touch on things so I got [Events Officer] to help me with events and before Christmas I talked to [POWMRI Director] into making [Events Officer] events and fundraising manager. So she still reports to me but she has her own position now. Just before Christmas we put on a bequest manager as well. So it is still a very hands-on role.'*
>
> POWMRISC01.

Within POWMRI, the role of the Communication Offices is similar to GARVAN and JCSMR with the main difference being that there are two full-time personnel with one person being fully dedicated to event organising and fundraising. POWMRI is a much smaller institute with approximately 100 full-time scientists where JCSMR and GARVAN both have approximately 400 full-time scientists. Even with an institute of 100 scientists, it seems that there needs to be a distinction between fundraising and PR roles at least for the sake of time. The Communication Office, as mentioned above, initially started out as a marketing/fundraising/public relations office but combining all these elements of communication made it too difficult.

> *'I have always said to [POWMRI Director] "You want big donations to come in then you have somebody who is dedicated purely to be fundraising manager, you cannot spread yourself out over so many things and hope to do justice to every one of them really well.'*
>
> POWMRISC01

When considering the role that fundraising may play in the communication of POWMRI, POWMRISC01 compared them to the Garvan, which is considered by these Communication personnel as one of the more prolific MRIs in Sydney.

> *'The GARVAN has a foundation but we don't have a foundation so the foundation is purely there to raise money. It has a CEO who is a designated fundraiser; she raises funds. That is what she is. She doesn't do public relations, she does marketing, and she doesn't do events. She has people under her who do events but her job is purely to raise funds and she runs that foundation and we don't have anything like that.'*
>
> POWMRISC01

However, despite not having a foundation like the GARVAN, the POWMRI does have separate roles within the communication office for PR and fundraising. The communication role involves:

> *'I do all the media obviously, generate all the stories, write the media releases, the newsletter, the annual reports, take all the photographs, provide a backup for all the publications that the scientists need, even website information that they can't*

get that maybe crosses over in a public sense so they ask me to search for information on particular things.'

POWMRISC01

This role also oversees some of the fundraising efforts but fundraising is primarily the responsibility of the Fundraising and Events Manager.

'The role really doesn't have a finite job description or boundaries and you tend to do many different things.'

POWMRISC02

Despite the lack of job description and boundaries in the field, POWMRISC02 continues on to explain what she is predominantly responsible for in her role;

'It is internal functions and events and external predominantly fundraising events and the fundraising program that is direct mail with our donors and acquisition mail outs.....a fundraising event and it probably has two key objectives one of them is to raise funds which is the obvious one and the second is to raise the profile of the institute and the work that we do here and so when people think of AD research they think of POWMRI.'

POWMRISC02

Despite having separate roles, the Communications Manager and the Events and Fundraising Manager are both working to a single goal, that of promoting the work of POWMRI. As described by POWMRISC02, the promotional aim of the communication strategy of the institute is that *"when people think of AD they think of POWMRI."* This is different from GARVAN where fundraising and communications are run by separate offices. In contrast, the communications office at QIMR is large with 12 full-time people predominantly focused on fundraising.

'In this particular department, marketing and fundraising, the ultimate goal is to raise funds so that QIMR can support itself in the future when it becomes more competitive. I'm sure every medical research institute has a goal similar to that in terms of supporting itself.'

QIMRSC02

When this is compared to the GARVAN, POWMRI and JCSMR all communication from this institute is directed at raising funds and not raising the public's awareness of the research being conducted at QIMR. In fact, despite having a dedicated 'Media Relations' officer within the institute who deals directly with the media issues, the main brief for that role is still focused on fundraising.

'As the media relations guy here, my job is to work with the scientists and to put their scientific papers and research into more user-friendly lay terms so we can use it as commercial material or for news releases. Basically, to communicate everything that we do to the public so they know what we are doing is geared towards raising funds and other income support for the institute.'

QIMRSC01

The communication department is named the Marketing and Development Office at QIMR and, although there are traditional communication roles within the QIMR, the main aim of this office is to raise funds so as to support the future activities of the institute.

'Basically all of us are here to raise funds. So whatever we do, we start with that end in mind so we think 'right if I'm doing this today, is that going to raise funds or nurture a client'?

QIMRSC03

This applies to all personnel in the QIMR Marketing and Development Office, regardless of their direct responsibility. As described below, the fundraising concentration at QIMR applies as much to the '*banking person*' as to the direct fundraisers or Bequest Managers.

> *'So you might have one person doing all the banking and receipting. Now they are not actually raising funds but if that donor doesn't give their receipt and get it done accurately, properly and in a timely fashion, then that could possibly stop getting funds from that donor.'*
>
> QIMRSC03

It is the responsibility of the Bequest Officers however, to directly *'nurture clients'* and raise funds. For these personnel, raising awareness of science is predominantly about raising the public's awareness of the cost of research and thereby raising funds to support their activities in the future. It is also about maintaining that awareness message consistently over a long period of time as some bequests may take years to come to fruition.

> *'You know we have two bequest officers who go out and obviously find bequests, actually engage seniors for potential bequest provision and provide information about our research to seniors who can't get out or travel now. Now and again a bequest can take 10 years to come to fruition but obviously through those visits they're creating awareness which down the track creates a provision for a bequest. So while everyone every day is not raising funds but certainly indirectly that is what we are trying to achieve.'*
>
> QIMRSC03

This emphasis on fundraising means that the QIMR Communication Office is distinctly different from the Offices at the other participating institutes. The main object of the QIMR communication office in contrast to the other Offices is to raise funds but, in addition, QIMR, like the other institutes, aims to also raise awareness of their research albeit raising the awareness of the cost of research;

> *'...to raise funds and awareness. You can't raise funds without awareness, so you need to raise awareness. [create a] high profile, engage your stakeholders and constituents, have an awareness of publicity and positive media but ultimately the aim and objective of the department is to raise funds for research programs, for PhD students, for equipment, capital works (new buildings and things) so ultimately to raise as much money as we can.'*
>
> QIMRSC03

The importance of raising funds at QIMR, however, overrides the aims of traditional science communication, with most of the interaction with the public being focused on stressing the cost of research rather than creating understanding and engaging the public about the science.

> *'With that goal in mind, that would be why the tours and all the communication is geared towards "the research costs this much" because without saying it they won't understand. I guess that is a strategic thing, sort of like prompting little thoughts in their mind that may make them think of financially supporting us without directly asking them for money.'*
>
> QIMRSC01

However, separate from this mainstream Marketing and Development Office is an additional separate internal organisation responsible for science communication activities. The Community and Consumer Participation Committee (CCPC) was established at QIMR as a pilot program for the NHMRC's statement of consumer participation in research (2002). It aimed to create an environment where *'consumers and researchers working in partnership based on understanding, respect and shared commitment that will improve the health of* *humankind'*. The Committee at QIMR is run primarily by the scientists and is committed to *'enhancing community engagement with QIMR's research and as a corollary, to facilitating our scientist's involvement with consumers and the community at large'*. The main responsibility of the Committee is to create communication opportunities for the scientists. Despite being a separate body for science communication activities, there is little interaction between the Marketing and Development Division and the Committee as they have vastly different aims;

> *'Well the CCPC are not interested in raising finds, they're interested mainly in ways to effectively communicate with the consumer, to get the consumer engaged in research, to get their feedback, to keep our fingers on the pulse as to what the general public is feeling about issues.'*
>
> QIMRSC02

There are, however, some difficulties with the CCPC that are typical of any engagement model of science communication;

> *'...about communicating your research with the community but its supposed to be two way, right, and this is the funny thing – the response from the scientists was 'the community wasn't going to tell me what to research'. So that was the initial response and we have had to try and play things very lightly to make sure that that didn't happen so we can't offer the community very much.'*
>
> QIMRSC01

Despite the above, the CCPC remains an essential aspect of QIMR's communication culture.

In contrast to the above roles of the internal PR departments, the roles that the WEHI PR Department assumes do not include fundraising. The WEHI PR Department is aware that it is unique in not having a fundraising element and instead concentrates on *'communicating excellence in science to the community'* and providing a printing service or scientists wanting to present externally. By providing this service, WEHI ensures that all external marketing material looks the same and follows the correct WEHI corporate guidelines.

> *'... instead of having dedicated people fundraising we have a very narrow fundraising focus which is quite diffused. My area actually produces books, posters, CDs, DVDs, brochures, all sorts of paraphernalia to support the science of the Institute and a lot of graphics. So we are quite different in that way.'*
>
> WEHISC01

This *'difference'* means that the PR Office at WEHI concentrates on the branding of WEHI to its internal and external stakeholders. This aim has its own challenges, including communicating these templates and guidelines to their own scientists in addition to ensuring that these guidelines are followed.

> *'Internally, we go to great pains and set up templates and style guides and all sorts of things to make sure that when WEHI scientists and presentations travel around Australia and the world it looks as good as it possibly can and has a WEHI look to it. In its colours, in its typography and its design, its dimension and proportions, and the quality in it so that you should be able to look at a poster on the wall from a distance away and say 'that's a WEHI poster'.*
>
> WEHISC01

WEHI Communication structure and aims are quite unique in Australia, especially when compared to the other participating institutions. Creating this 'brand' and maintaining this brand as *'fresh in the marketplace'* is the main driver of the WEHI PR Office. Additionally, researchers at the WEHI maintain close links with the University of Melbourne and the Royal Melbourne Hospital. This means that the PR Office at WEHI needs to work harder to ensure that WEHI achievements are publically recognised as WEHI achievements and are not confused with the other organisations that WEHI scientists collaborate with and maintaining a constant *'WEHI look and brand'* partially ensures this. By providing this service, WEHI controls all its external marketing and also provides an interesting catalyst for interaction with its scientists; as a scientist will have to communicate his research to the communication office in order to get his poster produced. This allows the communication office to keep up to date with the research being done at WEHI. In addition, by providing this service, the scientists understand that the communication department works with them to ensure that their research is presented in the best possible way.

> *'Here, the scientists have the luxury of us publishing for them. They know they can bring down some scribbled up rubbish and we'll turn it into a beautiful piece of writing with graphic art for them and no-one else in Australia has that type of service available to them. But we think it is important to give it, we call them our internal customers, give our internal customers the best possible service we can give them and a lot of that is based on promoting the brand name of WEHI and the corporate identity of WEHI on a local, national and international basis.'*
>
> WEHISC01

Interestingly enough, similar to POWMRI, WEHI still compares itself to other MRIs including the GARVAN and QIMR.

> *'QIMR and Garvan, in particular, are a problem in that they don't have the same degree of corporate identified in their posters as we do. It's all over the place and their scientists don't like to be told that they need to conform to a certain template. It's a do it yourself job up there - I can understand that because they do have to do it themselves. '*
>
> WEHISC01

The results of the above interview analysis are summarised in Table 4.3.1.1, which shows the number of people dedicated to specific tasks in the communication department of each participating institute. As indicated in Table 4.3.1.1, institute communication offices vary in the distribution of tasks. The GARVAN has two communication officers who are both concerned with PR/Communication tasks. At JCSMR, even though fundraising is part of the job description, the sole communication officer is primarily concerned with PR/Communications. Similarly, POWMRI has two personnel each with separate tasks and although the fundraising element is separate from the PR/Communications role the two task work in cooperation with each other to 'promote the research at POWMRI'. In contrast, QIMR has a communication department of 12 people with the majority (10 people) involved solely in fundraising. WEHI is different again, with the majority of personnel involved with producing high quality internal and external scientific publications.

Table 4.3.1.1
Summary of the Responsibilities allocated to Institute Staff in the Internal PR Offices

Institute	Total number of personnel	Fundraising	General Communication	Other
GARVAN	2	0	2	0
JCSMR	1	0	1	0
POWMRI	2	1	1	0
QIMR	12	10	1	1
WEHI	9	0	2	7

4.3.1.2 Maintaining a Good Relationship with the Scientists is an Essential Tool in Encouraging Involvement

One of the aims of the interviews was to investigate the relationship between the internal PR Office and the institute's scientists and the techniques used by the Office to engage scientists in communication activities.

The introduction of the internal PR office is a relatively new approach. Previously, science was predominantly self-regulated with funding agencies controlled by the researchers themselves, such as the NHMRC where the distribution of funds is determined by peer review (Benner & Sandstrom, 2000). Communication Offices therefore have adapted to become part of the research institute whilst remaining independent of scientific governance. This section looks at the techniques used to communicate to scientists and also to impress upon them the importance of the role of science communication.

At some institutes, getting scientists involved in communication activities can be difficult and maintaining a good relationship is vital. There are many ways in which Communication Officers can achieve this; the first one is by having a science background. The interviewees were asked whether it was essential, in their role, to have a science background;

> *'I also think that it helps that the scientists, the researchers are comfortable that if I present their science – I'm not going to botch it.'*
>
> JCSMRSC01

In addition to understanding the science, the ability to translate this research for public consumption whilst maintaining the integrity of the research is also important.

'...I spend a lot of time making sure that I can present the science to a lay public in understandable language and actually people often comment that it is the first time that they really understood what is going on in our laboratories.'

JCSMRSC01

JCSMRSC01 goes on to explain that the reason that she spends so long translating this research is because she acknowledges that the scientists within JCSMR find it hard to put their science in terms that will interest the public. This confusion is despite the JCSMR providing media and science communication training for their scientists.

'Because, sometimes it is very hard for the researchers to actually put their science into anything other than jargonistic terms. And even though we have training programs on campus for people to deal with media and deal with the public – it doesn't necessarily translate.'

JCSMRSC01

This is the same at the GARVAN where the members of the PR Office all have a science research background. GARVANSC01 explains below that there is a perceived value in higher science degrees. GARVANSC01 compares the current PR Office with the less 'scientific' PR Office before she joined the institute. In comparison, the scientists appreciate her knowledge and background and engage themselves with the PR Office more as a result.

'...there is value the higher the degree you have, I mean I hear things second-hand and there are people in the foundation that have a science degree but I have heard that they don't understand the stuff the way that [she] does because she has the research background and she can understand the whole problem.'

GARVANSC01

One example of how the current GARVAN PR Office benefits from their scientific integrity is explained below. In particular, the previous office's constant use of the word 'breakthrough' in external communications distanced the office from the scientists and their research.

> *'The person in this role before me wasn't, I hear, so successful because of her lack of science background. She was always looking for the "b" word – breakthrough. I think there is an advantage to on how I can handle the media, definitely.'*
>
> GARVANSC01

In both GARVAN and JCSMR, the Communication Officers not only have PhDs in Science, they also completed their PhDs at the institute they are now working for. This is not only important from the point of view of understanding the science but also in creating and maintaining a professional working relationship with the scientists of the institution. When it was asked whether they thought that the scientists viewed their work in a positive light, this was not only answered in the quote above from the GARVAN but also:

> *'Well, I've been extremely lucky in that the attitude of the researchers to me personally has been very positive, and I would have to say that I think that comes from the fact that I was a researcher within the school prior to moving into this position.'*
>
> JCSMRSC01

Again the experiences are compared to those of the previous Communications Manager who, as is said below, was not regarded as an *'important part of the research community.'* By having experience as a researcher within this particular community of scientists, this has helped her communicate with the scientists in her new role as the Communications Manager.

'Because the person in this position previously had very real difficulties, she was regarded as being not an important or integral part of the community by a lot of our researchers, not by everybody, but a lot of researchers.'

JCSMRSC01

Being a former researcher in the school is clearly seen as an advantage by those who have that experience but do Communication Offices without that experience perceive their lack of scientific education a barrier to understanding science? At WEHI, the Communication Manager does not have a scientific background but he perceives that as an advantage;

'They wanted someone for the first time to be a weather vane, to be community relations, to be PR and communicate with the public. So I know that I liked this stuff, so I applied for the job, called and harassed them and they said, 'Why would you be on the short list, you haven't studied science?' I said, "Exactly! That is why you should have someone like me running your communications area.'

WEHISC01

WEHISC01 mentions that he considers his lack of scientific research background beneficial. This benefit exists in his ability to have foresight into what the public wants to hear. The main disadvantage scientists have, is their inability to accurately gauge the public's interest in their research. His background, in his opinion, allows him to forget specific research and communicate it in what he described as "Noddy and Big Ears Language".

'cause you are a community of scientists who are accustomed to be self-reverential and reclusive and no-one out there - and I'd looked at their website - do you think half the people out there understand a word you are saying? There was silence at the end of the line, I said, "You should talk to me". So they brought me in and I basically ran that line with the Director'.

WEHISC01

He explains below, that his main task as the Communications Manager of PR is to remain part of the 'laity' and not integrate too much into the scientific community of the WEHI. His main advantage before joining the WEHI was being a member of the 'lay' community and, according to the quote below, the WEHI agreed to this.

'If you are going to talk to the laity then perhaps you should have someone who comes from a lay background to interpret it for you. Much to their great credit, they thought that was a good idea. So, I've been working in that role since the office began.'

WEHISC01

His university degree was in Education with a degree in Fine Arts with a speciality in Caravaggio. It would seem that this background is as far removed from science as possible, but he describes its relation to this present position as Communications Manager at WEHI as this:

'And from there when you are an art teacher in a school, if you're in art or in literature you get asked to write things or draw things and design things and promote things 'cause they just come to you - 'cause there is no money you just have to do it yourself. You learn to be very self-reliant and creative on short budgets.'

WEHISC01

The internal PR officer below regards his lack of science background as a personal obstacle to communicating and creating a relationship with the scientists of QIMR. This may be related to the way he approaches scientists about communication issues:

'I've only been in this role for a year so I'm still learning what is the best way to approach the scientists.' *QIMRSC01*

He describes below how very careful he is not to 'disturb or interrupt the scientists' with PR requests while they are working. In addition, as is shown below, his relationship with the scientists of the institute is based on the scientists' involvement in previous media activities. QIMR SC 01 does not maintain a relationship with the scientists of the institute; moreover he will introduce himself and form a relationship with the scientist only when they are needed for PR purposes. In contrast to other participating institutes, this approach to internal communication can be described as passive and reactionary, especially when compared to the upfront approach employed by WEHI SC01.

> *'Generally, I just do a warm-up email to say "Hello, I've heard about your particular work", and I usually look them up on the website first, so I have something to ask them about rather than just saying what do you do and give us all the information that you have on that. And then if we get a response we do a follow-up and ask them if they have done anything recently? And then work out a time to interview them?'*
>
> QIMRSC01

As was described above, QIMRSC01 views his lack of science background as a hindrance to his ability to communicate with the QIMR researchers. However, instead of being up front about his experience, as we saw with WEHISC01, QIMRSC01 prefers to learn about the science by being present, but not involved, with tours of the laboratories.

> *'... we have a talks and tours program that we do here with the community as well. We contact scientists as well to speak, for about five minutes, and I try as best I can to be present when they talk so without bothering them any further.'*
>
> QIMRSC01

Finally, as described below, QIMRSC01 uses his presence at the above laboratory tours as a gateway to contacting the scientists again and requesting their involvement in various additional PR activities. This is particularly true when what he understands about science is 'sciency enough' for a specific publication.

> *'I am actually aware of what they do and if it's science, sounds recent or very interesting for a particular publication or another media outlet that I might follow up and then might ring them and say "thanks for talking – would you like to do an interview for a newspaper or something like that.'*
>
> QIMRSC01

QIMR SC 01's method of approaching scientists is reserved. However, at the same institute, QIMR, another member of the internal PR department who has a scientific background, does not perceive any difficulty when communicating with the scientists.

> *'No, I haven't had any barriers, probably because I came from another science institution and that it had an academic environment for a long time. These are not strange beasts to me...'*
>
> QIMRSC02

In contrast to her colleague, QIMRSC01, when QIMRSC02 first arrived at QIMR her primary goal was to start building relationships with the scientists. This was achieved by taking the time to make personal visits to all scientists and laboratories at QIMR. As described below, QIMRSC02 sees her primary responsibility as breaking down the barriers between the scientists and the Marketing and Development Office. Despite this action, QIMRSC01 still feels that even though the scientists recognise her, they still do not understand the aims and objectives of the entire Marketing and Development Office at QIMR.

'Had I not made those personal visits up front, I think that it would have been hard but that is my job – is to go out and break those barriers down and I do find that they will, they still don't know what everybody does. '

QIMRSC02

In addition, she promotes herself as the first point of call for all scientists with communication enquiries. This role can be described as a bridge-maker; where she will know how the PR Office will work but will also understand the needs of the scientists. This is demonstrated below when QIMRSC02 describes that though initially she was still finding her feet in the PR Office, she recognised too that an important aspect of her role would be as a sounding board for the scientists.

'When I went to see all of them [the scientists], I was still very much trying to find my feet and sort of explain that these were the kind of jobs that I had to do, but I saw that they were wrong and that they could call on me at any time.'

QIMRSC02

Even though this person does not have the scientific experience that either GARVAN or JCSMR have, there is still no perceived barrier when talking to the scientists.

4.3.1.3 The Bald Baby Effect: Using Human Interest to Promote the Institute

There are several different activities that Communication Offices use in order to promote the institute. In order to get the best coverage for the institute, internal PR Officers will use specific scientists and scientific research subjects in order to promote the institute. This may be for many reasons including human interest and the communication experience of the scientist. The scientist will have varied control over when and how their research is communicated to the public. This section will explore why internal PR officers use specific communication techniques and how these techniques are used to promote the scientists and their research. In addition it will highlight the difference of opinions between scientists and communication offices of what the public find interesting about science.

The first task that needs to be completed when an internal PR officer prepares the science for public consumption is the elimination of any scientific jargon. The jargon is important to exclude not only so that their science will be understandable to the public but also so that the public can relate to the science. If the scientist can explain their science in *'Noddy and Big-ears language'* then the science is ready for public consumption;

> *'...scientists know they need to come to me and most of the time, it is because they are having a paper published in a prestigious journal; Science, Nature or Cell or something like that. And they say, 'I have a good story,' – they all have good stories according to them. And I say, "Okay, let's hear it then,' and they will tell me what this story is and I'll say 'Well thanks very much but I don't understand a word of it – you will have to make it in Noddy and Big-ears language because I'm not a scientist and you will need to talk to me like I am your 7-year old niece or your Gran.'*
>
> WEHISC01

This is no different at POWMRI. The simplification of scientific language for public consumption is extremely important;

> *'...it is adjusting it to be more lay language. And some scientists are easier about that. Some scientists you can go back and back again to ask them to please explain this and put it into lay language and you still don't get it, then you just find someone else within that area and ask them to give it back to you in lay language...'*
>
> POWMRISC01

The communication officers not only interpret the jargon but also attempt to educate the scientists about not using jargon when communicating to the public. This is described by our participants as one of their basic translational roles as internal science communicators. In addition to streamlining the scientific jargon, using specific research programs to promote the institute is also a technique used by communication officers. This can be for a number of reasons including the experience of some scientists in communication activities but also the level of human interest the 'public' has in a specific research area.

The main aim when choosing which scientists and research programs to use in a promotional activity is to find an 'angle' that that particular audience will find interesting. This could be a result of a 'hot topic' in the recent media but more often than not, Communication Officers will attempt to create a research story that the media can relate to;

> *'I try to base all media releases on their scientific papers if I can; "recent publications have shown..." and then all the statistics. I then to try and reflect it back into the community. So if it is about skin cancer then I would say 'a certain number of Australians are affected by skin cancer each year...'*
>
> QIMRSC01

QIMRSC01 attempts to make the science relevant to a particular disease are done despite QIMRSC01's acknowledgement that the scientific paper does not draw such parallels to public health. This is done, as described below, because the scientific paper is not written in the context of the public's need. It is therefore important, according to QIMRSC01, to put the research into the community context to remind the public of why this research is necessary.

'...put it back into their [the scientists] perspective even though their research doesn't say that at all. It [the research] certainly is still relevant because we don't want to just talk about that particular research that has just been published but also put it back into context of why it is important to the community that we do this research.'

QIMRSC01

Human interest is important and at the QIMR, so that people will feel compelled to donate money to the institute. This is where medical research has an advantage. Everyone is concerned with their health; everyone has a body and is concerned about its well-being. Likewise health issues that affect a large proportion of the population, such as cancer and diabetes, are more likely to appeal to the average member of the public. Communication officers are aware of this and are also aware of the restrictions that journalists face when deciding which news articles to publish.

'When I've got the gist of the story, what it is all about – they are all important – but there is a difference between being important and being newsworthy. They [scientists] don't see that.'

WEHISC01

It is then the responsibility of the PR personnel to be 'honest' with the scientist and to highlight what research aspects constitute a good media story;

'quite often it is my job to be quite honest with them and say 'what you are telling me is really interesting from a scientific point of view but it doesn't have legs and I won't get it a run because it doesn't have a sense of drama, tension or a human element that is really going to spark interest in a news room.'

WEHISC01

This internal PR officer stressed the issues with communicating science to a general news room. He outlines his criteria for a media interest in a science story below;

> *'...Number one – I have to get a journalist interested in it and they know their readers and number two – the journalist has to sell their story because there is only 'x' number of spots in the paper and there is 'x+20' stories. Science is a bit of a hard sell so it is my job to filter the stories and okay something only if I think it is prospectively a story...'*
>
> WEHISC01

In addition, when trying to raise money for the institute, the best research programs to promote are the ones where the potential outcomes will improve the health of the largest number of people. At POWMRI, the success of the fundraising events is usually directly related to the popularity of the research program being promoted. As a neuroscience specific institute that is primarily concerned with the clinical applications of its work in treating Alzheimer's Disease, Parkinson's Disease and Spinal Cord injuries, it is difficult to connect to sponsors on a personal level.

> *'Before Christmas, or September, we got a huge amount of publicity through information on Parkinson's [disease] and that was everywhere; on the ABC; Channel Seven and it hit so many different papers and that is how I judge success. Does that connect to how [POWMRI Director] sees as a success, which is money? Probably not – '*
>
> POWMRISC01

POWMRI SC 01 describes below that her job as a PR Officer for the POWMRI would be easier if there was a cancer program within the institute because it would attract more fundraising dollars from the public when compared to the current research activities at POWMRI.

'It would be nice to think like that but we don't deal with Cancer and that is one thing that we need. I ask [POWMRI Director] 'Can you please start up a Cancer project?" Because, honestly, it is the truth of it – If we had a cancer research program here, then our income through donations would go through the roof.'

POWMRISC01

Indeed, POWMRISC01 recognises that even though the research that is conducted at POWMRI is important and particularly unique in Australia, it does little to motivate the public to give money. This is because despite both Alzheimer's and Parkinson's Diseases being prevalent in Australian society, it does not have the same emotional impact as Cancer.

'...people can read stories about Alzheimer's and Parkinson's and they feel sorry for those people and yes, there are a lot of people out there who do have Alzheimer's and Parkinson's Disease but that doesn't have the same impact that Cancer or sick children...'

POWMRISC01

One extreme example of a research area that has enough emotional impact to motivate the public to give money is 'Kids with Cancer.' Interestingly enough, as described by POWMRISC01, just the image of a sick child on the front of an appeal letter is enough to stimulate donations, especially at specific times of the year such as at Christmas. Although people feel emotionally obligated to give money to sick children, they are not as interested in understanding the disease. This is definitely not the case for Alzheimer's and Parkinson's Disease where the main motivating factors for members of the public to seek out the POWMRI would be because of the desire to understand more about the disease and not because of any emotional desire.

'Kids with Cancer - I used to work for the Sydney Children's Hospital, put a bald baby on the front of any appeal letter and you will get a lot of money. A bald little old lady and people will think 'that looks just like my Granny, isn't she cute," but are they going to give you money? No, not one bit."

POWMRISC01

Her experience at the Sydney Children's Hospital has influenced her opinion of the POWMRI's ability to raise funds. She admits that neuroscience, POWMRI's major focus, is not as attractive as Cancer and Childhood diseases. She is aware that in order to gain the public's attention, there needs to be an emotive factor; *'every member of the public is personally aware and frightened of Cancer. They have either known someone with Cancer or had it themselves and therefore this drives them to donate funds.'* A sick child only amplifies this response, whereas Alzheimer's and Parkinson's disease do not:

'...I worked at the Royal Hospital for Women, before and it was easier to raise funds then – just put a baby in neonatal care. I mean this tiny little thing – you've seen them when you have the father's wedding ring as the baby's bracelet...People open their pockets for that but here [at POWMRI] it is a struggle I have to say.'

POWMRISC01

POWMRI has been moderately successful in fundraising using alternative methods such as bequests and private donations. Its major difference from the other participating institutions is an absent "Cancer program". As described above, having a cancer program is a major advantage for an institute not only in relation to the effectiveness of its fundraising efforts but also in its ability to relate to the public on an interest level.

'...I mean if you took cancer out of the mix for our local fundraising, we might as well shut the door. About 85% of our fundraising is for cancer programs.'

QIMRSC03

The interviewer then asked whether there any specific cancers that were 'hot' at the moment. According to QIMRSC03, 'the Big C' was a selling point for the institute but this was because the Australian public was specifically interested in Cancer. She compared this area of public interest in Australia to China where the interests of the community were focused on the diseases that affected them the most;

> *'Having the Big 'C' to sell, without that we wouldn't be in existence however, when you go to China, whilst Cancer isn't an issue, they're starved for information about rheumatic heart disease, Giardia, Malaria and Dengue Fever. You know that Malaria kills 4 children a minute, so again it does depend on the audience…'*
>
> QIMRSC03

At the GARVAN, JCSMR and WEHI, although fundraising isn't the main objective of the communication office, the 'human interest' angle is still important when communicating the science to the public not only for the sake of interest but also that people associate the institution with a particular medical condition.

4.3.2 Commercialisation within an Institute

Commercialisation of science in Australia is a relatively new concept. In 1999, the Australian Government in its policy package 'Backing Australia's Ability" emphasised the importance of science's public accountability, especially in relation to the commercialisation of science. As a result, MRI's have established their own internal Business Development (BD) office, with trained professionals attempting to work with scientists, in order, first, to meet government obligations; and, second to increase the institute portfolio's own commercial value. However, this interaction between scientists and internal BD officers comes with its own problems including how this new inclusion with science adapts itself to scientific culture and how it aims to educate scientists about this new obligation. This next section will explore the establishment of the internal BD office and investigate the common difficulties these offices find when interacting with the institute's scientists.

4.3.2.1 The Internal Commercialisation (BD) Office is a new addition to the MRI

Both QIMR and WEHI have established their commercialisation offices within the last 5 years. Previously, both institute's technology transfer was handled by an external company. Amrad Corporation Limited which was a part of CSL is now known as Zenyth Therapeutics. At WEHI, the Commercialisation Officer was brought in initially as a consultant for the development of the Business Development Office;

> *'The business development office here is actually a relatively new creation; it was created just over 4 years ago. I was called in to consult the institute and create recommendations for a Business Development Office and when they couldn't find someone else to do the job that is when I came back into the picture.'*
>
> WEHIBD01

Bringing the consultant into the institute as the Business Development Manager is beneficial as the Office has been designed independently. However, integrating the scientists and institute into the idea of commercialisation as having a partnership with science has still been difficult;

> *'...It has been a steep learning curve for the institute, backing 1986 through to about 1999 they [the institute] had a company called Amrad doing all of this tech transfer, in the classic sense of 'tech transfer'. So it meant that the institute itself had been protected all the way through the nineties from issues of translation and commercialisation...'*
>
> WEHIBD01

Amrad might have protected the institute prior to having an internal business development office but having an external company in charge of technology transfer would have made it difficult to bridge the gap between scientists, the institute and the external Amrad group. Having the person who consulted the institute on the development and now overseeing the office is advantageous as the independent consultant can now run the office as he intended without getting distracted by corporate goals. The aims of the WEHI business development office are therefore described as working in partnerships with the scientists of the institute;

> *'My job is to maximise, or at least enhance the chance of translational science.'*
>
> WEHIBD01

WEHIBD01 explains further that this 'enhanced chance of translational research' is not always measured in dollar amounts. Instead, he emphasises the importance of getting WEHI research out into the community where it can be effective. This is done by creating opportunities for scientists to network with businesses that can assist in that translation.

> *'So I don't necessarily measure that in dollars although dollars are very important but just getting translational research outcomes, in other words, our science either into the clinic or out to the community. So from that point of view, the job is really to assist networking, contacts, funding and that kind of thing.'*
>
> WEHIBD01

In contrast, at QIMR, the establishment of the BD Office was similar to the WEHI, however, when the contract with Amrad finished, QIMR did not immediately establish its own internal commercialisation office. Instead, QIMR engaged the CRC for Vaccine Technology to handle its technology transfer arrangements. This arrangement was no more advantageous for QIMR than the arrangement with Amrad as there was little to no interaction with the researchers in the commercialisation of their research;

> *'...QIMR had a deal with Amrad back in the late 1990's where Amrad would put some money towards research, but they would also have had our view of what would come of it – that first peak. After that it was the CRC for Vaccine Technologies and QIMR had its own commercialisation company – Vaccine Solutions looking after all of that [business development].'*
>
> QIMRBD01

For QIMR this interrupted the evolution of the BD Office as an integral part of the institute, as recognised by the researchers. As is explained below, as a result of this unusual partnership between QIMR and the CRC for Vaccine Solutions, a lot of intellectual property was put into the Cooperative Research Centre (CRC) for Vaccine Solutions rather than back into QIMR. As a result, as explained by QIMRBD01, the researchers were not involved in the development as much as they could have been and this inadvertently affected the reputation of commercialisation within the QIMR.

> *'A lot of technology from QIMR was put into the CRC. QIMR in its own right would not drive commercialisation or a fair proportion of its own IP. Vaccine Solutions would do that and I don't think that it did it very well as they didn't involve the researchers very effectively.'*
>
> QIMRBD01

Despite the lack of involvement of the researchers in the past commercial activities of the institute, the current internal BD Office recognises that communication for the researchers is an essential factor for QIMR scientists when considering commercialising their research. This was a predictable outcome according to QIMRBD01, considering the previous commercialisation arrangements. QIMRBD01 also reflected that if QIMR had initially implemented the internal BD Office model, not only would their commercial intellectual property portfolio be larger but also the BD Office would have been able to mature more, as well as develop firmer relationships with the institute's scientists. Communication with the researchers is therefore recognised as an important factor.

> *'...I do know that those sorts of arrangements are not healthy for a research institute that wants to drive its own commercialisation agenda. If they didn't have these frivolous interruptions QIMR would be further along and more mature in relation to commercialisation.'*
>
> QIMRBD01

In the above statement, the importance of an institute running its own research and commercialisation agenda is mentioned. An institute that runs its own commercialisation activities has the advantage of not only maturing within the scientific environment and maintaining the best interests of the institute in mind, but also the advantage of working with the institute's scientists on commercialisation matters. This can also have an educational advantage where the internal commercialisation office can work with the scientists about commercialisation and its role in science. What is most interesting about the statement by QIMRBD01, is the comment about how if there weren't the interruptions from Amrad and Vaccine Solutions and had the institute maintained its own BD Office from the 1990s when Amrad came on the scene, QIMR, in QIMRBD01's opinion would have been more relaxed about commercialisations role in science.

At the GARVAN, the commercialisation office has always been an internal part of the institute. However, the current commercialisation manager has been working at GARVAN for 4 years. Prior to this, the commercialisation manager was an eminent scientist, Dr Jon

Izant, who established the BD Office in 1997. When Dr Izant left the GARVAN, the institute considered outsourcing the business development arm but finally decided to keep it within the institute. The current manager recognises the importance of maintaining a relationship with the institute that can only be achieved by remaining an internal presence;

> *' I've been in this role for almost two years and I have been at the GARVAN for three, I restructured it [this office] as soon as I got the Director's role and I actually deliberately put together a team approach to how we handle everything.'*
>
> GARVANBD01

This team comprises of people from a variety of different backgrounds. More importantly, GARVANBD01 recognises the importance of maintaining staff that have sufficient scientific background to be able to build relationships and communicate with the GARVAN's scientists.

> *'So whilst I say I'm not a scientist, I recognise the importance of having a scientist on our team.'*
>
> GARVANBD01

When the current manager assumed Dr Izant's position, she initiated a training program for the scientists about commercialisation. This had the advantage of not only teaching the scientists about issues surrounding commercialisation but it also promoted the awareness of what the business development office does and how it can assist the scientists with commercialisation activities. The specific role of the commercialisation education programs at GARVAN will be discussed in the section below.

4.3.2.2 Interaction between the scientists and the Internal BD Office is a Catalyst for Changing Commercialisation Guidelines and Practices

As mentioned above, the business development office has become an internal part of the medical research institute only in the last 10 years. In addition, the office has been required to interact with the scientists of the institute despite negative criticism from the scientific community. There are many different ways in which the practice of business development has evolved in order to accommodate the culture of scientific practice. These include the idea that officers will work with and educate the scientists about the importance of commercialisation in a way that the internal BD offices becomes inseparable from the scientific culture and therefore partners in developing scientific research. In addition, the business development guidelines have evolved to accommodate the needs of scientists, especially in relation to publication. This section will investigate the way that the commercialisation office interacts with scientists. It will also highlight how the office has developed communication skills when interacting with the scientists and ultimately has become an essential component of the modern medical research institute.

In the past, 'commercialisation' has not been well regarded within science. It is seen as counter-productive to the aims of science. It is therefore important that business development/commercialisation officers build good relationships with the scientists and not be considered by scientists as a hindrance to research;

> *'Everything is based on empathy and personal chemistry. So, each scientist you have to treat totally on their terms. At the end of the day they are the prima donnas, the propeller heads, they have egos as big as the Grand Canyon some of them. You just have to work exactly on their terms. Which means a slightly different style of relationship for each scientist and how you add value for them?'*
>
> WEHIBD01

The interviewer then asked what other aspects of communicating with the scientists was important for raising the reputation of the BD Office with the institute's scientists. The answer was that communication was essential but more important was the Office's ability to maintain the trust of the scientist and to be seen as an ally;

> *'Trust is the other crucial thing so you end up being regarded as an ally, an asset rather than a hindrance.'*
>
> WEHIBD01

At WEHI, as mentioned above, it is important for the officer to work on the scientist's terms in order to be seen as a contributor to the research process. In contrast, at QIMR the officer considers himself as more than a contributor, a partner in the scientific research process, always ensuring that there is sufficient data for a preliminary patent;

> *'We see our role as a partner, rather than getting a hand ball over the fence and running with it....there are times that we want to be out in the front office but most times we are in the back office yelling and encouraging instructions saying 'why don't you try this'. That is the model I adopt anyway.'*
>
> QIMRBD01

This hands-on model contrasts with WEHI's model which is more non-interventionist. However, the QIMR method emphasises the importance of positively engaging scientists. More importantly, QIMR takes a long term approach by educating and guiding its scientists about commercial opportunities for their research from the grant writing stage up to the product development stage. Most important for QIMRBD01, was that he would always remind the scientists that he was there to work for them;

'...you need a positive engagement with the science and the scientists. You need to be there working for them, to be seen to be working for them and that's a lot of work.'

QIMRBD01

QIMRBD01 was then asked how this was achieved, in particular, in relation to persuading scientists to make business decisions in regards to their research, especially when the scientist has no previous experience in commercialisation. QIMRBD01 sees his role mainly as building positive relationships with the scientists that are open and relaxed. Otherwise, as described below, QIMRBD01 may find out about a particular technology second-hand and therefore not eligible to be commercialised.

'A lot of it is developing that relationship so that they trust you because they have two options when they publish a paper, publish a poster or do anything communicative. They can give you a call first and ask you what you think or you can find out three months later, or not at all...'

QIMRBD01

The above quotation adds further evidence to the point in the last section of this chapter that there are communication advantages to an internal business development office. The obvious disadvantage to the previous company, Amrad, having control of the institute's commercialisation is that there was no time for building relationships with the scientists. Indeed this type of relationship only reinforces the feeling of some scientists that commercialisation is a separate intrusion and counterintuitive to the objectives of scientific research.

In order to achieve the reputation of *'working for the scientist's,* QIMRBD01 approaches the task of the commercialisation of research in what he described as a 'cradle to grave' approach. This also helps nurture the relationship with the scientist. The strength of this relationship is also important in providing a good experience and making scientists aware of the role the Business Development Office plays in the research process.

> *'For commercialisation my philosophy is that you need a little bit of cradle-to-grave approach in that you need to work with scientists right at the beginning, when the grant is written, in terms of discussing commercial opportunities right through to seeing if something comes out of it, submitting a patent with them, discussing the commercial opportunities...If you just came up for three months saying essentially 'what have you got?'' then that is not the same.?'*
>
> QIMRBD01

In contrast again, at GARVAN, the office enforces a teamwork approach to the commercialisation process with definite roles for each participant. In addition, the BD Office employs a person with a strong scientific background to participate in these meetings and to provide a translational buffer between the scientist and the BD Officer;

> *'...when we have a potential new discovery we all sit down together at that initial meeting so that they actually understand the patenting process timelines but not because they have to do anything and I think this is a really important point '*
>
> GARVANBD01

In contrast to the QIMR, GARVANBD01, does not involve herself in the initial grant writing stage of the research but instead emphasises that her Office does not interfere or try to *'direct'* the research. By removing her influence from the initial research planning stage, GARVANBD01 attempts the raise the reputation of the BD Office by emphasising to the scientists that commercialisation is available to all GARVAN researchers but it is not essential for all GARVAN scientists to be involved in commercialisation.

'...they are researchers and that is what they should be. So our Office in no way shape or form tries to direct their science in an overt way.'

GARVANBD01

These meetings are also used to discuss the direction of the science and to potentially fund any additional research. The office attempts to not interfere with the science or to appear to direct the research in the way of a patent. If they are seen to be doing this the office is aware that the relationship with that particular scientist can be damaged by any appearance of involving themselves in the scientific decision making process. The office is aware of the separate roles of the scientists and the BD Office in the patenting process. Likewise, any appearance of directing any scientist can negatively impact their reputation with the entire institute.

'So I guess it is a different approach than saying 'you'll do this now' and risking resentment. So scientists who want to be a part of it – are, and scientists who don't,- don't but I have to say that, in my experience here, there are very few who aren't interested and don't want to know.'

GARVANBD01

This teamwork approach between the scientist, the BD Officer and the patent attorney also helps to outline the responsibilities of the participants without attempting to overtly direct the research. The scientist remains the main protagonist in the commercialisation process with the emphasis for the BD Officer on working with the scientist to provide the best outcome for the scientist and for the institute. This type of approach is advantageous for the BD office as they find that there are a very small number of scientists who are not interested in commercialisation. The positive opinion of commercialisation by the scientists at GARVAN reflects the efforts of the Office in not only their day to day interaction with the scientists but also the result of an intensive commercialisation education program run by the BD Director when she first came into the office;

> *'What I noticed coming in is that they didn't really understand what patents and patenting is really about apart from a number that you put at the end of your grant application...what I have done or tried to do is, first of all to educate the scientists about what commercialisation is but that is actually the pointy end of it...'*
>
> GARVANBD01

By educating the scientists about what commercialisation is and by explaining the steps involved for any scientist wishing to be involved, GARVANBD01 feels that there is a better relationship between the BD Office and the GARVAN's scientists.

> *'Now through the training program with the attorneys there is a much better team approach between the BD office, the patent attorney and the scientist.'*
>
> GARVANBD01

This is obviously a successful method not only to educate scientists about both the possible returns from commercialisation but also to de-mystify the rumours about the restrictions of commercialisation on academic freedom. In addition the training also helps scientists to see commercialisation as not just something that is *'put at the end of their grant application'*. The GARVAN is not alone in using techniques to promote commercialisation to its scientists, at the WEHI, financial incentives are used. However, these financial incentives are not just given to those involved in commercialisation but to the entire institute regardless of their research program'

> *'I think that part of the acceptance [from the scientists] is because we have a unique distribution policy so that all of our revenues that come in from*

commercialisation, 20% goes to all staff irrespective of who they are and students provided that they have been here for at least 12 months.... 30% go to the inventors'

WEHIBD01

This 'internal distribution' model for the financial revenues from the Institute's commercialisation activities is particularly important. Especially if all scientists benefit from the institute's commercialisation activities, it sets a firm precedent for scientists who are not involved in commercialisation of their research. Additionally, if every scientist benefits from the results of commercialisation it reduces the antagonism between the scientists who commercialise their research and the scientists who still view commercialisation as akin to *'selling out'* in science.

'So what that does is set up a really strong scene for everybody as everybody benefits from at least that side of commercialisation.'

WEHIBD01

This emphasises the type of financial rewards for scientists that can potentially stem from commercialisation. To those scientists in research programs with little opportunity for commercialisation, it helps promote commercialisation as not only an acceptable alternative source of funding but also an essential aspect of scientific practice.

There is another way that BD Officers promote the importance of commercialisation in science and that is not only by de-mystifying the rumours about the restrictions of commercialisation on science but also by facilitating change of the commercial practice regarding commercialisation. One of the major criticisms from scientists about commercialisation is that it suppresses their academic freedom, in particular their ability to publish their work. New commercialisation guidelines allow scientists to publish in addition to patenting their work. This is not because the law has changed but because commercialisation offices are aware of scientists need to publish and have changed their practice in order to accommodate the scientist's needs. This change has occurred across the institutions regardless of personnel. Officers can lodge a preliminary patent prior to a journal article being published in order to protect the scientist, the research and the interests of the institute.

> *'Now people [commercialisation officers] are slowly coming around saying "publishing is important and we just have to get the timing right"....Publishing always been important and probably in some ways you say that it was more important than the patent...'*
>
> QIMRBD01

This attitude towards patenting is remarkably different from the views expressed by scientists in the literature. Indeed, some opponents of commercialisation have scientists believe that research can either be patented or published but not both. QIMRBD01 continued to explain why the internal commercialisation office values published results and in fact, encourages it.

> *'...we go and talk to Amgen, Merck, they don't know what your IP looks like, you tell them you have some IP for biomarkers in Cancer, sure, they will take it, but they wont even look at the patent, they don't care about the patent numbers. What they will look at is the quality of the researcher and their publications.'*
>
> QIMRBD01

Commercialisation offices value the opinion of the scientific system where reviewed, challenged and replicable results represent a valuable investment for start-up and pharmaceutical companies. QIMRBD01 explains below why this attitude towards publishing has changed;

> *'Sophistication - sophistication of the people in the offices is one issue. I think the people who are in these [internal BD officers] positions are slowly becoming a little more experienced.... now they understand is that there is a balance between the two [publishing and patenting], kind of a maturity I think....'*
>
> QIMRBD01

At GARVAN it is no different and, as a result of the change in her commercialisation guidelines, it is possible to publish and patent. In fact, GARVANBD01 previously mentioned commercialisation training program has informed scientists of the internal BD Office's growing sophistication in relation to the scientific community's need to publish their results;

> *'...now that they have done the training program because of the training program. In fact, the first module is called "How you can publish and patent" and this is now totally doable.'*
>
> GARVANBD01

The increased sophistication of the internal BD Office and the personnel within it are being recognised by the scientists with the institute. As described below, the Director of the GARVAN, when asked about balancing the presumed conflict between publishing and patenting in science, emphasised that one way to avoid any conflict was to employ a full time internal BD Manager. Now, the job of the internal BD Office is not to chase down scientists and restrict their communication freedoms but instead to continually educate the scientists so that they do not forget their commercial responsibilities at conferences or on more informal situations.

'[the Director] just got up, and he gave a talk on commercialisation. That question which now, to me, seems an old fashioned question - he just said that in our experience if you have a professional BDM, it's just a non-issue. The issue is more probably capturing people who are out and about talking to people and just forget.'

GARVANBD01

The GARVAN BD Office, as in the other BD Offices, has identified the needs of scientists to communicate their work using formal methods and has re-evaluated their expectations to accommodate this need. The BD Office is concentrating more on changing the casual nature of internal science communication, for example, scientists using informal means of communication.

'...If there is a potential patent there and often they just want to talk when the data is still early anyway, you can revise the abstract and just explain to them what they cannot do. This is so they do not mention that a particular gene or so forth, you kind of coach them up to where they can stop [talking] or you just go ahead and file a provisional application.'

GARVANBD01

GARVANBD01 continues to explain how the commercialisation office has changed their practices to accommodate the desire of the scientist to publish their work. In order to allow this, the office will move quickly to commercialise the science if needed;

'Certainly regarding publications, it's rare now to miss anything and I don't think people, and this is the whole point about having a patent attorney who is visible to the scientist, is that they will turn around applications quickly if needed'.

GARVANBD01

By being visible to the scientists within the institute, this also means that the BD Officers need to be responsive to the needs of the scientists. On many occasions, this will mean being required to submit provisional patents within tight deadlines. This willingness to work to these tight deadlines by the scientists not only reflects the strength of the office's relationship with the scientist but also reflects the increased sophistication of the office in being able to adapt to the needs of the scientific community.

> *'So if a scientist will come in and say that he has to go to a conference in two weeks, the patent attorney is fantastic and we have trained them up - they are part of the team and understand what we are trying to achieve in this office – and so they'll get cracking.'*
>
> GARVANBD01

As demonstrated by the above quote, the commercialisation office accommodates the need of the scientists to both publish and patent by covering the commercialisation needs in as little as 48 hours notice. This good relationship, built on the needs of the scientist first and the needs of the institute second, reflects well on the commercialisation office and demonstrates a good working relationship between commercialisation and science.

4.4 Chapter 4 Summary

The discussion for this chapter and for results Chapters 5 and Appendix III will be presented in the General Discussion section in Chapter 6 however a summary of the results discussed in this chapter is included below. The aim of this chapter was to identify and to describe the different ways in which the internal PR (communication) and BD (commercialisation) offices operate within their respective institutes. A summary of the results presented in Chapter 4 are summarised below.

In relation to the internal PR Offices, a number of different activities undertaken by each institute's office were observed. For the JCSMR and GARVAN offices, the focus is on more general communication activities such as media releases and newsletters. At JCSMR, the internal PR office consists of only one person who constantly liaises with the ANU media and communications office to promote JCSMR in the community. The GARVAN supports a larger team of internal officers who work in coordination with The Garvan Foundation, an external fundraising arm of the institute. Despite this, the two offices coordinate a large number of tasks considering the size of each office relative to the size of their institutes. Both office responsibilities include a discreet and indirect fundraising role however, this is not the main focus of the internal PR Office at these institutes. In contrast, POWMRI and QIMR both support a large focus on fundraising as a prescribed role for their internal PR office. POWMRI is a smaller institute (and the smallest institute in our sample), that is focused on neuroscience related research areas. This can make the fundraising role more challenging as it is in the Office's opinion that the public is less inclined to donate to neurodegenerative disorders than to a cancer program, an effect aptly named the 'Bald Baby Effect'. POWMRI also supports a full time fundraising manager as part of the PR office, a responsibility that is described as essential for the success of the institute's fundraising objective. Despite this, fundraising focus however, the POWMRI internal PR office still regards itself as present to primarily promote the research of the institute and to ultimately act as an advocate for their institute's research, despite any Bald Baby Effect. In contrast again, the role of the internal QIMR office is ultimately geared towards fundraising. Each officer reflected in the interviews of how, in spite of fundraising not being the primary focus of their role, each one of their actions are either indirectly or directly aimed at positioning the institute in relation to maximising its fundraising potential. In response to this focus of the internal PR office, there is a separate body known as the Community and Consumer

Participation Committee (CCPC) that is a separate committee responsible for creating and maximising science communication opportunities for the QIMR scientists. The CCPC is primarily run by the QIMR scientists and is committed to *'facilitating our scientist's involvement with consumers and the community at large'*. It is vastly different and therefore is kept separately from the internal PR office because of the conflicting aims. The internal office at the WEHI does not include a fundraising aspect. As the oldest and one of the most prestigious MRIs in Australia, fundraising assumes a minor role to the efforts of the office that aim to create and maintain the WEHI brand and corporate presence. By controlling the look and feel of all material used by the WEHI scientists outside the institute, the PR Office ensures that the WEHI is promoted as a professional organisation to both public and scientific audiences.

In order to achieve results, it is essential that the PR office maintain a good relationship with the institute's scientists. At GARVAN and JCSMR, both PR managers are ex-students and/or scientists of their respective institutes. In their opinion, the knowledge and confidence in their scientific backgrounds results in a level of trust between themselves and their institute's scientists. This is especially in relation to communicating their science and research to the public accurately and efficiently without reference to the 'B word' (breakthrough), a generalisation the Officers are aware that can upset some scientists thereby jeopardising their relationship of trust between the institute's scientists and the internal PR Office. This is also, to a lesser degree, the same at the POWMRI where the PR Manager is an ex-nurse and so reportedly has no problem maintaining a good relationship with POWMRI's scientists. The WEHI manager, with an education and fine arts background, does not see his lack of scientific training as a disadvantage. In fact, he considers his lack of scientific background as an advantage. The main advantage is in prompting the scientist to speak in 'Noddy and Big Ears' language so that he may assess the angle of the research story that will be the most attractive to the media and to the public. The QIMR PR officers in contrast, are overtly aware of their lack of scientific training and are under the opinion that this disadvantages them as both advocates and communicators of their institute's research. The QIMR officers revere the institute's scientists and interact with them indirectly; failing to engage with them on a day to day level the same as was described at the other participating institutes.

When choosing a research program to best promote the institute, the internal PR officers described a number of techniques used to achieve maximum exposure in the media and to attract the most attention for the institute. In particular, generating a level of human interest in the research projects is very important. In fact, the best research programs to use as promotion, are the ones where the potential outcomes will improve the health of the largest number of people. With this in mind, cancer research programs are used extensively by all the internal PR offices to promote the institute. The public's desire for advances in Cancer research is an area that puts institutes such as the POWMRI at a disadvantage, especially in relation to fundraising. With a focus of neuroscience related disorders and disorders that effect primarily the elderly, it is difficult to generate the same level of interest in POWMRI compared to an institute with a well established cancer program. In fact, QIMR openly states that the institute's Cancer research programs account for a large majority of the PR Office's fundraising efforts. This is again a result of the level of human interest in Cancer research in Australia. This level of interest, however, would not be the same in other countries where the biggest public health concerns are Malaria or Tuberculosis, to use an example. At the GARVAN, JCSMR and WEHI, although fundraising isn't the main objective of the internal PR Office, the 'human interest' angle is still important when communicating the science to the public. This is not only due to the public's level of interest in these areas of research but also that people will begin to associate that institute with a particular medical condition.

In relation to commercialisation, the internal BD office is a new addition to three out of five of the participating institutes with the office only recently established internally in the last 5-7 years. GARVAN, WEHI and QIMR support an internal BD office whereas the commercial activities for both POWMRI and JCSMR are coordinated by an external, university affiliated BD Office. For the sake of the research questions of this thesis, however, this study is limited to the activities of the internal BD offices only.

For both WEHI and QIMR, the commercialisation activities were previously coordinated by external, independent companies. This, according to the current BD Officers, caused some tensions between the companies, the scientists and the institute. Establishing the internal BD Office for both institutes has allowed each to remain in control and monitor the progress of its commercial interests more thoroughly that was done previously. Another advantage that will be discussed further on is that maintaining the internal BD Office has allowed each Officer to form valuable working relationships with the scientists and to promote the engagement with commercial companies in a more positive light than was done previously. In contrast, the internal BD Office at the GARVAN has been a recognised addition to the institute since 1997. The internal BD Office team at GARVAN comprises of people from a variety of different professional backgrounds. This is seen as a major advantage for the internal team, that sees maintaining staff with a sufficient scientific background as essential to building relationships and communicating with the GARVAN's scientists. This positive engagement with the institute's scientists is also seen by the internal BD Offices as an essential catalyst for scientists to participate in more commercialisation activities. This is especially in relation to commercialisation previously being viewed by scientists negatively and against the accepted norms of science and of scientists.

In addition to this, all internal BD officers stated that maintaining a level of trust between themselves and the institute's scientists was imperative to a successful internal BD office. For QIMR, this trust was built up over time and in order to achieve this, the internal BD officer would adopt a 'cradle-to-grave' approach to research. This meant that the internal BD Office would be involved in the research process from the time that the initial research grant application was written, to the time the patent is filed. In contrast, the GARVAN internal BD Office stresses that it is important that the office not be seen to direct the research in any overt way. This way, they remain an active partner in the commercialisation process but do not interfere in the research program on any level. The WEHI adopts a different approach through a unique distribution policy in relation to funds achieved through commercialisation. By distributing 20% of all funds generated by commercialisation to all WEHI staff irrespective of whom they are or if they have ever been involved in commercialisation, WEHI employs a unique method of stimulating institute-wide support for commercialisation successes. It is also hoped that this type of distribution policy will reduce any antagonism between the scientists who commercialise their research and the scientists who still view commercialisation negatively.

Additionally there is a willingness of the internal BD Office to adapt their policies and procedures to meet the needs of the scientists. All internal BD Officers acknowledged that restricting a scientist's ability to openly communicate about their research is seen as a major disadvantage of participating in commercialisation. To combat this, the office will frequently file preliminary patents or aid the researchers in any way necessary, to allow the scientists to communicate their research at scientific conferences or publishing journal articles. This level of professionalism and the level of maturity of the internal BD Officers quickly make any scientific concerns regarding communication superfluous.

It is hoped by all internal BD Offices that increased education about the commercialisation process, the existence of incentive schemes, an increased number of scientists engaging in commercialisation and the increased professionalism and maturity of the internal BD Office will stimulate more interest and a greater level of engagement with commercialisation for all scientists.

Chapter 5: Results

"Now, firs' thing yeh gotta know abou' Hippogriffs is they're proud," said Hagrid. "Easily offended, Hippogriffs are. Don't never insult one, 'cause it might be the last thing yeh do."

Malfoy, Crabbe and Goyle weren't listening; they were talking in an undertone and Harry had a nasty feeling they were plotting how best to disrupt the lesson.

"Yeh always wait fer the Hippogriff ter make the firs move," Hagrid continued. "It's polite, see? Yeh walk towards him, and yeh bow, an' yeh wait. If he bows back, yeh're allowed ter touch him. If he doesn' bow, then get away from him sharpish, 'cause those talons hurt."

"Right – who wants ter go first?"

Most of the class backed further away in answer.

Harry Potter and the Prisoner of Azkaban

J.K.Rowling pp 88

5.1 Introduction

Like Hippogriffs, scientists are a largely misunderstood group of people. They can appear proud, unapproachable and demand respect. This chapter offers an alternative viewpoint, one that gets past the sharp talons to investigate what makes a scientist. Specifically, the main aim of this chapter is to examine the different views of scientists regarding communication and commercialisation of science as well as examining some of the consequences of the increased emphasis of public accountability. In particular, it will focus on the relationship of scientists with the internal BD and PR Office strategies of their own institutes. It will also explore the presumed effect of the increased emphasis of communication and commercialisation as arms of public accountability on how scientists practice science.

In this chapter, I will track the motives of scientists from each institute. I will follow their motives for pursuing a career in science and their attitudes towards communication and commercialisation of science. By comparing these attitudes with those of other in other institutes I will attempt to further understand the motivations and aims of scientists in regards to this increased level of public accountability.

5.2 Methods

Also see General Methods

5.2.1 Interviews

Interviews were scheduled with scientists from each participating institution, with the consent of the communication offices and the institute Directors. The interviews with the scientists and with the Office professionals were conducted during the same visit to the institute. This allowed for the cross comparison of themes highlighted by the scientist interviews with themes in the internal BD and PR Office interviews.

Scientists indicated their interest in volunteering for the interview by contacting the Communication Office, who then gave me a list of names and contact numbers in order to arrange a time for the interview to take place. Additional interviews were scheduled with interested scientists as I met them during my time at the institute. All interviews were done in person and were recorded for transcription. Interviews lasted for approximately 30-60 minutes each. All interviews were semi-structured with a list of themes to be covered. This purposeful lack of structure also allowed the interview to progress more like a conversation with particular questions to be covered.

5.2.2 Field Classification

Each scientist has been codified by a notation that relates to their affiliated institute and a identification number. In addition, scientists were further classified into their field of research in order to draw comparisons within and between research fields. Each scientist's field classification is provided after their quote, next to the identification number in brackets. A list of the different fields of research classifications is given below in Table.5.2.2.

Table 5.2.2
Field Classification and Definitions used in the Interview Data Presented in Chapter 5

Abbreviation	Field Classification Definition
CHD	Cancer and Haematology (Including Cancer Research)
DNG	Neurobiology (Neuroscience)
IMM	Immunology (Basic Immunology)
MBD	Molecular Biology (Basic Moloecular Biology)
EPI	Epidemiology
INF	Infection and Immunity (Infectious Diseases, Vaccines)
GBI	Genetics and Bioinformatics (Basic Genetics and Bioinformatics)
ATD	Autoimmunity and Transplantation (Asthma, Diabetes)
JPS	Joint Proteomics (WEHI Specific)
HBP	High Blood Pressure
MGC	Molecular Genetics of Cancer (Including Applied Genetics)
SBD	Structural Biology
OTHER	Other Miscellaneous Research Areas

5.2.3 Analysis

All interviews were fully transcribed and were then hand-coded for analysis. In conjunction with the interview notes taken at the time of the visit to the institute, the interviews were initially analysed for common themes between scientists, fields and institutes.

5.3 Results

5.3.1 Scientists are Scientists for mostly Altruistic Reasons

The first question asked of the participating scientists was why they chose science as a career. By doing this, I hoped to standardise the background information of each scientist in order to draw parallels between past experience and the attitudes they expressed about communication and commercialisation in science. However, what was found was that scientists had different reasons for pursuing a career in science that fell into one of two categories; curiosity and altruism.

It was found that scientists with a strong clinical focus tended to answer the questions in line with altruistic reasons. Overwhelmingly, these were the major reasons cited by interviewees. Those who did not were mostly grouped in fundamental research fields. Those scientists who entered science for altruistic reasons were usually involved in a directly applicable and clinical field of study and those who were in fundamental or basic science tended to express non-altruistic reasons. It was interesting, however, that even though curiosity was, for many scientists, a main motivator for a career in science; these scientists still wanted their research to have some application to the improvement of public health.

For example, the first scientist, when asked why he became a scientist answered;

> *'I wanted to combine discovery with doing something useful. I wanted application as well as to find something new and different...'*
>
> WEHI006 (ATD)

His success in translating his research into clinical application has been evident from his PhD student days to the present. His passion for finding application for his research is evident in his activities with the National Coeliac Association (NCA), but his involvement with finding application for his research does not stop at the laboratory. In addition he regularly writes articles for the NCA magazine describing his research (for more information of WEHI006 communication activities please see below). His passion for the subject and for eventually reaching his goal of developing a vaccine for Coeliac Disease and is his main motivation for pursuing his career in science.

This enthusiasm for finding an application for research is also a main motivator with other scientists at the WEHI, the GARVAN, JCSMR, the QIMR and the POWMRI.

One scientist at the WEHI described his reason for becoming a scientist as a way to repay the world for his enjoyable childhood spent in Papua New Guinea and Africa. Whilst growing up in these countries, he saw firsthand what diseases can do to developing countries. Although, not his primary motivator for working with diseases such as malaria, it is rewarding to apply his research findings to the benefit of communities such as the one he lived in as a child.

> *'I have a very wide field of interest ranging from very molecular stuff through to translational and product development research, public health, population health*

> *research and health policy.... It gives me an opportunity to travel to the developing world and on an ethical note I think I had such a privileged and unusual childhood it also give same an opportunity to, in a small way, to give back something for what I received as a child in Africa and PNG.'* *WEHI005 (INF)*

His father was a Medical Doctor in Africa and PNG and although he did not follow the medical path completely he still finds that his main motivator involves translating his research to benefit the community.

> *'...the fact that I'm working on one of their major health issues, and I think there is applicability that results from basic research through that public health in the long run. And the ethical component grows with importance as I get older. I think it wasn't a huge motivating factor when I was young but it certainly is now.'*
> WEHI005 (INF)

At the GARVAN Institute, the motivating factors are the same. With close alliances to St Vincent's Hospital, the GARVAN Institute has a reputation with the public for its high quality research. It is no surprise, then, to find scientists with an altruistic motivation for selecting a science career.

There are, however, some scientists that choose a scientific career for reasons other than philanthropy. They include innate curiosity and the urge to discover new things. In more fundamental or basic fields of scientific research scientists tend to be motivated by their own curiosity. This trend can also be seen between institutions with fundamental research groups such as at the WEHI and JCSMR. One scientist, in the Molecular Biology field (MBD), at the JCSMR mentioned that his main motivating factor, as well as curiosity, was that he had a good science experience at school;

'I guess I always wanted to wear a white coat (laugh). I was always interested in science at school; it was probably my favourite subject so I just followed down that path. I didn't particularly want to teach, so I always wanted a research career.'

JCSMR029 (MBD)

Likewise, at the WEHI, a good science experience at school encouraged many scientists to pursue their career;

'I suppose way back in school I was interested in the world and nature and natural things and I suppose if you do well in maths and arithmetic in the early days you started to enjoy it or you feel that you got some type of reward from doing well, but then in high school it was my Chemistry teacher in Year 11 and 12 who was a really clever and funny guy.'

WEHI009 (SBD)

Innate curiosity is also a very popular motivator among some scientists from applied areas of research. One scientist from the WEHI described his motivation as;

'I think the main reason is that I always wanted to know what made things tick. And I had a strong biological bent. So I wanted to know how the body worked and that started from a pretty young age.'

WEHI004 (ATD)

Surprisingly, as seen in the notation, this scientist is involved in applied research, that is the *Autoimmunity and Transplantation* Area, but he is unusual. His original career path involved a much more applied field. He initially studied and practiced as a veterinary surgeon before choosing to follow a career in science.

There were also a number of researchers who indicated curiosity as the reason why they pursued science careers. At first, this answer seemed to negate any altruism on the behalf of these scientists. However as the interview progressed it became clear that despite their reasons for embarking on a scientific career, their awareness of the application of any research outcomes to public health was evident. For example, the scientist recorded below, despite entering a science career because he was always a *'curious person'*...

> *'I've always been a curious person. I've always been fascinated with, say, the unknown questions....of all the science the one that I was most interested in was biology and I was fascinated with how nature works. It seemed like such a natural thing for me to pursue my education in the biological area.'*
>
> QIMR006 (GBI, CHD)

Despite being fascinated with his work and pursuing a career in science for its interest, QIMR006 still recognised that in receipt of public funds, his main driver and reason for conducting research was for the benefit of public health, rather than any personal gain;

> *'I was interested in translating the basic science and technologies to something that was useful clinically to the community and so naturally I became more interested in medical research per se than just cell biology.'*
>
> QIMR006 (GBI, CHD)

In addition, scientists' involved in the traditionally 'basic' sciences, still were acutely aware of their 'reasons' for science as recipients of public/government funding;

> *'I think it is an absolute necessity to repay the people that are investing in research...the two ways of doing that are through improving healthcare and creating jobs...'*
>
> WEHI002 (MBD)

The following sections of this chapter will explore other characteristics of scientists keeping in mind that the impetus to join the scientific community would reflect on other attitudes.

5.3.2 The Role of Commercialisation in Science

Commercialisation is still considered by most scientists as a new influence in science. In fact, when asked about the role of commercialisation in science, most scientists reflected that its role was at a time considered a *'dirty'* aspect to science and more shockingly, that involvement in industry was something that scientists did only if they could not be successful in science.

GARVAN001 described the attitudes of scientists towards commercialisation 20 years ago as;

> *'...if you went back into the '80s in Australia the culture with regards to commercialisation was very much – the poorer the scientist, the better the science'*
>
> GARVAN001 (CHD)

He went on to describe that scientists were not expected to personally profit from their research that they were to conduct their research in accordance with traditional scientific norms. In particular, Merton's norm 'disinterestedness' implies that no scientist should have a vested financial interest in the outcome of their research. When this scientist started his post-doc in the US no fellow scientist within his laboratory had even considered combining academia with industry;

> *'I remember at the time at the University of California when we did that [cloning human growth hormone gene] and one of the university lawyers came around to talk about patenting this and it sounds ridiculous in this day and age but I swear*

that most of the researchers in our researchers had no idea what a patent was. Never heard of the word!'

GARVAN001 (CHD)

This was also the case at other institutes;

'...when I started in science, commercialisation was a dirty word whereas commercialisation now is very much highly regarded.'

WEHI004 (ATD)

This, according to many scientists in addition to GARVAN001, has changed dramatically, especially at the GARVAN.

'That changed dramatically around the world with the development of biotechnology where it became very clear that the science had changed suddenly in biology where basic research discoveries were much closer to commercial outcomes than they might have been before that technology was there.'

GARVAN001 (CHD)

The negative attitudes that scientists have demonstrated in the past towards commercialisation are described in the literature as commonplace in science. Indeed, all scientists treat commercialisation with a level of cautious scepticism knowing that despite commercialisation being a tool for the delivery of their results to patients, they are acutely aware of the potential tradeoffs of commercialisation such as the scientist and the industry partners conducting the research for different reasons as well as the fear scientists feel about losing control of their research to the industry partner. In addition, as seen in the previous section, scientists are generally in research for the altruistic and curiosity reasons whilst industry is more involved for the financial gain. This difference in particular can be a source of tension for scientists.

> *'It was very successful from our point of view but because the funding regime changed they more or less pulled the plug on the whole thing which was very disillusioning to us because we had felt that we had held up our end of the bargain.'* *GARVAN002 (ATD, MBD)*

This scientist was involved in a high-risk project with an industry partner. Unfortunately, even though the research team was conducting successful research, the industry partner suddenly pulled the funding, halting the research and as a result the scientific group felt a lack of control of their own research.

Despite this, it is the evolving maturity of the internal BD offices that is cushioning the impact of being involved with industry. As a result success stories are slowly emerging that are silencing the horror stories and therefore are gradually attracting more scientists to be involved with the commercialisation process.

> *'I think here it's developed quite rapidly over the last decade or so and its becoming lots more streamlined in terms of procedures and forms for viewing potential IP to getting it ratified and getting lawyers to draw up patents if it looks as if it is a viable entity.'*
>
> QIMR006 (GBI, CHD)

Some institutes and scientists also make sure that their scientists remain involved in the research as well as maintain their *'scientific integrity'* by not allowing the industry partner to dictate the terms and the direction of the research;

'...we go to a lot of effort to make sure that the tail doesn't wag the dog, If a major pharmaceutical company or industry came to us saying 'we want you to do research on x.' If that wasn't exactly what we wanted to do anyway, we wouldn't even contemplate it.'

GARVAN001 (CHD)

This is in particular reference to the concerns most scientists have felt regarding how involvement with industry affects their ability to freely publish their research results. In the literature there have been reported cases of the industry research partners delaying the publication of scientific articles whilst protection of the research is being processed. For many scientists interviewed this is not a concern, with very little publication delays experienced;

'If I'm working on a paper that is really cutthroat and in a competitive field so I have to get it out quickly, sometimes it can make me feel really anxious but the thing is that we've got a lawyer [in the BD office] here and we can make up the contract and it says that if a publication is coming out they [the commercial partner] is bound to check it and approve it within a couple of days so that is fine.'

GARVAN004 (DNG)

The lack of delay in submitting publications expressed by these and a majority of scientists are contrary to those described in the literature. However, the following quote demonstrates that a delay in publication by commercial partners is a real concern for some scientists involved in commercialisation. Their colleague's experiences with their commercial partners are contrary to their fears about holding up and delaying their publications.

'The only thing they require is that if we write a publication they want to see the manuscript before we submit it. Initially we were fearful that maybe they would sit on it for a very long time but it actually turned out to be much better than we

thought. The last manuscript that we sent to them they okayed it for sending off within 24-48 hours of us sending it to them, that's a heck of a lot better than I feared so we haven't had any problems'

WEHI011 (MGC)

There were, however, some differences between institutes in relation to the attitudes the scientist have towards commercialisation and this was mainly in relation to publication delays. When this trend was further investigated, the differences in each institute's effectiveness of communicating the benefits and advantages of commercialisation in science were particularly in reference to whether the institute had an internal commercialisation reference point.

Institutes such as the GARVAN which maintains an internal commercialisation reference point, had an overwhelmingly positive attitude towards the role of commercialisation in science. For GARVAN specifically, the institute has developed a reputation for their involvement with commercialisation. This is mainly due to the success their scientists have had in past commercialisation ventures but also because of the range of incentives the GARVAN offers its scientists to be involved in commercialisation;

'...The first $10K goes directly to the researcher up to $100K is shared 50/50 and then over that is 30% to the researcher, 30% to the research department, 30% to the institute.'

GARVAN001 (CHD)

The scientist goes on to explain how an individual scientist or a research group's success with commercialisation is used to benefit the entire institute;

'On top of that – if you were researching on a patent and some money from that comes into the institute e.g. if you earn $50K, you may get $25K and the institute would get $25K but we would also say to you that if you wanted to take that $25K personally then that is fine but if you decide to simply use it to fund more research in your research group then the institute would match that again and invest in your research.'

GARVAN001 (CHD)

This sharing of the success of the commercial partnership both benefits the scientist and the institution at large. This also indirectly demonstrates to the GARVAN scientists who are not involved in commercialisation the benefits of a relationship with industry, adding to the team environment of the GARVAN whilst encouraging other scientists to seek commercial finding for their research.

At JCSMR, an institute without an internal commercialisation reference, scientists overwhelmingly feel that their ability to communicate their research results, both formally and informally, is restricted by their industry collaborator. Also the delay in publication was longer for scientists at JCSMR who were involved in commercialisation compared with the delays for scientists at the GARVAN or at WEHI;

'Part of the agreement, of all commercial agreements, that you have a 60 day clause that any work that you are going to publish needs to be run past by them within 60 or 30 days of submitting it.'

JCSMR026 (CHD)

One scientist described another disadvantage of communicating research whilst being involved in commercially funded research. This was despite the scientist not being involved in commercialisation.

'...When you try and discuss it [your research] with other people, you can't anymore because people now repeat the same experiments over and over again because no-one actually tells you what they have already been done.'

JCSMR020 (DNG)

It seems that without the continual presence of an internal BD reference point, scientists at JCSMR are prone to believing only the negative aspects of commercialisation. In addition, the lack of success stories within the institute fails to convince any other scientist at JCSMR to pursue industry relationships.

In addition, at JCSMR, there have been negative experiences with publishing and commercial involvement which have also failed to positively promote commercialisation to other scientists within the institute. Scientists at JCSMR still feel extremely restricted in their freedom to publish their results in scientific journals if their research is funded, even co-funded, by industry. This indirectly affects the opinions of other scientists in relation to commercial involvement and may help to dissuade them from seeking industry funding in the future, such as the scientist quoted below. He is concerned about his ability to freely communicate when funded commercially and this is a main inhibitor of his seeking out industry funding.

' ...commercial in confidence means that you can't publicly present your data to other scientists but if we set that aside and think of more general ways in which it might affect communication then I think that it probably tends to inhibit free communication because purely academic scientists would tend to free-associate when they are chatting to their colleagues or with people at meetings which is often how good ideas emerge....I can only hypothesise because I haven't really been in that position.'

JCSMR006 (DNG)

This is obviously not always the case with commercially funded research. However, this scientist, even though he is not involved in commercialisation, imagined commercial involvement as something that would inhibit his role as a scientist to communicate his research to other parties. In fact, both the presence of an internal commercialisation representative and the amount of the experience the office has are essential aspects related to how the institute's scientists feel about commercialisation and its role in science. This presence needs to be constant, something JCSMR has failed to achieve through its association with an externally controlled BD office. At QIMR, this was also the case when the external company, Amrad was responsible for handling commercialisation matters before the establishment of the internal BD office.

Scientists are also aware that some fields of investigation are more easily commercialised than others. For this reason, commercialisation has become less about bringing cures and treatments into public health and more about protecting their basic scientific discoveries so that they may protect their research and also so that they may be able to contribute to more applied studies through collaboration.

> *'Tried to patent something once but it was sort of half-hearted, not very serious. I mean I'm not in science for a commercial purpose; I'm in science to discover new things and to protect my research. As I said, I'm an old fashioned scholar and a modern company won't be able to make much money out of me.'*
>
> JCSMR020 (DNG)

This is also particularly relevant for basic research scientists, where the research is not very easily commercialised;

> *'I've also had problems with the basic research focus and then using that and then you are made to commercialise it, then there are problems because it is hard to*

commercialise basic research. If you are made to do basic research then you shouldn't be made to commercialise it.'

JCSMR005 (MBD)

However, by patenting and therefore protecting their research, scientists can indirectly allow other scientists to contribute to the development of treatments that benefit public health. It also allows them to continue researching by receiving funds from industry and collaborators that would not have been funded from the limited public funding purse such as the ARC or NHMRC. This is also, according to some scientists, what the public expects in return for their investment in medical research.

'I see that what we do gets paid by the taxpayer and taxpayers have an expectation that at the end of the day their tax money is going towards medical research and will produce some sort of medicine or cure, a pill they can pop to cure any disease that comes along.'

WEHI007 (SBD)

It must also be noted that the scientists interviewed were less likely to be involved in commercial activity for remuneration benefits and more likely to be partners with industry in order to get their research out to the public, treating and saving lives. One scientist remarked that because science as a career had been poorly remunerated in the past, benefits from commercialisation may be used to lift the bar of a scientist's earning capacity thereby attracting the best people into science and the best scientists to the GARVAN Institute.

'As I said earlier, the poorer the scientist, the better the science but the trouble is that if you extrapolate that what happens is no one with a brain in their head would go into science because there is no remuneration, no future financial reward.... by improving the financial reward for scientists, not just in the immediate sense for Garvan scientists but also permeating outwards to make sure

that we raise the remuneration levels for scientists in general because of their value to the community'

GARVAN001 (CHD)

Institutes such as the GARVAN are starting to use their relationships with industry as the basis for their marketing strategies both to attract high quality scientists but also to inform the public about their research and to attract money. The following sections in this chapter and the Discussion Chapter 6 discuss this further.

5.3.3 The Role of Communication in Science

Previous research in the area of science communication has indicated that scientists are either unwilling or incapable of effective science communication (Stocklmayer et al., 2001). In the preceding years and before the establishment of science communication as a discipline, the opinions of scientists about those involved in science communication were not good. During the interviews it was necessary to identify the scientist's opinion of science communication before continuing with the questions. A scientist's attitude towards science communication is revealed in the following sections about commercialisation and competition in science.

As already discussed in Section 5.3.1 of this chapter, scientists overwhelmingly see 'the practice of science' as a form of public service and one of the motivating factors for doing so is the benefit their research may have in the treatment of disease or in the improvement of public health. Unfortunately, these discoveries do not happen every day and until the day it happens, the role of communication to the public is one that scientists use to inform about of the progress of their research. As this section discusses, scientists use communication for many reasons; to excite the public about science and research; out of a sense of duty in return for taxpayer funded research dollars; and also as a means to attract further funding of their research.

Before identifying the motivations scientists have to publicly communicate their research, it was essential to determine the attitudes the participating scientists have towards communication in science. It should also be noted for this section that unless specified otherwise, the definition of communication will relate to external communication. That is, communication from science to other, non-scientific parties.

The results showed an overwhelming positive attitude towards communication in science even though the importance of communication in science wasn't part of their traditional scientific training.

> *'When I first started in science...it was very much in cloistered hallways that the general public didn't really get to hear much about ...the average scientist nowadays will need to do a lot more in communications in general.'*
>
> WEHI004 (ATD)

Another scientist mentioned that he didn't consider being a scientist as a role that would require a communications role. In fact he decided to become a scientist mainly because he thought that there would be little communication on his behalf necessary in that role;

> *'I really didn't consider that because I didn't want to become a teacher because I'm probably not a good communicator so I became a research scientist because I could get away with that without communicating. I was a bit naive though because you have got to get out and sell your stuff and the public deserves to know about it if they are funding it.'*
>
> JCSMR029 (MBD, MGC)

This comment echoes the first two sections of this chapter, namely that scientists' are more than aware of their public obligations in receipt of public funds. Even though not all research becomes a 'product', communication of science to the public is seen by many scientists as part of their duty in exchange for research funding by the taxpayers.

> *'...it has gone hand in hand with an understanding that the world doesn't owe us a living. We really do have to sing for our supper and explain, I mean if we are getting money from the taxpayers we should be explaining what we are doing with it.'*
>
> GARVAN002 (ATD, MBD)

This however was not always the case with some scientists only recently becoming aware of these obligations. Certainly as reported through the interviews there is a greater appreciation of this duty than there was previously and the participating scientists regularly reported their responsibility in communication their research to the public.

> *'...there is generally a greater appreciation of the need to communicate more clearly and in part that is motivated on the part scientists who realise that they owe their politicians at least, and society in general a better accountancy of what they do and that appreciation has definitely grown and that is a very good thing.'*
>
> WEHI005 (INF)

In addition, one scientist remarked that she saw science communication as a part of the commercialisation of her research, commercialisation to the public as opposed to industry. The scientist first acknowledges that when she started her scientific career that she was unaware of her accountability to the public;

> *'I didn't even know there was an outside world of people who might be interested in the stories that were coming out of my research...I never thought of everyday*

commercialisation where you actually sell the institute or you sell your research project to everyday people.'

GARVAN004 (DNG)

However she now sees her role as one that includes promoting her institute to the public in receipt of bequests and endowments. She sees public communication as similar to commercialisation in science where she commercialises her research is return for extra funding for the institute;

'...I sell my research to drug companies and they give me money. I also sell it to food companies and they give me money and I also sell it to the public in public seminars and PR and they give the institute money in endowments and bequests.'

GARVAN004 (DNG)

This unique view of public communication focuses the attention of communicating research results on gaining money from the public for the institute rather than out of some duty to communicate the research results to the public for already received funding.

Not all scientists view this behaviour favourably; in fact, many scientists felt that this motivating factor for communicating research was in conflict with the *'spirit of science'*. One scientist expressed his frustration with the over-communication of research mainly when public communication is done primarily in search of extra funding;

'...a lot of scientists like me are suspicious of other scientists that go with half baked stories to a newspaper and present themselves as the guru who is going to come up with the next cure for cancer because those of us who have been around a long time have seen it before and nothing came out of it so you become quite cynical [of communication in science].' *WEHI 011 (MGC)*

Another scientist from the WEHI stated that she saw the pursuit of extra research funding not provided by the traditional sources such as the ARC or NHMRC as *'a bit disturbing'*. She singled out many scientists known to her as engaged in these activities and described it as a reflection on how the nature of science has changed since she started her career;

> *'So we have someone like [names colleague] who is in this particular disease and he funds his research by forming a foundation and going to the [disease] society and convincing them that he's a good thing...and they raise money to help further fund his research. And we, my age is showing - find that a bit disturbing because I guess we have the underlying feeling that we are in it for the good of mankind and not self-interest.'*
>
> WEHI008 (ATD)

WEHI008 is concerned with the other scientist's motivations behind their 'extra-curricular' public communication activities. However, a closer investigation of these motivations of, in particular GARVAN004, who though at a different institution and not directly referred to by WEHI008, also considers public communication as a fundraising activity for her institute. Her motivations however disturbing to WEHI008 are stilling largely *'for the benefit of mankind'* with, however, the added benefit of also being philanthropic for her institute as well. In fact, despite referring to the practice as commercialising research to the public, her motivations did not differ from the norm, the norm being a sense of responsibility that all scientists feel to communicate their research to the ones that fund it, the taxpayers.

> *'Public commercialisation, selling our research to the public is also good in many ways because it gives them [the public] hope and education, so they are up to date with what is happening with its government funded research as that is research that they have already paid for.'*
>
> GARVAN004 (DNG)

The further motivations of scientists like GARVAN004 to seek extra funding through these extracurricular science communication activities will be addressed in a later section (Section 5.3.4 of this chapter) in this chapter about *Competition in Science.*

A large majority of medical researchers have also been trained as physicians and who, as physicians, are specifically trained in meeting patient needs. Further to this, doctors and physicians are trained in communication, more commonly known as bedside manner. One of the most important aspects of this specific type of science communication is described below;

> *'...it is always about communicating with patients, do they understand what you are talking about, are you giving them the information so that they can take on what they need to make the decisions that they make.'*
>
> GARVAN007 (OTHER)

The doctor also realises that effective science communication is not only about changing the opinions of the public. It is achieved by being open and accessible so that the public may get the information that they need to make the decision that is best for them.

> *'As a doctor we often think that we tell patients what to do and they do it but of course people do what they want to do. You can say do something or other but if they are not convinced that that's the right thing then they won't do it....communication is fundamental.'* *GARVAN007 (OTHER)*

This method of communication is described as beneficial and helps with how confident these scientists feel when talking to the public. They feel more prepared and therefore more confident as they have received some formal training in communication skills.

'...I was trained as a doctor and as a clinical doctor, so in that sense we do get a lot of training and experience in how to talk to people'

WEHI006 (ATD)

For this particular scientist, the skills he learnt as a doctor have transferred well to those skills required by a scientist to communicate to the public about their research. It also allowed the scientist to relate closely with his patients and to other doctors who allow him to directly communicate the importance of his research whilst increasing the visibility of his research to patients and practitioners.

'So I could communicate directly with the people with [this disease] so I was able to tone my language and communicate to the people that really mattered the most, the patients. At the same time, I matched that with an education program for GP's...so basically the idea was to raise the profile of [the disease] in Australia and NZ recognising that only 1 in 6 people in Australia had been diagnosed.'

WEHI006 (ATD)

The benefit of this type of communication is two-fold; first the scientist was able to use his skills as a doctor to influence patients understanding of the disease and second; he was able to make a significant difference to how this disease was viewed by the public and treated by doctors. This mirrors the first section of this chapter that describes the reasons why scientists have to *'practice science'* are mostly altruistic and to influence public health positively.

The above descriptions by the participating scientists describe two distinctly different modes of science communication; science promotion and science awareness. Although the science promotion aspect of science communication is conducted by the internal PR office, the scientists themselves are involved in a variety of self regulated science awareness activities.

For many scientists involved in basic research, public awareness activities provide a method of giving back to the community, especially if their research doesn't produce any viable product. This is particularly true for many scientists who are involved with applied research but in a disease area that is neither a national priority nor one that directly affects large numbers of westerners, they use public awareness as a way to reach the few people that may be affected by the disease they research.

This is certainly the case for POWMRI 015, as his research area, spinal cord injuries, only affects a small minority of the population. Only 15 people per year in Australia experience some type of spinal cord injury (www.scia.org.au) (*The Spinal Cord Injury Association of Australia*). For this scientist his work directly with patients and the communication of his work to deliver the research results to other patients is of main importance for him.

> *'I still see patients one day a week which is important....you need some scientists that are directly linked to patients.'*
>
> POWMRI015 (DNG)

He sees this direct link with his patients as the main form of his public communication as a scientist in receipt of public funding. By directly dealing with spinal cord injury patients, he can deliver the results of his research without going through the rigmarole of patenting his research. He is also able to directly deliver the benefits to patients with spinal cord injuries.

> *'Whether we can tell people about that and then it can be tested on patients. That's the way to help these people [with spinal cord injuries] and it is not to patent the idea. It's the type of thing that we work on which determines whether a patent in appropriate.'*
>
> POWMRI015 (DNG)

Scientists also are aware that with the greater expectation to communicate with the public comes even greater responsibility. Many scientists reported that they frequently receive phone calls and emails from members of the public as a result of their increased accessibility through public communication. Many of the public who have contacted the scientists have heard about a 'miraculous breakthrough' in the media and are interested in being involved in the research or want to know where and when this 'miraculous breakthrough' is available.

> *'Sometimes when you go out there and you give the media messages and then people start calling and they want to be in the trials of the drug that is going to cure anorexia or obesity.'*
>
> GARVAN004 (DNG)

With all this positive goodwill towards public communication of science, scientists are also aware of the responsibility they hold in providing accurate information to the public as well as not to give out any false hope. The above scientist goes on to explain what she and her colleagues try to do when they receive these phone calls;

> *'We, and one of my colleagues, often we get calls from people, really sad people saying 'Oh my son is dying because of this or that' and you just feel so bad as it [the message] gives false hope.....I give them honest information and find that very often honest information and kindness and just being kind and empathetic can help.'* *GARVAN004 (DNG)*

On one particular occasion, this scientist was able to communicate her research whilst clearing up the misunderstandings this member of the public had about her health problem. Furthermore the scientist was able to refer the caller to an appropriate physician who would be able to provide more information.

'This lady got off the phone and she seemed to be feeling better. She had a mission and it was to call this particular surgeon and she had another avenue to look at.'

GARVAN004 (DNG)

Despite this, the scientists believe that public communication of research results is part of the way medical research leads to the improvement of public health. Scientists are still particularly receptive to members of the public directly and endeavour to communicate the information correctly and to clear up any misunderstandings that have been communicated through the media or any other external communication.

'If there are treatments available then the patients should be told what they are, which is always a balance between not getting their hopes up and telling them what they are.'

QIMR006 (GBI, CHD)

Some scientists, however, see this as the most difficult part of public communication. It is a major failing of the internal communication office as well as the media in general;

'They tend to tell stories that are explosive stories rather than stories that are about thinking. I mean all of us have great achievements but they are not necessarily hot.'

WEHI004 (ATD)

This aspect of science communication, science promotion, is increasingly frustrating to scientists. The overuse of words such as 'breakthrough' in media reports as well as used by science communicators is considered by some scientists as particularly patronising. This is especially the case if the scientists are used to engaging in their own, self-regulated, science awareness activities. Through these self regulated science awareness activities, scientists are conscious of their responsibility not to raise false hopes in the public. In contrast, the internal PR offices frame their science promotion activities in order to gauge the public's interest in scientific research and to promote the institute. This science promotion can have the unfortunate side effect of raising false hope and further promoting misunderstandings and doubts towards science in general.

> *'...Journalists, one of the questions they ask is 'How long before this will be a treatment?' Which is a ridiculous question...I usually talk about a paper that has been published in a high impact journal and journalist still ask 'How is this going to help people.'*
>
> WEHI003 (INF)

A story to demonstrate how this phenomenon happened to JCSMR026 is detailed below. What is interesting about this story are the repercussions not just from the public but from the scientific community as well. JCSMR026 deals with cancer research which is of particular interest to the public. He had been working on this discovery for many years before it caught the attention of the media. The discovery had applications in cancer treatment and, at the time, seemed very promising. What followed was JCSMR026's *'baptism of fire with the media'* where the story was published firstly in the local paper and then was followed with a press conference at the National Press Club and subsequent stories in the major newspapers.

> *'All this media exposure was a bit of a shock to the system anyway so I gave this interview and it went around the world 3 times in the next 20 minutes actually cause everywhere heard about it – it just took off. It was crazy.'*
>
> JCSMR026 (CHD)

The scientist attempted to communicate the facts of the discovery. Unfortunately, a collaborating partner saw the media reports and disagreed with the way that the research was being communicated. Her reaction to these media reports is detailed below;

> *'She actually sent a letter in disassociating herself from the work to the newspaper and 'The ANU Reporter' and then...got on to major journalists who then started to talk to other scientists around the place and wrote this article about her and how this work could raise false hopes in Cancer patients and she managed to get a whole heap of people to comment...'*
>
> JCSMR026 (CHD)

This was obviously a distressing time for JCSMR026, who had to defend his claims. In particular, it must be noted that the journal article detailing these results had not yet appeared and so, to the scientific community, the external communication of the results seemed a little premature.

> *'And then I had to write this letter to 'The Age' stating my case forward. The media are so bad that I had to leave home and go down the coast because they had my home phone number and the phone was ringing all the time, so I actually had to leave. So that was my baptism of fire with the media and most people hadn't experienced it. '*
>
> JCSMR026 (CHD)

He describes the worst part of the experience was the reaction of his peers and collaborators;

> *'The worst part of it was that I was attacked personally and some of the academics in the school saying that the way I was reporting to the media were un-academic and it was against the spirit of how we should do science.'*
>
> JCSMR026 (CHD)

This story also demonstrated the difficulty with communicating basic science through external sources such as the media as opposed to communicating applied science. The public is mostly interested in what the research means to them and scientists are not always able to communicate the applied side of the research as sometimes it does not even exist yet.

> *'Well when you go out and visit..... you have a room full of people who are suffering from that terrible disease and they all want to know what you are doing to save them. And that's always very awkward when you say 'Well we're doing this fundamental research and we hope it may have some sort of effect' and we always come across people whose children have muscular dystrophy or some other disease and they ask 'why aren't you working on this, this is an important disease' and you have to explain that a lot of the real discoveries are fundamental and then they have applications.'*
>
> JCSMR029 (MBD, MGC)

This is of particular importance in medical research, where its name suggests a direct link to public health and wellbeing. One scientist described himself as a Chemist who moved into medical research because of its applicability. He describes how it was more difficult to communicate chemistry research to the public than medical research;

> *'...Medical research is a little bit easier [to communicate] because you can always point to a problem, a disease or a need then work from there but with Chemistry you don't have that direct connection with people.'*
>
> WEHI009 (SBD)

However as seen above this *'direct connection with people'* can also make the research harder for scientists to communicate. Many scientists are aware of the ease of medical research communication and are also aware of the differences between applied and basic medical research communication. However, how to address this for public communication differs between scientists. Some accept that their science is considered 'basic' science and as a result are always trying to remain aware of the applications the research might sometimes have;

> *'I guess what we do is mostly basic but we are always looking for the applied side as to where it can lead.'*
>
> QIMR006 (GBI, CHD)

However, scientists remain aware of their public duty, that if it is in receipt of public funds their research should always have an applied aspect to it. When it comes to communicating to the public, this aspect should always be emphasised as the general public is impatient with wanting 'results' from their funding.

> *'... The general public want to know about application, they don't want to know about the processes. They want to know when it will be ready, will there be any side effects and what they have to do to make it happen. By and large people aren't interested in a disease unless they have it or someone they know has it.'*
>
> WEHI006 (ATD)

As shown, the majority of scientists accept science communication as part of their social contract with science in receipt of research funding. There is however, a difference in the scientist-regulated awareness mode of science communication and the internal PR Office controlled promotion mode of science communication. Whereas promotion mode is controlled by the internal PR Office, the awareness mode is regulated by the scientists themselves and directly aims to inform those people who would benefit the most form the information, the patients.

How the internal PR Office crafts each scientist's message is also examined here. In particular, do the scientists see the internal PR office as a necessary part of the institute and of their research and therefore a tool? Or do scientists largely regard the PR Office as still an agent for external communication influences such as the media and fundraising?

For GARVAN004, she sees the internal PR office as a tool for scientists to use when seeking advice in areas that they don't specialise in;

> *'...now we have this new whiz bang science communicator lady who has come in. She's got a whiz bang team of three in the place of science communication...they make all these slides so when we go out to conferences we have fantastic slides that give a brand and the logo for the institute. They also do posters that are all streamlined so we have these swanky posters that look great.'*
>
> GARVAN004 (DNG)

Likewise, the majority of the scientists at the GARVAN recognised the importance of having an internal PR Office that could mainly filter messages to and from the public. In particular, GARVAN002 recognised that the load of public communication and full time research is difficult for any one scientist and so there need to be people specialised in that are to concentrate on the communication aspects of the research;

> *'There have to be roles for specialised people within organisations who can carry that load to an extent as well.'*
>
> GARVAN002 (ATD, MBD)

At the WEHI, a majority of scientists commented that whilst public communication of science was important, not all scientists should be expected to communicate. This view was particularly interesting. Each scientist was invited to elaborate and it was generally acknowledged that not all scientists were good at communicating and, that therefore would not best represent the WEHI or the research being conducted at the institute.

QIMR was also interesting, with a majority of scientists recognising the role of the CCPC rather than the more formal, internal PR office in public communication. Many scientists at QIMR commented that although the internal PR office would frequently look for scientists to volunteer and speak to visiting groups, they were more inclined to be involved with the activities of the Community and Communication Committee (CCPC) mainly because the aims of the CCPC were more in line with their personal aims for communication;

> *'...we have a PR department and they are always looking for people to talk to individuals or groups who come into the institute...we also now have the internal CCC where they are looking to give back some of the research to the community at large and also have those people also influence the kind of things, priorities that the institute is driven by...'*
>
> QIMR006 (CHD)

However at POWMRI and JCSMR, the small size of the institute's internal PR office means that most of the public communication is organised by the individual scientist. For some scientists, especially that of POWMRI015 discussed earlier, this is a preferable method of public communication. Recognising that the field within which he works is small and that communicating discoveries in his research that will only affect a handful of patients, POWMRI015 is more than content to communicate directly with these patients as well as the specific support groups. For POWMRI015, the aim of his public communication is awareness and by communicating directly with his patients and the support groups to which they belong, he can be sure that the right information can be communicated to those people that need it most.

Finally the interviewer questioned whether it was essential for these internal PR Offices and their representatives to have a scientific background. The results were mixed although a majority of scientists felt that although a science background was not essential that it would help them to understand the direction of the research. In addition, scientists overwhelmingly saw that if the internal PR Office was *'scientifically literate'* then scientists were more likely to trust them when freely communicating their research results to the public.

For those who thought that the internal PR office representatives did need a scientific background, their main concern was that the lack of experience they had in the scientific community, in particular what was important to scientists and what were their motivations.

> *'...unless you have really been through that and rubbed shoulders with scientists you don't understand.'*
>
> GARVAN002 (ATD, MBD)

There were however some scientists who even though they felt a scientific background was essential for their internal PR officers, they still recognised that there were skills that were necessary that weren't learnt in a research role.

> *'... The job would be better done if they [the internal PR officers] had a scientific background provided that they had a lot of other qualities to go with that. Just having a science background is not enough.'*
>
> WEHI002 (MBD)

These responses were not institute specific and varied greatly over the 5 participating institutes. All scientists recognised the need for an internal communication presence in order to facilitate public communication.

'In many ways science is like the music industry in that there are a lot of people who want to be a star and there are very few who turn out to be a star. But once you are approaching stardom, or hopefully before you are there, you need a manager. You need your manager to educate you about what the steps are and how to present yourself and how to deal with the media and how to strategically use journalists to your advantage.'

WEHI006 (ATD)

As the scientist above explains, scientists need guidance when navigating public communication. Whether this is navigating scientists in the direction that they want to go will be discussed further in the Discussion Chapter 6.

5.3.4 Competition in Science

Even though it was not the interviewer's main intention to examine the current state of competition in science, the topic was frequently mentioned. In addition, it was so intertwined with the topic of commercialisation and communication in science that it is essential to consider it here. Competition in science is a topic of interest with many higher education researchers. Competition for research funding and the increased use of metrics used to rank researchers and institutes have all been reported to have had a profound effect on the practice of science.

Scientists are increasingly competing with each other for resources so I will also describe here some of the incentives offered by each institution in order to *"raise the bar"* of the quality of science within an institute. Additionally, scientists expressed their experiences with this increased competition, locally and internationally, for funds, for publications and for media coverage.

All scientists noted that they felt that the level of competition in science had increased dramatically in recent years in relation to publishing. Scientists felt that in order to publish in higher impact journals, they needed more collaborators and more data than they had presented in the past. In addition, scientists felt greater pressure to publish in higher impact journals in order to compete with other Australian scientists who would also compete to gain ARC or NHMRC funding. The extent of this rise in competition is expressed below in a quote from a scientist from JCSMR;

> *'... If you are to make significant discoveries and publish in the higher impact journals, you need more money, bigger teams and it's really hard. It also seems to be that there is much more emphasis on publishing in high profile journals so that's obviously made it much harder to practice science, especially in relation to resource allocation.'*
>
> JCSMR005 (MBD)

This was not felt just by scientists at JCSMR or scientists engaged in basic research. Even WEHI scientists, WEHI being described above as a fairly competitive institute, still felt that it was sometimes difficult to match the competition in terms of publishing and additionally, resource allocation.

> *'... I think [science] has become more difficult....one of the measures that we judge is generally papers and I think papers have become a lot more difficult to produce, you require a major teams rather than the input of individuals....I think getting published in Nature or Cell is probably beyond the scope of any one individual...the amount of data that is included in papers and supplementary information is monstrous.'*
>
> WEHI002 (MBD)

This feeling of increased competition in science especially in relation to publishing is a common theme across the 5 medical research institutes. The comment *'...getting published in Nature or Cell is probably beyond the scope of any one individual...'* describes the difficulty this scientist feels when publishing his work. That is, that publishing in high impact journals is impossible for small research groups, no matter the quality of the science.

According to these comments, it is necessary for scientists to be members of large collaboration teams and have larger laboratories in order to be able to actively compete with other scientists internationally. We pursued this line of questioning in order to determine what was actually meant by this need for more collaboration between scientists and how this related to publishing articles in scientific journals. The scientist below suggested that the increasing specialisation of science as well as the emphasis in multidisciplinary research was one of the contributing factors.

> *'We are more specialised these days and we have become a little more general through some of the things such as systems biology and animal knockouts. You can't afford to stay on one little enzyme or gene anymore, you're looking at broader interactions.'*
>
> GARVAN002 (ATD, MBD)

It seems that internal communication between scientists has increased in order to address the need of journals to have big picture science. Scientists are now collaborating with people outside of their fields and, moreover, this type of collaboration is proving necessary in order to be published in a high impact journal. The scientist below explains this phenomenon in more detail, specifically that higher impact journals are requesting more multidisciplinary papers. These papers are not restricted to one research or laboratory group but are involving larger collaborations and consequently a larger number of authors.

'It's much more focused on getting the bigger impact papers...it seemed enough just to get publication whereas now it seems that the scientific community wants bigger and splashier papers. They want the paper that is 'the answer' to things so that means that the science has become more exciting,'

GARVAN004 (DNG)

The scientist mentions below those scientific journals, in her opinion are looking for more complete papers. In addition it should be noted here that many of the different research groups at the GARVAN are separated into different levels and so when *'looking up and down different levels'* is mentioned, the scientist is relating to the activity of scientists who are boundary crossing. This boundary crossing means that scientists are crossing over to different research groups and departments in order to achieve this *'bigger splashier paper'* that will undoubtedly serve the requirements of the high impact journals.

'More 'wow how can we find out the mechanism that controls that' so people are looking up and down levels and going to different departments saying 'do you know how to do that and can you do it for us?'

GARVAN004 (DNG)

This is not a bad thing and, as the scientist explains below, the increased collaboration across different medical research disciplines is contributing to the perceived increase in competition in science.

'There is much more collaboration and much more swapping of ideas, much more using technologies and I think it is moving faster and faster.'

GARVAN004 (DNG)

Some scientists are still concerned about what this means for the future. One laments that publishing single authored papers although not impossible is still too difficult for some laboratories with *'one staffer and one technician'*.

> *'You can publish single authored papers, I'm not saying that you can't but you wouldn't be able to get them into the top journals because you wouldn't have been able to cover all the bases.'*
>
> JCSMR026 (CHD)

He goes on to explain that in order for him to publish in the top journals of his field, he needs to have a transgenic mouse model, the molecular biology covered, the cell biology covered whereas in the past one of these discoveries would have been sufficient for a high impact paper. He also mentions that for one person to do all of these things would be extremely difficult technically as well as physically and so the top journals often contain work that is more collaborative.

> *'The really top findings are much more collaborative...you have to collaborate to survive, to be able to get all the reagents you need these days. So you need bigger labs, it is hard for small labs with one technician to survive.'*
>
> JCSMR026 (CHD)

Scientists aren't alone in their quests for higher impact papers. Institutes themselves are actively encouraging their scientists to publish in higher impact journals through internal incentive schemes which allow for a scientist to be financially rewarded for publishing in higher impact journals. Of the five participating medical research institutes only three offered publishing incentive schemes, these were; the GARVAN, the WEHI and QIMR.

At the GARVAN the incentives surrounding publications are competitive and contribute to the success of the institute;

> *'If there is anyone here that is an author of a research paper published in a journal with an impact factor over 10, which is the top make of journals; they get a thousand dollars each time.'*
>
> GARVAN001 (CHD)

There are obvious issues with this type of incentive especially for institutes like the GARVAN which supports research programs in a wide range of disciplines. That is, the problems that not all research fields are created equal. Some research fields such as immunology have a higher chance of publishing in a high impact journal than a paper in a field such as neuroscience or infectious diseases.

> *'There are criticisms of if you are working in a field where the publication field is suitable for Science or Nature or whatever, then you can convince them that you are good enough. However if you are working in a low publication field like public health/tropical health the impact factors of the top journals in your field are 3 to 5 or maybe 6 at the most. So you would never get a bonus if you were the best practitioner publishing in tropical or public health.'*
>
> QIMR002 (INF)

There is also the issue that some of the top scientific journals often follow a theme at a particular point in time. These themes are usually based on the size and popularity of a research field and if you are not publishing in that area or if your research paper does not follow this particular theme, then you will be unable to publish in this journal. This can be particularly difficult for scientists working outside the particular field who are still subject to the same incentive programs that do not take into account these biases in the top journals.

'We are lucky to get one publication in Lancet but that was like an overarching publication of work spanning 10 years. You couldn't expect to get one of those every year because our research field is not suitable for Lancet or Nature.'

QIMR002 (INF)

The scientists interviewed also mentioned that the incentive scheme would do little to boost the number of articles published in high impact journals as scientists in general already targeted high impact journals for their articles without the influence of financial incentives.

'I think we should be always striving for the best journals so if it makes people more aware that this is something that's going to be considered for promotion or bonuses or whatever it probably just makes it in the back of your mind all the time, But I don't think that people are going to change research fields or journals so that they can get high impact factor journals and get their bonus.'

QIMR002 (INF)

The scientists seem very self-regulating when it comes to strategically choosing journals in which to publish their articles. Whether these incentive schemes and the perceived increased in competition in science for funds and papers have had any effect on the output of science will be discussed in the Discussion chapter of this thesis. This discussion chapter will also take into account the results presented in Chapters 4, 5 and 6 of this thesis.

5.3.5 Withholding Behaviour in Science

It was essential during the interviews to ask the participating scientists about what has been described in the literature as 'withholding behaviour'. Studies of withholding behaviour in the literature have been extensive and are outlined in more detail in Chapter 2. The aim of this line of questioning was to determine whether withholding information, results, methods or reagents was commonplace in Australian medical research. The literature on the subject suggests that withholding behaviour in science is common and the interviews sought to discover whether these scientists, the majority of which were in science for mainly altruistic reasons, had ever withheld or experienced withheld information. The results were mixed.

Some scientists indicated that they thought withholding behaviour in science was against the 'spirit of science' believing that every piece of information available should be used for the benefit of public health as a whole.

> *'If someone asks for our results or reagents we will give it to them...that is what science is all about. That's the spirit of science and I know that the reagents that I will give will contribute to someone else's research and maybe even a cure for cancer.'*
>
> JCSMR005 (MBD)

This was mainly in relation to withholding methods in already published papers as well as the exact nature of a compound. This was particularly true at scientific meetings where scientists that withheld information about an important compound would frustrate fellow scientists in their field. Many scientists believed that withholding such information would considerably slow the progress of science whereas others like the scientist below, believes that fierce competition in science is a catalyst for bigger discoveries.

> *'People are constantly evasive about materials, it's an integral part of competitive science....information is at the heart of science and people tend to keep information to themselves.'*
>
> WEHI005 (INF)

Most scientists described the nature of science currently as mostly still collegial and that open and fair communication in science was still regarded as the norm by most scientists even though scientist's willingness to share results and other information had dropped a little recently.

> *'Science is still largely collegial but it is different....there is also that the competition is stronger. I think people's willingness to give you reagents and willingness to share things with you has probably dropped a little bit but I think that it is still largely collegial.'*
>
> WEHI004 (ATD)

Despite this, WEHI004 still noted that she was unwilling to share information with any of her competitors in specific situations and unfortunately this is a trend with a large number of scientists;

> *'In terms of a reagent certainly if it wasn't patented or hadn't been published nevertheless, because we are working in this field if somebody asks for it [the reagent] we wouldn't give it to them until we had filed a provisional patent and published it...not just commercialisation that has inhibited it, its competition as well.'*
>
> WEHI004 (ATD)

Competition in science is a major deciding factor when deciding whether to share or divulge information to other scientists. However, as the scientist below will explain, this has been happening in science for a while and that withholding information can be a catalyst for establishing collaborations with other groups.

> *'There has been a long tradition of not telling your competitors what you are doing...there is a constant two-step that goes on at meetings often when you offer up a little sample of what you are doing and you expect something in return...you are constantly having to monitor yourself, how much you are promoting and divulging.'* *JCSMR006 (DNG)*

However, many of the scientists who indicated that they regularly withhold results also mentioned that they do sometimes share results, if and only if, a Material Transfer Agreement (MTA) is in place. These MTAs are preferred by scientists as it is a way of protecting their results and to ensure that their real competitors do not have access to your research.

> *'We have used MTA's for vectors and things. It is actually a good mechanism to stop people passing things around without you knowing it.'*
>
> WEHI003 (INF)

The MTA's are administered by the internal BD office on the scientists' behalf. On one hand, scientists invoke MTA's in order to protect themselves and their data from being used without proper recognition. On the other hand, scientists frequently use MTA's as a method of establishing large collaborations with other research groups. These collaborations are then useful when attempting to publish in higher impact journals as with more authors, big science can be produced and also it means that any successes of the shared information can be accrued back to the individual scientist and their institution.

> *'You do say to people sometimes that there has to be a MTA. That basically just means that if they use something and get some benefit from it that that will accrue back to the institution and me. Most people don't have any problems with that.'*
>
> GARVAN007 (OTHER)

Even with the MTA's in place, science is still mainly collegial. However there are now more gates to pass before a scientist is willing to share. In addition, the ease with which the participating scientists refer to and use the MTAs in their everyday research activities certainly reflects the maturity of the internal BD Office. The implications of this in relation to the literature will be discussed in full in the Discussion chapter of this thesis.

5.4 Chapter 5 Summary

For a full Discussion of the results of this Chapter, please refer to Chapter 6; General Discussion. However, a preliminary summary of the major themes addressed in this thesis is included below.

This chapter aimed to investigate the motives of the scientists within our participating institutes. Of particular interest were the scientist's attitudes and opinions towards the role of communication and commercialisation in science. It was hoped that by comparing the attitudes of difference scientists across institutes and different fields that this thesis will gain a better understanding of the barriers scientist face when considering communication or commercialisation of their research. This will be of particular interest in relation to their attitudes towards the internal PR and BD Offices of their respective institutes. In addition, the results presented in this Chapter will contribute to answering Research Question 2 and also establish the social guidelines with which to analyse the publication data in response to Research Question 3.

The first area of investigation centred on the motivations of the scientist to initially pursue a career in science. Interestingly enough, scientists with a strong clinical focus in their research tended to report their motivations for becoming scientists as mainly altruistic in nature. Researchers involved in the basic, non-clinical research fields; however, were more likely to report their reasons for pursuing a career in science for interest based reasons. Despite this difference between basic and applied researchers, all scientists irrespective of their research field or institute, reported a desire for their research to have some level of influence in improving public health. In order to achieve this, scientists would participate in a number of self-regulated communication activities such as interacting with a number of interested patient groups through giving talks and contributing to the public awareness of their science.

The next section investigated the participating scientist's attitudes and opinions towards the role of commercialisation in science. Previous research has highlighted the dysfunction between scientists and the concept of commercialisation of scientific research. The results presented in this chapter showed there has been a change in emphasis in relation to how scientists now view the role of commercialisation in science. Previously, the scientists reported that commercialisation was considered a 'dirty' addition to science whereas now, participation in commercialisation is highly regarded by the entire scientific community.

However, the main concern of the scientists in regards to being involved in commercialisation was still related to their fears that commercial engagement would restrict their freedom to communicate about their research within the scientific community. This fear is well documented in the literature (Harman, 2001, 2002). Despite this, the scientists recognised the role of the internal BD Office in facilitating this process and this will be discussed in detail further below. In addition and again, despite this fear, the scientists recognised the role and the value of the internal BD Office in streamlining the commercialisation process and allowing the scientists to continue to publish and promote their research within the scientific community. For those scientists with access to an internal BD Office, publication delays were now seen as an inconsequential part of the commercialisation process. Additionally, the scientists recognised that staff of the internal

BD Office additionally acted as advocates for the institute's scientists during negotiations with industry or business. At the two institutes without an internal BD Office, all scientists failed to recognise both the role and the potential of commercialisation in their research. This was surprising especially for JCSMR, a multidisciplinary institute supporting many research programs with the potential for commercialisation. In fact, the scientists at JCSMR still felt that engaging in commercialisation activities would negatively affect their freedom to communicate openly about their research. This was also the main reported reason why scientists were reluctant to engage in commercialisation of their research at JCSMR.

However it was discovered that scientists who were involved in commercialisation however were less inclined to engage in commercialisation for personal benefit. Alternatively they saw engagement in commercialisation as fulfilling their desire to improve general public health through research. This point is in line with the initial investigation in this chapter regarding the motivations of scientists to pursue a career in science, where scientists were interested in positively affecting public health through their research thereby using commercialisation to help them achieve this desire.

In relation to communication, previous research has focused on the hostility of scientists towards communication in science. Scientists were either unwilling or incapable of participating in communication activities as described by Stocklmayer et al. (2001) and instead were content to be left to do their science separate from public interference or trivialities such as their social contract with the public. This chapter revealed a different attitude of the participating scientists towards their role in communicating their research to the public. In contrast to previous research, scientists were all too aware of their responsibility towards taxpayers in communication science's and their (as scientists) value to the public. Although many scientists reflected how this openness toward the role of communication in science was still a relatively new attitude among Australian scientists. This was likely a result of communication not being part of their training as scientists. Instead, scientists now saw communication as part of their 'duty' as scientists who were in receipt of public funds. However, some scientists participated in communication activities not out of a sense of duty but rather as members of their institute in order to attract philanthropy to the institute. This behaviour, understandably was the cause of some tension between the scientists who participated in fundraising activities and the scientists who considered such behaviour as 'against the spirit' of science. Tension usually manifested itself as the frustration scientists felt towards the 'over communication' of science which usually used the 'B word' too many times. This, in turn, would cause suspicion amongst the scientific community towards the quality of the science being promoted. In addition, some scientists expressed concern about the over-communication of science with the aim to attract further funding. This behaviour, according to one particular scientist, drew attention away from the science being 'for the benefit of mankind' and focused communication for monetary gain. Despite this, however, by analysing the motivation of the 'overly communicated' scientist in more detail, it is revealed that these scientists view their communication activities as primarily a method used to inform the public with the secondary motivation albeit the added benefit of attracting funds to the institute.

In addition, and in relation to the above points regarding the aim for science communication being to inform the public about research advance, many participating scientists reflected how their training as medical physicians largely influenced to what level they currently engaged in communication. Interestingly, many scientists still maintain a dual role as scientist and as physician at the institute affiliated hospital. This position not only gives the scientists important skills in relation to the public communication of their research but also allowed the scientists to directly communicate about this research to the people who need it the most, their patients. Indeed, for the majority of scientists, public communication is a way of giving back to the community and a main motivating factor for becoming scientists. However, for those scientists not involved in research areas of high public interest, playing this dual role between physician and scientist is an effective way of ensuring that advances in medical research is delivered directly to the patients. In this way, scientists in the smaller, less publically interesting fields self regulate their communication activities in order to ensure that the patients, of the people who need the information the most, are able to have access to the information without it being filtered by the media or by the internal PR office.

There are other ways in which scientists self-regulate their communication behaviour. Many scientists reported receiving direct calls from the public pertaining to some media exposure conducted by the institute or scientists. For the scientists, the majority of this contact with the public was spent clarifying misunderstanding on the behalf of the public about the patient for cures or the existence of a 'breakthrough' drug or clinical trials. In this way scientists ensure that the correct information is portrayed to the public and also engages in science awareness activity that is not regulated by the internal PR office or the media, reducing further misunderstandings of the public's behalf. Finally, the majority of the scientists understood the value of the institute in having an internal PR office. Interestingly enough however, they saw the internal PR role as more about promoting the institute rather than promoting their research or providing opportunities form scientists to promote their research to the public. In contrast, the scientist preferred to remain self determinants of their engagement in science communication.

Another theme to emerge from the interviews was in relation to the change in the level of competition in science. It was not the original intention of the interviewer to address this issue, however as the interviews progressed it became evident that the theme of competition in science was increasingly important to investigate in relation to the research questions of this thesis. All scientists felt that the level of competition in science had increased, in particular in relation to publishing in science. Scientists felt that they were increasingly expected to publish in higher impact journals and gain a higher level of visibility of their research. This, according to the interviews, required a larger amount of data, larger teams and more funding than was currently offered through government funding agencies. The term 'big science' was used continually to describe the quantity and quality of the science required to be published in higher impact journals such as Nature, Science or Cell. This perceived increase in competition in science had also required scientists to collaborate both nationally and internationally in order to produce the quantity of data required by the higher impact journals. Collaboration now also was required across different fields in order to demonstrate originality thereby gaining the attention of journal editors of these high impact journals. This perceived requirement of increased collaboration has also meant the demise of the single authored papers and this therefore can disadvantage smaller, specialised laboratory groups and emphasising the advantage of being a member of a large institute such as the participating institutes in this study. In addition and in order to encourage scientists to publish in these high impact journals, many institutes are now offering financial incentives to authors who achieve this high impact publishing. These incentives can include as much as one thousand dollars per author for an article published in a journal with an impact factor over 10. Although many scientists were of the opinion that high impact publishing should be the target for all scientists regardless of any financial gain, the existence of these incentives only serves to increase the level of competition in science.

Finally, the issue of withholding in science was investigated. Withholding behaviour has been described by many authors as a result of the involvement of commercialisation and business motives in science. This thesis wanted to investigate how the internal BD Office had affected and thereby adjusted this behaviour in science. What was seen was that the maturation of the internal BD Office has made such concern negligible for scientists. In fact, many scientists despite reporting that the willingness of other scientists to share results, reagents and methods had decreased, the willingness of scientists to share results was positive if a Material Transfer Agreement (MTA) was in place. The role of the internal BD Office was therefore vital in ensuring that the efficient exchange of these scientific assets was done smoothly and with limited delay experienced by the research scientist. These MTA's also played an important role in promoting further collaboration in science both between institutes in Australia but also internationally.

Chapter 6: Discussion

6.1 Introduction

In an environment characterised by increasing public demands for accountability, the visibility of research both publicly and academically is becoming a major aim for the individual research institute. In this environment, research funding agencies both internationally and in Australia are less open to research whose sole purpose is to advance scientific knowledge and communicate only with other scientists. These changes result from an increasing amount of effort on the part of governments to track their investment in science and arguably, these changes are also part of scientist's ongoing social contract with society viewing society as an active partner in the research process.

With this in mind, this thesis examined the role of communication and commercialisation – two measures of the social contract with society, within five Australian Medical Research Institutes. I have argued that the addition of the professional offices for Public Relations (Communication) and Business Development (Commercialisation) are a part of the move of individual institutes evolving from the traditional Mode 1 to the more modern Mode 2 model of organisation as defined by Gibbons et al. (1994). Separately from the main argument I have also analysed the fears expressed within the literature about the inherent dangers of Mode 2 commercial activities to the integrity and practice of scientific research through academic publishing.

This thesis has presented data sets from a combination of methodological techniques as well as from a number of different sources. The aim of this thesis was to, use the data presented to paint a picture of the complex set of interactions between scientists and the internal professional offices, as well as between the scientists and the concept of a scientific organisation that I have termed the institute. The institute is one that is separate from a university and shares similarities with business organisations but remains committed to the promotion of scientific norms.

This discussion chapter will also address the current gap in the literature with regard to the number of empirical studies that have linked individual actions and the influence of organisational subunits with the implementation of strategic initiatives. As such, this research provides one of the first micro level studies on the effect of external pressures such as the increase in public accountability as expressed through communication and commercialisation of research and how scientists within institutes, and the institutes themselves, adapt to these changes. In addition, with the institutes only recently adopting their own internal representatives of these external influences, examining the opinions and motivations of scientists to engage in these Mode 2 activities in light of the presence of these professional offices will provide new information regarding the evolution of scientific research.

This chapter will review and further explore the main themes identified by the interview and publication data presented in Chapters 4-5 and Appendix III of this thesis. Together, the results presented paint a relatively complex and dynamic picture of the differing environments of the participating institutes and the relationships between the Office professionals and the scientists, as well as reflecting on the changing practice of modern medical research.

6.2 Structure of the Discussion Chapter

This thesis set out to answer three broad research questions regarding the evolution of the internal PR and BD Office within medical research institutes. The research questions to be discussed in this chapter are outlined below;

Research Question 1

What are the responsibilities and communication strategies of the internal PR and BD Offices within Australian Medical Research Institutes?

Research Question 2

How do the scientists in these institutes view the role of these Offices and more broadly, communication and commercialisation, in their research?

The third research question refers to the quantitative analysis presented in Appendix III. This appendix is separate from the main argument in the thesis and aimed to validate the assertions by the interviewees in Chapters 4 and 5.

Research Question 3

Has there been any change in scientists' publishing behaviour as a result of the increased level of public accountability in science and/or the introduction of these internal Offices?

The elements of discussion within this chapter have been grouped into themes to be discussed under the relevant research question. With regard to Research Question 1; the responsibilities and the strategies employed by each PR Office and BD Office within the participating medical research institutes will be discussed. In particular, the roles identified by this study will be discussed in relation to models of public relations and the controversy surrounding the privatisation of scientific research institutes.

Research Question 2 focuses on the opinions of the scientists towards these offices and how scientists are open to the role of communication and of commercialisation science with regard to their responsibility towards to the public for research funding. Both communication and commercialisation are seen as methods that can be used to return some value to the community through the improvement of public health. This section also compares the views and opinions of the scientists with the views and opinions of the internal PR office in relation to the role of communication of science. Tensions exist regarding the format in which information exchange between the public and science should take place. Scientists themselves are more amenable the awareness mode of science communication, whereas the internal PR office is focused primarily on the promotion mode of science communication. Tensions can therefore arise between the aims and methods of these two modes of science communication. Both the awareness and promotion modes of science communication are discussed further in response to Research Question 2. Finally, and closely related to the distinction between awareness and promotion modes of science communication, the scientific and public interest in the 'cancer' field of research is discussed by combining the interview data with some of the results from the bibliometric analysis from Appendix III.

The final research question, Research Question 3, which is separate from the core argument of this thesis, will further combine the results of the bibliometric analysis in Appendix III with the qualitative data to investigate the change in publishing behaviour of the participating scientists over the period 1999-2005. This section will also discuss the claims by the scientists and institute heads in Chapters 4 and 5 about the increased level of competition in science in relation to the publication data.

Finally, this section will investigate how publication incentives offered by each research institute have, if at all, changed the publishing behaviour of the scientists within that institute. Both quantitative bibliometric data and the qualitative interview data will be used to discuss this aspect of communication.

6.3 In Response to Research Question 1: What are the responsibilities and communication strategies of the internal PR and BD Offices within Australian Medical Research Institutes?

6.3.1 The Internal PR Office

An entire thesis can be written about how the internal PR offices of the five participating institutions conform to one of Grunig & Grunig (1992) models of Public Relations. This was not, however, the main aim of this study, which instead investigated how the internal PR office has adapted itself to become part of the scientific institute as well as how this has affected, if at all, scientists opinion and engagement with science communication activities.

It is, however, essential to discuss briefly how the structures of the current internal PR offices conform to the models described in the literature. This is of particular interest as currently there is much debate within the field of science communication about the inherent value of the internal PR office, especially with regard to whether it creates barriers to the public accessibility of science and scientists (Pitrelli, 2008). In this study, it was clear that the models used within the participating organisations were either the public information model or the two-way symmetrical model as defined by Grunig (1984) and Grunig & Grunig (1992). In this section, the results of Chapters 4 and 5 are discussed below in relation to the above described models of public relations as well as the science communication and entrepreneurial management literature.

Within the five participating medical research institutes, there was a range of communication activities with which the institute engaged the public and promoted the institute. For JCSMR, the aim was to increase awareness and the profile of the institute to the public as well as to the scientific community. This was achieved through a variety of different activities that were mainly performed by the PR Officer rather than engaging the scientists. In fact, when the PR Officer (JCSMRSC01) was queried about the level of involvement from the JCSMR scientists in communication activities, JCSMRSC01 talked about having to 'beg' for a level of compliance in relation to communication activities from the scientists. Instead, JCSMRSC01 actively engages in talking to the community, especially interested community groups such as Probus, as a representative of the science conducted and the scientists working at JCSMR. The level of autonomy that JCSMRSC01 enjoys stems from her prior experience and education as a PhD student and as a Research Fellow at the Institute before becoming the Public Relations Manager. In JCSMRSC01's opinion, this creates a level of trust between her and the scientists as *'I also think that it helps that the scientists', the researchers are comfortable that if I present their science, I'm not going to botch it'.*

At JCSMR, there is also a minimum focus on fundraising as part of the internal PR Office's responsibilities and this is mainly due to the JCSMR being promoted under the wider, ANU image, rather than a stand-alone Medical Research Institute. This is a main source of contention for JCSMR's scientists who do not believe that other similar institutes, such as the GARVAN, regularly receive funds from external fundraising. The role of fundraising as part of Public Relations within the participating institutes will be explained further below; however, this misunderstanding of the JCSMR scientists about the role and difficulties of the internal PR office reveals a disjunction between the perceived value of the communication and more specifically, PR, in science.

Likewise, the Internal PR Office at WEHI does not actively engage in fundraising activities. In this way, like JCSMR, WEHI emulates the public information model of public relations, using one way communication techniques to distribute the organisational information. According to WEHISC01, the PR Office does not need to directly engage with fundraising activities; instead the Office focuses on *'communicating excellence in science to the community'*. This is done mainly by ensuring that the one way promotional material is of a high quality and this, according to WEHISC01 is enough to attract fundraising and bequests to the institute.

In contrast, the GARVAN actively separates the fundraising aspect of their PR plan from the other communication activities. This is done by maintaining an internal PR Office that conducts the public communication activities and is separate from the Garvan Foundation, an external body made up of community members that coordinated the fundraising activities. The Garvan Foundation is the fundraising arm of the institute and aims to promote the research of the Garvan in order to raise funds externally. GARVANSC01 acts as a boundary rider for the foundation, facilitating communication directly between the scientists, the Garvan Foundation and the public, ensuring that the science and scientists of the institute are well represented in the Garvan Foundation's fundraising exercises. This arrangement works well, according to GARVANSC01, and allows her to distance herself scientifically from the fundraising attempts of the institute and helps her maintain good relationships with the institute's scientists. Another factor in maintaining this good relationship with the institute's scientists is that, like JCSMRSC01, GARVANSC01 has previous experience as a PhD student within the institute. According to JCSMRSC01 and GARVANSC01, the scientific background and familiarity of the PR Office is a major advantage to their roles as the Communications Manager. For GARVANSC01, there is also an increased awareness of the issues involved with science communication with the public including the scientist's aversion to the 'B' word, Breakthrough. This awareness, according to GARVANSC01, began in her previous role as a scientist and the level of respect she exhibits for the science, including the avoidance of the 'B word', is an important way in which to remain on good terms with the institute's scientists as well as act as a constant representative of the importance of the role of communication in science. Thus for these organisations, the combination of the PR role with previous scientific experience in the institute works well.

In a very similar way, POWMRI separates the fundraising arms and the science communication arm of the internal PR Office. This separation occurs, however, through different personnel roles within the office rather than a separate organisational arm such as with the Garvan Foundation. The reason for this separation was described as essential because one person was incapable of doing both roles while trying to compete with the other Australian MRIs, a sentiment embodied by POWMRISC01's PR role; '*...you want big* *donations to come in then you have somebody who is dedicated purely to be fundraising manager, you cannot spread yourself out over so many things and hope to do justice to every one of them really well'.* Despite this extra role concentrating solely on fundraising, POWMRI's general aim of the communication office is to raise the awareness of the research at POWMRI. This is mainly because POWMRI finds it difficult to compete for funds with the larger MRI's because the research being conducted at POWMRI does not include the bigger, 'sexier' topics such as Cancer. This phenomenon has been termed by this study as the 'bald baby effect' and will be discussed at length in Section 7.6 of this chapter. It is important, however, to note here the difficulty POWMRI feels in promoting itself, with its research emphasis on neuroscience, to the public; *'...people can read stories about Alzheimer's and Parkinson's and they feel sorry for those people and yes, there are a lot of people out there who do have Alzheimer's and Parkinson's Disease but that doesn't have the same impact that Cancer or sick children...' POWMRISC01*. Some scientific fields are easier to promote than others and POWMRI with its emphasis on neuroscience, find this experience a main obstacle for them when communicating to the public.

In contrast again, the internal PR Office at QIMR's objective is purely to raise funds. According to the interviews presented in Chapter 4, increasing the public's awareness of the science conducted at QIMR is done only as a precursor to fundraising; *'... [Our role is] to raise funds and awareness. You can't raise funds without awareness' QIMRSC03*. The internal PR Office at QIMR still supports a media relations position and other more traditional PR roles; however, it was made clear that the purpose of the internal Office was fundraising and not a science awareness or promotion role. In contrast, within the QIMR, the scientists developed the Consumer and Community Participation Committee (CCPC) which is run independently from the Internal PR Office, and attempts to emulate the two-way symmetrical model of PR as well as the engagement model of science communication by providing opportunities for their scientists to engage with the public and vice versa. It is clear that, at least within QIMR, the existence of the internal PR office does not determine the level of engagement while research scientists have with public communication activities. This is not surprising considering the results discussed in the previous section that explained that scientists embrace their responsibility to public communicate their research results. In that section, it was hypothesised that the presence of the internal PR office was a powerful catalyst for the evolution of this acceptance which was in contrast to earlier reports of scientist's motivations to communicate. In QIMR, at least, this does not seem to be the case as scientists within that organisation, at least, regulates their communication activities independently from the existence of the office. The extent to which scientists are self regulators of their communication behaviour will be explained in the next section about the role of awareness and promotion in science communication. The next section will argue that despite this separation of communication activities at the QIMR, the internal PR office still plays an important role in the public visibility of an institute's scientists.

According to the above results, all institutes differ in both the size and the function of the internal PR offices. Of interest is that the roles of the Internal PR Office can be divided into one of two categories; promotion or fundraising. It is complex therefore to measure the value of the internal PR office and this value cannot be solely measured by the amount of funds raised by the offices, especially since not all participating institutes are involved in the same level of fundraising. Grunig & Grunig (1992) argues that the presence of public relations increases the effectiveness of organisations by managing the interdependence of the organisation with publics that restrict its autonomy. Organisations manage interdependence by building long term, stable relationships with those publics. Building this relationship, however, may be conducive with the promotion aspect of the Internal PR Office's strategic plan but not necessarily with the fundraising role. It is already known that there is an increased level of competition between scientific research organisations for public funding.

Grunig (1992) recommends the 2-way symmetrical model for excellent public relations practice. In fact, fundraising activities as part of public relations do not correlate well with the ideal model suggested for the operation of the scientific PR department. Instead, fundraising activities were found to correlate with the 2-way asymmetrical model where persuasion and manipulation influences the public to behave in a way that the organisation desires. In the case of QIMR and POWMRI, this manipulation persuades the public to donate money to the institute. With this in mind, the direct role of fundraising in the strategies of the QIMR and in some respects, the POWMRI internal PR offices, may not be in the organisations best interests for public awareness of science. Additionally, in relation to achieving public engagement between scientists and the public, the existence of a direct fundraising arm within the internal PR office may actually negatively affect achieving a desirable dialogue.

In relation to the value of the internal PR office, irrespective of its engagement in fundraising activities, the question remains of whether the existence of this office makes a research institute and its scientists more accessible to the public. It is argued that the 'privatisation of science communication' makes public research institutes less transparent to the public. As such, there are fears that the internal science communicators therefore do not remain objective to the needs of the scientists (Pitrelli, 2008). These concerns are based on the fear that public relations practitioners remain loyal to the institution and not to the science or scientists but, as was discussed in the previous section, scientists embrace their responsibility to communicate to the public in a variety of different forms. However, this thesis has shown that the scientists' participation in institutional communication activities did not affect their engagement in their own, self regulated communication activities such as talking to patient groups. The scientists still required guidance in relation to communicating the institutional message, and the internal PR office (and officers) takes an active role in moulding and projecting this voice of the institute. This requires the internal PR officers to act as part of the 'scientific team' and not to separate from it. The value of the internal PR office lies in how it has adapted itself to become a recognised part of scientific practice. Not just at the organisational level. Scientists now consider the institutional voice when considering communication and this is a result of the communication representative being a *visible* part of the institute. For the PR Officers, remaining visible to the scientists also means that the scientists also remain visible to them. This allows the internal PR people to keep up to date with the research programs and reduces the frustrations on the scientist's behalf when explaining the basic premise of their science over and over again to different audiences.

Finally, the loyalty of the internal PR Office to the organisation does also extend, in scientific research institutes, to the research being conducted and the scientists of the institute. Certainly for POWMRISC01, the lack of public and media interest in the neuroscience/degenerative disease research conducted there does not diminish her belief in the importance of the research being conducted at POWMRI. This loyalty means that POWMRISC01 actively promotes the research to the media in the hope that it will be taken up by journalists as readily as a cancer article. If POWMRI's research was left on its own, without an internal PR Officer, it would not necessarily get any form of media coverage by journalists as the public's interest in the research is limited when compared to other fields such as cancer; especially breast and skin cancer. This is a result of journalists being loyal to the story (Peters, Brossard, de Cheveigne, Dunwoody, Kallfass, Miller, & Tsuchidas, 2008) and not specifically as the internal PR Office are to the institutes and research projects. MacKenzie, Chapman, Johnson, McGeechan, & Holding (2008) used the example of the poor media coverage of lymphoma to explain how more complex topics might be avoided by the media because of the difficulty in explaining the complexity of the lymphatic system. The advantage of the internal PR Office is obvious here, as they may act as an intermediary and explain, in simpler terms than a high level researcher might be capable of achieving how the lymphatic system works in order to promote the importance of the research results. Likewise, Beeker, Kraft, Southwell, & Jorgensen, 2000; Greisinger, Hawley, Bettencourt, Perz, & Vernon (2006) found that participants were poorly informed about colorectal cancer because it was poorly reported in the media. This is especially the case for journalists who are not experts in the field and therefore may not immediately acknowledge the importance or impact of the results. With this is mind, it is important that scientists such as the ones in this study have the freedom to communicate directly with patient groups and members of the public. The scientists who communicated directly with the public were not involved with the research that the institutional PR Office chose to promote, however that does not diminish the importance of the information being communicated or the importance of the scientists engaging the public in their research. Instead, this type of communication ensures that the information is directly communicated to those who will benefit most from it.

The role of the internal PR Office is therefore an essential one as an advocate for their scientists' research programs but it is also essential that all researchers have an opportunity to engage with the public despite this 'bald baby effect'. This is especially the case when the research may not be of the greatest public interest, as defined by the media or the internal PR office.

The ability for excellent internal PR offices to increase the public accessibility of the scientific research organisation is also related to their increased level of professionalism. This thesis found that scientists are more open to the role communication in science in contrast to the views and opinions expressed by scientists in the mid 1990s when the push within the field and the profession of science communication began. Since this time the professionalism of the internal PR office has become more science focused and more accommodating of the expectations and needs of scientists. There are still, however, some levels of tension surrounding the role of fundraising in these offices but some institutes (WEHI, JCSMR, GARVAN and to a lesser extent POWMRI) have recognised the role of the institute in fundraising as well as the need for it to be separate from the research activities. The increased professionalism of the science communication practitioner within these institutes has also manifested itself in other ways, such as the awareness by offices about scientific culture and a scientist's aversion to the 'B word' (Breakthrough). Perhaps in addition to educating scientists about the need for' communication skills' the internal PR practitioner is also increasing the awareness of science communication as a legitimate career and promoting professional standards for those within the career that will help the communication and engagement with scientists.

6.3.2 The Internal BD Office

It has been discussed above how there is concern by some science communicators about how the privatisation of science communication and of other outreach activities within institutes could be detrimental to the progress of science communication and the level of transparency in research. This section, addresses this claim more directly in relation to the results presented in Chapters 4, 5 and Appendix III of this thesis. In particular, this section will investigate how the professional BD Office within a research institute can positively promote the adoption of Mode 2 endeavours and recognition of public accountability for science. This section will specifically look at the role of the internal commercialisation office (BD Office) and the challenges these offices have experienced in adapting as part of the modern medical institute. These will be discussed in relation to some of the common challenges the concept of commercialisation in science has faced that have been reported in the literature and in the context of Research Questions 1 and 2.

I will first discuss how each institute handles their commercialisation agenda. I will then discuss the strategies used by the BD Office to encourage and reward commercialisation activities and success with the scientists. These strategies include, most importantly, the ability of the internal BD Office to be flexible with regard to commercialisation policies and procedures. This section will therefore address Research Question 1 of this thesis.

6.3.2.1 The Structure of the Internal BD Office: Integration versus Separation

First, not all participating institutes support an internal BD office and for those institutes that do, the office is usually both small (1-2) people as well as a relatively new addition to the institute. Neither JCSMR nor POWMRI supported their own internal BD Office; alternatively, if a scientist within these institutes needed to access commercial related advice or expertise, this would be available to them through their affiliated universities (ANU or UNSW respectively). For JCSMR, the BD Office is not located within the institute and at the time of this study, there was no internal BD representative either. Likewise, there is no internal BD representative at POWMRI either. POWMRI's concentration on the neurosciences separate it for direct entrepreneurial activities but this does not isolate the scientists from conducting science 'in the context of application' as the scientists at POWMRI maintain close ties to the hospital (Prince of Wales Hospital in Randwick) and their patients. For the spinal cord group, in particular, delivering their research results directly to their patients is more important for them than engaging in Mode 2 commercial activities. Across the three medical research institutes that did support internal BD (Commercialisation) offices (GARVAN, WEHI and QIMR), two major themes were identified that will be discussed further in this section; (a) the existence of incentives to commercialise; and (b) the BD office's adjustment and change of their practices to accommodate the scientific needs of the institute's scientists. Finally, the advantages of the internal model of BD will be discussed in relation to the theories outlined by Etzkowitz (2003).

The BD Officer (Manager) at the WEHI was hired first as a consultant investigating the need for a BD Office and how to incorporate it into the institute. After the initial investigation and report was complete, the BD Officer decided to stay on and attempt to build the office based on his recommendations as a consultant. Before the establishment of WEHI's own, internal BD Office, an external company, Amrad, oversaw the commercialisation activities for the scientists. This was acknowledged by WEHIBD01 as not being adequate for the commercialisation needs of the institute; *'the job is really to assist networking, contacts, funding and that kind of thing...' WEHIBD01*. In his current role, however, the BD Officer facilitates networks and contracts for the scientists as well as helping facilitate the translation of their research to the community; *'My job is to maximise, or at least, enhance the chance of translational science,' WEHIBD01*. QIMR also maintained a relationship with Amrad and then with Vaccine Solutions as the external commercialisation arm of the institute before establishing their own internal BD Office. This was not as advantageous as having their own internal office, according to the officer, as they did not involve the researchers and this created some animosity towards commercialisation in science; *'QIMR in its own right would not drive commercialisation or a fair proportion of its own IP. Vaccine Solutions would do that and I don't think that it did very well as they didn't involve the researchers very effectively,' QIMRBD01*. The BD officer reported having to work harder to further promote his agenda in spite of these bad beginnings. In addition, QIMRBD01 reflected that a healthy research institute is one that drives its own commercialisation agenda, an advantage of having their own internal BD Office. However QIMRBD01 reflected that there was still a lot of ground for QIMR to make up, *'...I do know that these sorts of arrangements are not healthy for a research institute that wants to drive its own commercialisation agenda. If they didn't have these frivolous interruptions, QIMR would be further along and more mature in relation to its commercialisation,'*. The strategy now employed by QIMRBD01 is described as the 'cradle to grave' approach. This approach is when QIMRBD01 is actively involved in research from the grant writing stage to the commercialisation stage without directly influencing or directing the research in any overt way.

In contrast to the other two institutes, commercialisation has been a recognised partner at the GARVAN for a long time. This initiator of the internal BD Office was previously described as an eminent scientist before the role was taken over by the current BD Manager four years ago. The Garvan has the largest BD Office of the participating institutes and incorporates people from a variety of different backgrounds, including a legal and a science background. Although the BD Manager herself does not have a science background, GARVANBD01 specifically separates herself from the scientific process: this is described as an expressed goal of the office; *'...they are researchers and that is what they should be, So our Officer in no way shape or form tries to direct their science in an overt way,' GARVANBD01*. This, in her opinion, allows the scientists who want to involved commercialisation to be involved whilst also not forcing the issue on those scientists who do not want to be involved in the commercialisation process. This technique is recognised positively by the Garvan's scientists, with the internal BD Office enjoying a good reputation amongst the scientists as well as positively promoting the benefits of engaging with commercialisation.

The above examples of the ways in which the participating institutes handle their commercialisation activities provide a number of different methods of engaging science with commercialisation. Promoting a balance between the commercial and scientific activities has been described as potentially painful and difficult to achieve by the literature (Ambos, Makela, Birkinshaw, & D'Este, 2008) and currently there are mixed reviews about the capability of universities to develop commercialisation (Gittelman & Kogut, 2003; Krimsky, 1991; Markman, Gianiodis, & Phan, 2008; Markman, Siegel, & Wright, 2008; Owen-Smith & Powell, 2003; Slaughter & Leslie, 1997; Stern, 2004). The heart of the challenge is in essentially to take an institute that is equipped for and accustomed to doing academic research and ask it to build a capacity for commercialisation of technology and ideas (Ambos et al., 2008). In particular, the challenge is extended by asking the scientists to develop the simultaneous capacity for the two categories; academic rigour and commercialisation. It has been reported that the failure of attempting to balance these has been related to a number of factors including lack of adequate university structures and policies as well as career tracks and training for individuals (Ambos et al., 2008). In particular, Etzkowitz (2003) who proposed models of how academic ventures can be balanced with commercial ventures, provides the most important theories with which to interpret the results of this thesis. To summarise, Etzkowitz (2003) proposed that research groups act like 'quasi-firms' assuming business qualities that are inherently different from scientific norms. More importantly, Etzkowitz (2003) identified two ways that universities have attempted to engage with industry; first, by separating the academic and business activities; and second by integrating research and business activities under the rubric of a broader institutional mission. Etzkowitz (2003) proposed that the separation approach is the preferred and ideal model and that the integration model will be likely selected when the new mission of the institute is explicitly identified. In the results presented in this thesis, I have shown examples of both of these models.

Three participating institutes; QIMR, GARVAN and the WEHI employ the integration model as defined by Etzkowitz (2003) by having established their own, internal BD Offices. Despite Etzkowitz (2003) recommending the separation model because conflicts of interest can be avoided by placing distance between the activities involved in the advancement of knowledge and those involved in commercialisation, these three institutes have chosen to negate this by attempting to reduce the 'distance' between scientific research and entrepreneurialism. In contrast, the other participating institutes, JCSMR and POWMRI, use the separation model, as described by Etzkowitz (2003) where the financial interest is separated from the research interest by defining boundaries or creating structures that mediate between the two activities. For both JCSMR and POWMRI, the boundaries that are defined are institutional, where the research of the institute is conducted separately to the BD interests of their affiliated universities. There is tension; however, with the mediating structures that Etzkowitz (2003) recommended, because for both JCSMR and POWMRI, no mediating/liaison personnel or structures were identified between the institute and the body responsible for promoting commercialisation of their research. Interestingly enough, for the scientists at JCSMR and POWMRI, a difference in the understanding of the role of commercialisation in science was identified in the interview data presented in Chapter 5. The scientists at JCSMR and POWMRI were not uniformly against the idea of commercialisation but their outlook for the future of science and industry was more negative than with the other institute's scientists. In contrast, scientists from the WEHI, QIMR and GARVAN were more open to the role of commercialisation in science. For these scientists who work with an internal BD office, the negative opinions towards commercialisation in science was considered as a thing of the past; *'....when I started in science, commercialisation was a dirty word whereas commercialisation now is very much highly regarded,' WEHI004 (ATD)*. The scientists here both acknowledge and embrace the role commercialisation will play in helping scientists get their research to those who need it most, their patients. Those who work without an internal BD office did not comprehend the value that commercialisation would bring in delivering their research to patients. Instead, they primarily considered the negatives that are described in the literature, such as restrictions to publishing and the shifting of research agendas, to name a few. Without an ever-present internal BD Office, there are no close professionals to mediate a scientist's fears about these common concerns about commercialisation. There are therefore, attitudinal advantages of having an internal BD representative present both for the scientific researchers as well as to the evolution of research institutes to Mode 2 behaviours, especially in regards to social reflexivity. With participating institutes in this thesis, the integration approach is preferable to the separation model. However, according to Etzkowitz (2003) the preferred integration model is one that can only be achieved over time and also by clearly spelling out the rights and obligations of all involved parties; professors, students, the university as an institution and industry. Additionally, the integration model will only be selected when the broader institutional mission is recognised and practiced by all parties. Using the definition of an institute outlined in Chapter 1 of this thesis, Etzkowitz (2003)'s integration model is more likely to exist within research institutes than in the larger, more diverse universities. This section will now investigate another criterion for the successful integration of commercialisation and science, and that is flexibility on the behalf of the commercialisation officers and their policies and procedures.

6.3.2.2 Strategies used by the BD Office to Promote Commercialisation within an Institute

There has been a lot of research about the transition of universities to adopting IP policies and commercial capabilities. At the heart of this, the challenge essentially involves taking an organisation that is equipped for and accustomed to doing one thing (academic research) and at the same time asking it to build the simultaneous capacity for doing something entirely different (commercialisation of technologies and ideas). Fisher & Atkinson-Grosjean (2002) investigated this integration in Canadian universities. In these universities the ILD (Industry Liaison Departments) role was described as including translation, bridging the 'gap' but ILDs were still found to provoke tension in Canadian universities. The tension at an individual officer level was where officers were criticised by the academics for being too closely aligned with industry and therefore not responding to the needs of the scientists. On an organisational cultural level the offices still regarded their activities as separate and opposite to those of science. In my study, I did encounter some culture clashes between the scientists and the office, however overall the scientists saw the BD Office as a means to achieve their altruistic goals for the improvement of their patient's health. In addition, as was also found by Fisher & Atkinson-Grosjean (2002), the integration and separation models of BD within institutes produced different sources of tension. Conflicts over ownership and disclosure were most likely to occur in universities that adopt the integration model rather than in those who adopted the separation model. However the 'at arm's length' approach of the separation model also reportedly created suspicion in the minds of some academics about the motivations and integrity of the offices. Although there is still some uncertainty with regard to the advantages and disadvantages of the integration and separation models the literature recognises that the university landscape is slowly changing to one that is more accepting of the role of commercialisation.

Bercovitz & Feldman (2008) found that the decisions individuals make to actively engage in technology transfer activities signal their acceptance of the university's initiative for academic entrepreneurialism. However this is not always the case as a scientists' motivation for engaging with technology transfer may be completely separate from their attitudes towards the role of commercialisation in scientific research. In this thesis, a similar motivation was described. Indeed, altruism as well as a desire to generate a return for taxpayer funded research was described by the scientists as being a major motivation to engage in commercialisation; *'...Taxpayers have an expectation that at the end of the day their tax money is going towards medical research and will produce some sort of medicine or cure, a pill they can pop to cure any disease that comes along,' WEHI 007(SBD).* A number of other motivations have been described in the literature for scientists to participate in commercialisation activities. These include the ability of commercialisation to deliver alternative research funding (Welsh et al., 2008) and the organisational IP policies protecting scientists from industry influences.

Gibbons et al. (1994) suggest that many academic scientists still hope that the changes in the institutional landscape will have a limited impact on ability to conduct science and that the number of new actors (including industry influences and representatives) will remain small. It is also suggested that the way in which Mode 2 becomes established in a particular content will be determined by the strategies used by institutes to adapt themselves to the new, Mode 2, situation. For the participating institutes in this study, this has been achieved by combining three distinct strategies; first, office staff and policies surrounding the role of the internal BD Office; secondly, monetary incentives for commercialisation; and finally, one way understanding on the office's behalf of the importance of both the scientist's need to publish and also the institute's need for the scientist to publish as part of their list of achievements in a competitive scientific world.

The first strategy used by the internal BD Office identified in this thesis is with regards to the office staff and policies surrounding the role of the office. Though each internal BD Office was particularly small, each office still recognised the importance of having both an appreciation and understanding of the institute's research; *'...trust is the other crucial thing so you end up being regarded as an ally, an asset rather than a hindrance,' WEHI BD001.* The managers of these offices have been described in the literature as the quintessential boundary workers who are charged with translating academic science into intellectual property (Fisher & Atkinson-Grosjean, 2002). This boundary role is successful in a number of ways but a number of Officers in this thesis described the importance of combining trust and scientific integrity as a method of engaging with their institute's scientists.

The second strategy used by the BD Office and identified in this thesis was in relation to the existence of monetary incentives as motivators for scientist engagement in commercialisation activities. The results are mixed. Although the office professionals interviewed were eager to describe the incentives available to the scientists and institute for commercialisation, no scientist mentioned that the existence of these incentives was a motivator to engage in commercialisation. Between the participating institutes, a number of unique incentive policies for commercialisation existed. The role of incentives for Mode 2 behaviour will be discussed in more detail later, but the specific incentives available at each institution for engagement in commercialisation must be briefly investigated here.

There are different incentive policies at work in the three participating institutes with internal BD offices. For QIMR, there were no financial incentives for commercialisation activities in place at the time of the interview. For the GARVAN, however, the first $10K earned from commercialisation activities goes directly to the researcher. After that, up to $100K is split evenly between the researchers and the Institute. If the commercial activity is more successful in that it earns over $100K, every dollar from this point onwards is split three-ways, between the researcher, the institute and the research department. However there is a catch to this arrangement, one that is specifically designed to encourage the institute's scientists to engage in commercialisation. The researcher is given a choice; whether to take their share personally or whether to invest their share back into their research project. If the choice is made to invest the money back into the research project, then as a sign of good faith and also to encourage further commercialisation behaviour, the research institute and department will also reinvest their share of the profits back into the research project. Likewise at the WEHI, a similar albeit less complex monetary incentive scheme for commercialisation is in place, however all profits from commercialisation activities are divided thus; 30% goes to the inventors, 50% goes back to the institute and 20% is divided equally between all institutional staff and students (providing that the students have been with the institute for a minimum of 12 months). This unique policy was described by the BD Office as one that is designed to break down the scientific opposition to commercialisation and to those scientists involved with commercialisation and ensure that both the institute and the scientists benefit from commercial success;' *So what that does is set up a really strong scene for everybody as everybody benefits from at least that side of commercialisation,' WEHIBD01*. In addition, it is hoped that this policy will also promote the benefits of commercialisation and encourage all scientists to become involved on some level.

A few studies have mentioned the use of financial incentives in university commercialisation policies. Indeed, studies evaluating the opinions of scientists towards commercialisation behaviour have found that scientists see commercialisation primarily as a method for attracting extra research funding as well as the main purpose of university IP policies was to boost licensing income (Welsh et al., 2008). Indeed, the financial incentives in place by the participating institutes' definitely enhanced the benefits of commercialisation for the scientists. In addition, Thursby et al. (2001) found that in the opinion of scientists the income generated by university Technology Transfer Offices is the primary measure of their success. A number of studies, however, have stated that despite financial incentives being necessary for successful scientist engagement with commercialisation, the incentive structure of academia does not encourage commercialisation activities. In fact, academia, if anything, discourages commercialisation as it diverts effort away from more fundamental research endeavours (Goldfarb & Henrekson, 2003). However, for both of the incentive policies in place at GARVAN and WEHI, the focus of these policies was to spread the benefits evenly between the inventor and the other scientists of the institute, thereby actively investing the profits of the commercialisation activity back into these fundamental research endeavours that are described as being ignored by Goldfarb & Henrekson (2003). Although, the scientists involved in this study did not mention the financial incentives as a motivator for involving themselves in commercialisation, these incentives may be working more subtly as suggested by WEHIBD01, by ensuring that all scientists benefit from the commercial success. The barriers previously described in the literature towards commercialisation by scientists are slowly eroding and being replaced with a community that is more open to the possibility as well as to the benefits of commercialisation. Indeed, as incentives exist for all members of the institute and with the models described by WEHI and GARVAN, Mode 1 and 2 models exist side by side as suggested by Gibbons et al. (1994) as both basic and applied research benefit from the engagement and success of commercial activities.

The final strategy identified within this thesis was a one way understanding by the Office behalf of the importance of both the scientist's need to publish and the institute's need for the scientist to publish as part of the institute's list of achievements in a competitive scientific world. Perhaps the greatest disincentive towards being involved in commercialisation as mentioned by the scientists in this thesis was the fear of the lack of freedom to communicate to their scientific peers that their commercialisation involvement would bring. Much of the literature describes the potential threats to the autonomy enjoyed by scientists, some of it based on empirical evidence and some purely hypothetical. Secrecy, withholding behaviour and communication restrictions are three different issues that have been described extensively in the literature. In addition to the concept of commercialisation and individual profit from the results of research being against Mertons original CUDOS norms, empirical research has discovered that a large number of scientists are involved in withholding data from other scientists or delaying publication because of their commercial interests (Blumenthal et al., 1997; Campbell, Weissman, Causine, & Blumenthal, 2000b; Rosenberg, 1996a). This literature has generated a lot of fear within the scientific community, including within the participating institutes in this thesis, about the tradeoffs which commercial engagement demands. Within this study, scientists were more than aware of these possible interruptions to their scientific practice. In fact, in some cases the concept of delaying publication as a result of commercial involvement was still daunting to some scientists; *' ...if we write a publication they want to see the manuscript before we submit it. Initially we were fearful that they would sit on it for a very long time... 'WEHI011 (MGC).* However these fears have been quickly dispelled by the maturity and the professionalism of the internal BD Office that acts both as a buffer for the scientists and as a facilitator of the commercialisation process; *'...but it actually turned out better than we thought. The last manuscript that we sent to them they okayed it for sending off within 24-48 hours of us sending it to them, that's a heck of a lot better than I feared... 'WEHI011 (MGC).* This demonstrated how the presence of an internal (integration model) BD Office mediates the fears of the scientists about commercialisation.

As a result, I did not encounter any inherent withholding behaviours or negative attitudes towards the necessity of communication restrictions. This is, no doubt, directly related to the professionalism of the internal BD Office. Instead of scientists changing their behaviour to accommodate the introduction of Mode 2 through commercial science/entrepreneurial science activities, the offices within these institutes have, instead, adapted their behaviour to suit the needs of the scientists. An example of how this works was described similarly across all institutional BD Offices: the filing of a preliminary patent can now be done in as little as 24/48 hours, thereby allowing scientists to publish and/or speak at a conference and not interfering with their scientific practice; *'...if a scientist will come in and say that he had to go to a conference in two weeks the patent attorney is fantastic..they are part of the team and [will] understand what we are trying to achieve in this office...and so they'll get* *cracking,' GARVANBD01.* These efforts are not unnoticed by the scientists ; *'it's becoming more streamlined in terms of procedures and forms for viewing potential IP...'QIMR006 (GBI, CHD).* The success of the internal BD offices lies in its flexibility to adapt to the scientific needs (scientific community norms and culture) of the scientists of that institute.

6.4 In Response to Research Question 2: How do the Scientists in these Institutes view the Role of these Offices and more broadly, Communication and Commercialisation of their Research?

6.4.1 Scientists Embrace Their Public Accountability

Initially, many assumed that scientists were incapable of communicating to the public and had little interest or concept of their responsibility to communicate. In fact, it took government initiatives first in the UK and then other nations, to emphasise the requirement and duty of scientists to communicate their science. Despite this, all scientists who were interviewed openly acknowledged and accepted their public accountability in receipt of taxpayer funds. In other words, the scientists in this thesis embraced their social contract as defined by Gibbons (1999) where research and scientists are supported in their efforts to produce 'reliable' knowledge, provided that scientists communicate their discoveries. In this section, the motivations of the scientists' desire to participate in science communication activities will be explored. In particular, the two main motivators identified in this thesis; altruism and public responsibility will be discussed. By discussing these motivations this section will investigate a shift in scientist's attitudes towards the role of science communication as part of the research process. Finally, this section will discuss how the presence of the internal PR Office has acted as a catalyst for this paradigm shift.

In this thesis, I highlighted the reasons scientists chose to pursue careers in science. All scientists within this study mentioned the desire to apply their basic results to public health. With this in mind, the scientists talked about wanting to *'translate basic sciences and technologies into something that was useful clinically to the community.'* This self realisation about their role as public scientists, and repaying the community and taxpayers for their funding was common across all participating institutes. In addition, scientists from a number of fields expressed not only their desire to *'combine discovery with doing something useful'; WEHI006 (ATD)* but also their desire to give back to the community. Certainly WEHI005 (INF), who grew up in Africa and Papua New Guinea, saw his role as a scientist working in the Infectious Disease field (INF) as giving back to the cultures that enriched his childhood by potentially eradicating Malaria, a disease that threatens these communities. Previous research has demonstrated ambivalence towards the concept of altruism in science by researchers Slaughter & Leslie (1997), and participating scientists did talk about how they felt drawn to a research career because of their aptitude for maths/science and their innate curiosity. Regardless of their motivations for becoming scientists, the scientists both acknowledged and openly embraced their 'duty' to communicate and repay the public as part of their 'social contract' with society (Gibbons, 1999) - *'I think it is an absolute necessity to repay the people that are investing in research' WEHI002 (MBD).* In my study, all interviewed scientists were involved in some type of communication activity whether it was talking directly to tour groups within the institute or giving media interviews. The role of communication for these participating scientists has therefore evolved since Dunworthy and Ryan's (1985) survey and the Bodmer Report of 1985.

The concept of public accountability has also undergone a change in the scientific community, becoming an important part of the Institute's organisational culture. There has also been a shift in how scientists view the role of commercialisation in science, another aspect of public accountability considered by this thesis. Scientists now see commercialisation as a method with which they may deliver their research to public health. In particular, scientists are more acknowledging of the role of commercialisation in contributing to their sense of altruism in science and their desire for their research to have a real effect on their patients and wider public health.

In addition, the views expressed by the participating scientists in this study are in contrast to studies in the literature that suggest that scientists are innately hostile to the role of communication and of commercialisation in science. A survey of social and physical scientists in 1985 found that most scientists felt that there was little to be gained within science by engaging in the public dissemination of research without such activities leading to some type of external reward such as increased research funding or career advancement (Dunwoody & Ryan, 1985). It was also suggested in this paper that one of the reasons for the scientist's reluctance to participate in public dissemination of their research results was their environments (Dunwoody & Ryan, 1985). The study found that the environments, influenced by organisational culture and policies, did not encourage scientists to get involved in public dissemination of information (Dunwoody & Ryan, 1985). Two aspects of these environments were identified as barriers to the popularisation of science – the social system of science and the type of scientific employer. However, at the time of the Dunwoody & Ryan (1985) study there would have most certainly been no internal PR Office and the university would not have supported a media liaison role. All institutes would have failed to maintain the internal presence or reminder of a scientist's social contract with society. The professional science communicator's role has also matured to the extent that it does not try to control a scientist's behaviour. Indeed, within this thesis, the participating scientists all acknowledged the important role the internal PR Office played in aiding their public communication and helping scientists to effectively frame their communication messages.

Previous research has overlooked the importance of the internal PR Officer or science communicator when studying the motivations behind scientists who engage in communication activities (Poliakoff & Webb, 2007). An additional aspect highlighted in many studies of the motivations behind scientists' decisions to participate in public dissemination of their research findings was that overall, scientists felt poorly equipped to do so (Matthews, Kalfoglou, & Hudson, 2005). Many initiatives have attempted to better equip scientists by offering training programs in communication and media skills (Gascoigne & Metcalf, 1997). However, this thesis has argued that a main catalyst for the revolution in science of embracing the role of communication within the research process has been the implementation of the internal PR Office.

In the 1990s when science communication began to gain momentum as a research area, there was a strong emphasis on scientists in receipt of public funds having a responsibility to communicate to the public. This thesis has shown that scientists within Institutes have evolved with the concept of public accountability in science and presently acknowledge the role of science communication in research by constantly engaging in public dissemination of research results. This seemingly universal acceptance of the role of public accountability in science has only been heightened by the inclusion of 'community engagement' questions in research funding applications (Pearson, 2001) and in this way, the role of the internal PR

Office reasserts itself as an essential partner in the research process. This is of particular relevance to medical researchers, many of who are also practicing physicians and therefore view communication as of particular importance especially to their patients.

The role of the internal offices as promoters of public accountability in science has been discussed in the literature as having both advantages and disadvantages. One important disadvantage is the potential of these offices to reduce the transparency and accessibility of scientists in research institutes. This *privatisation* of science is concerned with how these internal offices construct academic barriers to the public and therefore can potentially institutionalise the deficit model of science communication (Pitrelli, 2008). The reality, however, is far different, with my results indicating that the existence of these offices influences scientists to embrace their public accountability as well as providing access to dissemination activities that satisfy the scientist's motivations, specifically, by allowing the scientists to more easily benefit their patient's health.

In summary, the internal PR Office acts as a constant representative for the scientists of the institute of their contract with society. The scientists interviewed as part of this study all viewed the role of communication in science positively and actively engaged in communication activities and did so because of a realisation of this social contract with society. More importantly, scientists acknowledged that communicating with the public was one way they satisfied their altruistic desires to contribute to the improvement of their patient's health. Finally, the openness with which the scientists embrace the opportunity to communicate with the public is a relatively new phenomenon as previous research has shown mixed motivations of scientists to communicate with the public, not all of them positive. An overlooked contributor to this change as demonstrated by this thesis is the internal PR Office. This office has a dual role, one as a buffer to prevent the overload of the scientists and to allow them to continue researching but also as a trainer, one that coaches the scientists around communication activities and ensures the science is communicated effectively to the public. It is also acknowledged in this thesis that scientists engage in their own communication activities by liaising with patients and patient interest groups as part of their dual role as scientists and physicians. This dual role may set medical researchers apart from other scientists in relation to their science communication behaviours. The next section will explore the distinction between awareness and promotion modes of science communication identified as operating within the participating research institutes.

6.4.2 Awareness and Promotion in Medical Research Institute Communication

In Chapter 4 I have shown that internal PR offices use a variety of techniques to communicate the institute to the public. These include promoting the 'sexy' research aspects of the science, in particular cancer, as a major attraction for the institute. Additionally however, one of the main objectives of the internal PR offices of each institute is to, directly or indirectly, raise money for the institute. In this section, I will address the differences in the modes of communication with which each scientist and internal PR Office engages and I will attempt to classify these into two distinct areas of science communication. I have termed these modes as; the *awareness* mode and *promotion* mode of science communication. This will help the internal offices to better target communication activities that will engage their scientists and public whilst avoiding activities that run perpendicular to the nature and motivations of science and scientists, thereby causing tension.

In this study, participating in the awareness mode of science communication is done by the scientists where they create a dialogue between themselves and their patients. In this way, engaging with the public is a natural activity for the scientists seen in the five participating research institutes. This contact with patient groups means that scientists can deliver their research results directly to the people that can use them the most. The scientists are self regulators of their own communication involvement. Within the five participating medical research institutes, scientists are already practicing the awareness mode of science communication as part of their research activities. This open participation with interested patient groups, which is regulated by the scientists themselves, is an example of how 'science awareness' activities differ from the 'science promotion' activities run by the Internal PR Office.

For the scientists, communicating openly with members of the public who have a vested interest in the information being communicated is a role that is considered important to the progress of their research. In my study, it was seen that scientists involve themselves with communication to primarily to increase the public's 'awareness of science' that is; speaking about their research to interested patient groups and people who can use the information; *'...So I could communicate directly with the people with Coeliac Disease so I was able to tone my language and communicate to the people that really mattered the most, the patients,' WEHI006 (ATD).* In fact, a number of the participating scientists freely described situations when they have engaged in the awareness mode of communication. This does not, however, make the scientists any less inclined to participate in the institute-led PR activities but rather these awareness modes of communication bring their own individual set of advantages for the scientists. Indeed, as seen in Chapter 5, POWMRI02 (DNG) is involved in a field that affects only a small percentage of the population and therefore he would prefer to engage with the patient support groups because he realises that the media would be less inclined to include stories about such a small population. He prefers to involve his spinal cord injury patients in his research through participation in experiments. This ensures that the patients gain access to care whilst remaining engaged with current research and researchers that will potentially improve their health. The same is true for WEHI006 (ATD), who originally trained as a medical doctor before engaging in full time research. WEHI006 (ATD)'s main motivation is to contribute tangible improvements to the quality of life for people with Coeliac Disease which is the focus of his research. WEHI004 (ATD) was the founder and still is an active advocate for the Coeliac Foundation and considers his role as a researcher in this disease as an extension of his role as a medical practitioner. It is his research however that allows him to more directly contribute to the welfare of his patients. Finally, GARVAN007 (OTHER) also comes to science from a medical background and unlike the above examples still practices as a medical practitioner at the GARVAN's affiliated hospital, St Vincent's Hospital in Darlinghurst. GARVAN007 (OTHER) also states that his role as a medical practitioner aids his ability to communicate to the public about his research. In a similar fashion to WEHI004 (ATD), GARVAN007 (OTHER) is able to deliver the knowledge produced in the laboratory straight to his patients in the hospital; '*...it is always about communicating with patients, do they understand what you are talking about, are you giving them the information so that they can take on what they need to make the decisions that they want to make'*. These examples demonstrate how the scientists in this study are engaged in differing levels modes of communication that are distinct and separate from the Internal PR Office run communication activities. In addition, scientists regulate their own participation in these activities in order to benefit the patient ahead of their institute. This participation in this awareness of the science was found to be only emphasised through the institute's relationships with a public hospital. In particular, the institutes; WEHI, POWMRI, GARVAN and QIMR are all located close to hospitals and maintain strong ties and affiliations.

In contrast to the awareness mode of science communication, the promotion mode of science communication supports different aims, motivations and outcomes for successful science communication. One strong example of the promotion mode of science communication relates to the institutes that concentrate on fundraising as a main function of the internal PR office.

For QIMR, the internal office maintains the objective of raising funds from the public; this is why communication is important for them. This role of fundraising as a function of the internal PR Office was also seen at POWMRI. The difference in communication functions and outcomes is one main difference between the awareness and promotion modes of science communication. Another difference between the awareness and promotion modes of science communication relates to the biases the promotion of science activities have towards fashionable or sexy aspects of science. This phenomenon, the 'bald baby effect' by which the internal PR Office promotes the institute positively in the public's eyes and attracts more media coverage; *'the journalist has to sell their story because there is only 'x' number of spots in the paper and there is 'x+20' stories. Science is a bit of a hard sell so it is my job to filter the stories and okay something only if I think it is prospectively a story' WEHISC01*. It is the sexy science stories, more often Cancer stories that will be most likely reported in the public press and bring the most return to the institute. For POWMRI, an Institute concentrating on Neuroscience, it is recognised that having a cancer program would stimulate donations; *'If we had a cancer research program here then our income through donations would go through the roof,' POWMRISC01*. This relationship between the amount of funding and the type of program being promoted has been observed previously. Corbett & Mori (1999) identified a 2-way concurrent relationship between breast cancer funding through donations and the amount of media coverage. By using the 'bald baby effect' the promotion mode of science communication bypasses the scientific merit of the research in favour of communicating the 'B-word'. By using selected research programs the promotion mode of communication is sure to trigger emotive cues in the public thereby gaining media attention as well as public support.

There are fears that true open science communication cannot be achieved with an institutional internal body filtering the information. This is the concern of Pitrelli (2008) who warned against what he described as the 'privatisation of science communication'. He described how an institutional PR office would reduce the 'visibility' and 'transparency' of science and that this direction was in opposition to the field's goal of a true dialogue in science. However, even though there is a separation and therefore tension between awareness and promotion modes of communication within research organisations they can still work cooperatively. An example of this was described in Chapter 5 with scientists receiving direct phone calls from members of the public who are seeking more information on a particular field of research. While the promotion mode of science communication works to highlight the research of the institute as well as the profile of the researchers involved, not all information communication via this mode is accurate. Nevertheless, this mode still enables the public to locate researchers whom they have seen profiled in the media. In these situations, it is the promotion mode that help the public locate the researcher within the institute, whereupon the awareness mode takes over with the scientists communicating directly to the public about their research and its relevance to the enquirer.

Increasingly, as science gains more exposure in the public media (science promotion activities), scientists are fielding more calls from members of the public asking for further information regarding research topics. This is an indication of how the promotion mode of science communication is working. One example of this outlined in Chapter 5 is with GARVAN004 (DNG) when she receives calls from the public. These calls involve enquiries about clinical trials or how to get access to the 'breakthrough' treatment that will cure them of a disease. As a scientist in this situation, she sees her responsibility as clarifying the misunderstandings of the public and to not give 'false hope'. Despite her research being misrepresented by the promotion mode of communication her duty remains to remind them of the value of research;*' I give them honest information and find that very often honest information and kindness and just being kind and empathetic can help' GARVAN004 (DNG).* Receiving these phone calls is not an isolated incident restricted to GARVAN004 (DNG), scientists from all institutes recalled situations when they received calls from the public and were required to clarify the misunderstandings the public had about the potential of the research. These public misunderstandings are usually the result of the promotion mode of science communication. Using the term 'breakthrough' to stimulate emotive cues from the public subsequently over-represent the future possibilities of the research. Indeed, a number of scientists resented the use of the 'B-word' as they thought that these over representations were harmful to the profile of research.

In light of these distinct modes of communication and described example situations, the future aims of the Internal PR Office will be to balance the scientists', self regulated awareness mode with the institute's desire to promote itself via the promotion mode of science communication. As with all science communication, the challenge is to promote accurate scientific information to the public sufficiently without promoting the public's false hope for a 'breakthrough'.

In summary, the awareness mode of science communication is characterised by scientists who regulate their own communication behaviours in engagement with the public via their role as a medical practitioner, engagement with patient interest groups and direct public phone calls. In this way, scientists use their science to inform the public and these activities are separate and distinct from the efforts of the internal PR Office. In contrast, the promotion mode of science communication is mainly controlled by the Internal PR Office as part of creating, selling and maintaining the institutional message and public profile. By concentrating on this, however, the internal PR Office often fails to recognise the value of promoting the scientist regulated science awareness mode of science communication. Both modes, however, can work cooperatively and the challenge for the Institutes in these situations is to be able to *promote* scientific information sufficiently to raise the *awareness* of the research being conducted at the Institute without falsely promising a breakthrough. What is evident from the results presented in Chapters 4 and 5 was that the internal PR Office and the scientists was that both have very different ideas of what constitutes effective communication in science. Further research is needed to investigate both modes of communication more thoroughly in order to develop more efficient and successful science communication strategies.

6.4.3 Cancer is Big News both Scientifically and Publically

The analysis of the bibliometric data in Appendix III of this thesis revealed that the majority of the change and growth in the publishing behaviour of scientists occurred in the MGC and CHD fields of research. Likewise, the interview data showed that for the professionals within the communication and commercialisation office, there was a realisation that a cancer story was more likely to engage the public's attention (and the media's attention) as well as promote the institute in a positive light. This section will discuss this result more thoroughly and in relation to the interview data outlined in Chapters 4 and 5 of this thesis. In particular, this section will concentrate on discussing the following results; the growth in the impact factor of the articles published during the period 1999-2005; the growth in co-authorship/collaboration of journal articles over time; and the difference between institutes for the MGC field and small significance in the growth in the CHD field between institutes.

For the internal PR Office especially, there is a realisation that the cancer aspect of their institute's research is particularly effective when promoting the institute to the public. Indeed, the internal PR Office often biases the promotion of science activities towards fashionable or sexy aspects of science. Previous research has also investigated the media's and public's preference and increased interest for research stories regarding cancer. MacKenzie et al. (2008) reported that 'cancer' was the fifth most reported health issue and in all 25 different cancers were identified in the media the most popular being breast cancer and melanoma. Studies have found that television news coverage of cancer in Australia can be melodramatic, often inaccurate and sometimes at odds with scientific consensus (MacKenzie et al., 2008). Additionally media coverage of research over-represents celebrity diagnoses and claims about scientific 'breakthroughs' (Ooi & Chapman, 2003). There are also some reports that scientists may be developing an area of science apt to be published as a piece of news but lacking in scientific integrity. Behind this hypothesis is a number of studies that show a direct relationship between publishing scientific research in the press and a subsequent increase in the SCI index (Elias, 2008; Phillips, Kanter, Bednarczyk, & Tastad, 1991). This however might not be a real relationship, as my results in Appendix III show in this research, Cancer (CHD, MGC), Immunology (IMM) and other applied scientific research areas are more likely to be promoted by the internal PR office through the media because there is an understanding that this is what the public wants to hear. Cancer and health in general is a topical issue and one that affects the larger population, therefore it is not surprising that the public want to read about it. Likewise, because these research areas are important to our Nation's public health, the majority of government funds are being directed into these areas, allowing for the growth of research groups, researchers and national and international collaborations. Despite some poor studies, (Elias, 2008), there is still a handful of papers that suggest that scientists and health practitioners are made aware of new studies and research papers through the media. This may influence ISI citations (O'Kefee, 1970; Phillips et al., 1991) and this too could be used as an explanation for my findings.

There is a however, a degree of caution felt by scientists towards the media and the public in relation to communicating cancer related research results. In particular, as scientists are aware of the high value the public holds for cancer research information (Ooi & Chapman, 2003), scientists are also conscious that the media can and often does exaggerate the results and overuse the 'B' word thereby misrepresenting the current state of cancer research to the public and raising false hope; *'...give the media messages and then people start calling and they want to be in the trials of the drug that is going to cure anorexia or obesity,' GARVAN004 (DNG)*. The overuse of the 'B word' and misrepresenting the integrity and true potential of the research has been shown to be frustrating for researchers especially towards the media (Deary, Whiteman, & Fowkes, 1998). Deary et al. (1998) illustrates one example of the misinterpretation of research results by the media and how the media look for the controversial angle rather than explain what the scientists feel are the important aspects of the research. This misrepresentation indirectly affects the scientist's scientific reputation. This view is particularly common in the older, more traditional institutes (WEHI and JCSMR). In fact, one scientist in this study commented that she felt scientists could involve themselves too much in communication and promotion of their research and that this behaviour borders on self interested promotion rather than for the good of science; *'...I guess we have the underlying feeling that we are in it [science] for the good of mankind and not self-interest,' WEHI008 (ATD).* Recent research has found audiences will pay more attention to certain dimensions of science over others depending on how an issue is 'framed' in the news coverage (Bubela et al., 2009). Journalists use frames to condense complex information into interesting news coverage and according to Bubela et al. (2009), if organisations want to use the media more effectively, they need to switch the frame with which they communicate science. The internal PR office is the body within the organisation that is responsible for framing the communication of the institute's research for public consumption. By using the 'bald baby effect', the internal PR office is able to frame the institute's research so that it is communicated positively. This is especially important as Bubela et al. (2009) described the public as lacking the motivation to play close attention to science topics. Instead, they rely on mental shortcuts, values and emotions to make sense of an issue and are drawn to news articles that reinforce their pre-existing beliefs. Using the bald baby effect the internal PR office is assured of grabbing the audience's attention and by using emotive cues is able to promote the institute and its research positively. For institutes such as QIMR and POWMRI, successful promotion using emotive cues and frames, results in the public donating funds. However, POWMRI described this as a difficult task for their research because their topics of research, neurodegenerative diseases, did not stimulate the same emotive cues; *'...put a bald baby on the front of any appeal letter and you will get a* *lot of money. A bald little old lady and people think 'that looks just like my Gran, isn't she cute,' but are they going to give you money? No, not one bit'; POWMRIS01.*

In addition, the scientists are aware of the bald baby effect of public communication. For scientists, however, this is interpreted as increased competition in the field to get published and to receive research funds. In addition, for the researchers involved, increased public interest in cancer is perceived as an increased level of competition in science, between individual scientists, research groups, institutes and countries. In Chapter 5, many scientists reported that it was becoming increasingly difficult to publish research results without larger funding and research groups; *'...I think getting published in Nature or Cell is probably beyond the scope of any one individual...the amount of data that is included in papers and supplementary information is monstrous,' WEHI002 (MBD).* This competition is partially demonstrated in the bibliometric data presented in Appendix III where the main change in the publishing behaviour of the participating institutes and their scientists was seen for the MGC and CHD fields. There was also a change seen for the MBD fields however this can be explained through the close association between MBD methods in more applied cancer research areas. Interestingly, the same strong relationship was not detected for the smaller, more basic research fields such as DNG (Neuroscience).

This result however cannot be entirely explained by an increase in competition in science. It could be because of the increasing availability of new high impact journals in the cancer areas, or because of the increased funds to this area of research that results in a higher publishing output. To investigate this, future studies could include an average number of citations per paper for each field. The number of authors per citation for each field must be calculated to further investigate the nature of this perceived competition in science.

Increased competition in science, whatever the components of this competition may be, is not a negative aspect of modern medical research. Indeed, over the last seven years, there has been an increased number of publications for each institute as well as an increase in collaboration (internal science communication) for research groups. In addition, Australian medical research publications are increasingly being published in higher impact journals thereby achieving a greater level of visibility internationally. The following section will further explore the patterns of publications between our participating institutes and relate them to each institute's area of research expertise.

6.5 In Response to Research Question 3: Has there been any change in scientists' publishing behaviour as a result of the increased level of public accountability in science and/or the introduction of these internal Offices?

6.5.1 The Patterns of Publishing across the Five Specialist Medical Research Institutes

This section will discuss the results presented in support of Research Question 3 which investigates whether there has there been any change in scientists' publishing behaviour as a result of the increased level of public accountability in science and/or the introduction of those internal PR and BD Offices. This research question is separate from the core argument of this thesis as outlined in Research Question's 1 and 2, however the discussion of the results presented here are both essential as validity tests of the interview data presented in Chapters 4 and 5.

In Chapter 5, a majority of participating scientists reported that they had felt that there had been a change in their publishing behaviour. Scientists reported that they felt obligated (for competitive reasons) to publish in higher impact journals and to achieve a greater level of visibility within their field, both nationally and internationally. The Journal Impact Factor (JIF) has been used to investigate the change in the publishing behaviour of the scientists during the period 1999-2005.

Appendix III attempted to identify the exact nature of this change in publishing behaviour by using the JIF as the dependant variable and testing this against a variety of independent variables such as the year, institute, research field and the rate of collaboration (number of authors per article). I hypothesised that there would be a significant change in the JIF of the journal in which a scientist within the participating institutes would publish.

The first hypothesis under investigations is that there has been a significant increase in the JIF of the journal in which the average article would be published over the period 1999–2005 ($p=0.012$). In other words, scientists are achieving a higher level of international visibility by publishing in significantly higher impact journals than they were in 1999. The JIF of the publishing journal is firstly associated with the larger citation rates of the individual articles (Callaham, Wears, & Weber, 2002). A similar trend towards gaining a higher level of visibility by publishing in higher impact journals was observed by Althouse, West, & Bergstrom (2009). However, the total number of references listed has also increased over time, and this would lead to higher citation levels and indirectly, higher journal impact factors. This result is also related to the reward maximisation theory which states that scientists will always aim to publish in the highest impact journal possible, working their way down a ranked list of journals until publication is achieved. The results presented in this thesis lends evidence to the reward maximisation theory as the scientists commented that they were unlikely to change their choice of journal or field of research in order to gain the monetary incentives offered by their institute in receipt of high impact publishing. The scientists did, however, state that they always strived to publish in the highest impact journal for their field irrespective of the incentives offered.

In Appendix III, a significant difference was found in the journal impact factor of the articles between different institutions (WEHI, POWMRI, JCSMR, GARVAN and QIMR) ($p<0.001$). This result is closely related to the finding that a significant difference was found between the journal impact factor of the articles between different fields (CHD, ATD etc). Differences in the JIF of different fields is not a new result and such differences have been extensively explored in the literature (Ball, 2008; Falagas, Vasilios, Kouranos, & Drosos, 2008; Hakkalamani, 2006; Vinkler, 2002). This result, however, will be discussed in the context of the unique field classification methodology employed in this study. The five participating medical research institutes all specialised in a different field of research. Both JCSMR and GARVAN were classified as generalist institutes however, JCSMR has a reputation for basic research and GARVAN's reputation is for applied research. The remaining three institutes are more specialised. WEHI's reputation centres around Immunology (IMM) and its related fields. This can also be seen in WEHI's history and the achievement of winning a number of Nobel Prizes in this area. QIMR, in contrast and in accordance with their location in Queensland, Australia, specialises in infectious diseases (INF). Finally, POWMRI is wholly a neuroscience (DNG) specialist institute with no other research fields taking place there. All research institutes, with the exception of POWMRI, supported different cancer programs of study but as the results in this study show, some of the institutes were shown to have a stronger publication output than other research institutes in this field. An unexpected result emerged of a significant interaction between the JIF and the MBD publications between institutes ($p=0.002$). This result is explained by examining the classifications of the participating scientists. The majority of scientists in the bigger, more applied fields such as MGC or CHD also classified themselves as MBD. The area, MBD is a basic science field and in order to do the more applied research areas such as CHD, MBD techniques are required. It is not surprising therefore that when there is an increase in the applied CHD field there is also a corresponding increase in the MBD field.

There was also a significant change in the level of collaboration for the average journal article for the participating institutes. This was shown by the average number of authors per article increasing linearly over the period 1999-2005 (r^2=0.97, P<0.05). This result could be related to the reports from the interviewed scientists about their realisation of the necessity to collaborate broadly, over a variety of different fields in order to achieve the amount of data necessary to publish in high impact journals. Indeed there are acknowledged discipline differences in the level of collaboration and therefore competitive fields would require a larger level of collaboration than the smaller, more specialised fields (Qin, Lancaster, & Allen, 1997). Previous research has also reported the rise in the level of collaboration over time; in particular one study found that the incidence of group authorship has been reported to be steadily increasing over the last 20 years (Weeks et al., 2004). Indeed, multidisciplinary science has been found to be more cited than single subject, single authored papers (Levitt & Thelwall, 2008a) and there has also been an increase in collaboration among nations and research institutions over 20 years (Melin & Persson, 1996). This study concentrated on the sub fields within medical research, which proved to be diverse, by controlling for these subfields. The study attempted to gain an accurate picture of publication activity within several disciplines of medical research. By examining 4.2 million papers over 30 years, Jones et al. (2008) found that multi university collaborations had increased over time. More importantly, Jones et al. (2008) found that not only was co-authorship the fastest growing type of authorship structure but that is also produced the highest impact papers. Additionally, when a paper included a collaborator from a top-tier university there was a significantly increased citation advantage. This demonstrates how collaboration can benefit the overall impact and visibility of a paper and indirectly, the institute.

Finally a significant interaction between the level of collaboration (as measured by the average number of authors per journal article) and the JIF of the journal in which the article was published was found. Similar relationships have been observed in a number of previous research articles; however the incidence of such articles is small. This may be a for a number of reasons including the inability for bibliometrics to accurately pinpoint a paper and journal's field, an issue partially covered in the methodology of Appendix III by requesting that the classification be done by the scientists themselves. Another explanation for this relationship between the journal impact factor and the number of authors per paper may be related to the open access of an article. Indeed the ease of accessibility can be related to cited-ness by having a large number of authors per paper. This would increase the probability of self-citations in future work, as well as the related work of each author's laboratory thereby increasing the overall number of citations. In relation to visibility of the research, there are many ways of increasing the visibility of a piece of research many of which are related to the behavioural and personal characteristics of the author of the article and the journal editors. In fact, many studies have identified relationships between behavioural aspects of publishing and have therefore attempted to predict both the impact factor of the publishing journal and the citations a paper will receive (Callaham et al., 2002; Levitt & Thelwall, 2008b; Lin, Wu, & Zhang, 2009; Wu, Fu, & Rousseau, 2008; Zhai, Wu, & Zhang, 2009). The findings of this thesis is related in part to the general characteristics found of high impact papers and that the level of visibility achieved through publication in high impact journals is of similar importance to scientists (Aksnes, 2003). Therefore, gaining a high level of visibility through publication is not necessarily related solely to the properties of the individual papers and instead may be related to the behavioural qualities of the scientist, the collaborators and the institute. Additionally, there have been a number of reports about journal editorial teams manipulating journal properties in order to increase the impact factor of their journal (Falagas & Vangelis, 2008). Self-citation is also a widely reported behavioural mechanism used by scientists and editorial teams to boost the citations and the impact factors of a journal (Falagas & Vangelis, 2008). Although this study did not look at the influence of self citations in the visibility of the researcher and the institution, future studies should take this into account.

An acknowledged limitation of this study in light of the introduction of publication incentive schemes may have confused the results of any effect of the increased competition and/or emphasis in commercialisation has had on the publication output of the participating institutes. However, this thesis also showed that scientists were unlikely to change their choice of journal or research field in order to achieve these incentives. Future research should attempt to control for these factors in order to achieve a clearer understanding of the affect changes in the research community has on publication output.

6.5.2 'Science is like Sport': Competitive and Sometimes Ugly

During the course of the interview stage of this research project, one researcher remarked off hand that science would be easier and more interesting to the public if it was communicated more like sport, where the competitive and ugly nature of being a scientist was emphasised. This section concentrates on just that, the competitive and ugly nature of scientific publishing. In an effort to answer Research Question 3, the section analyses whether there has been any change in the competitive nature of science perceived by the scientists and reflected in the quantitative bibliometric analysis for the period 1999-2005.

The acceleration of ranking using quantitative data has created a culture that is constantly being 'watched' and evaluated based on numbers including, the JIF. The intended effect is to create competition amongst organisations and research thereby increasing their efficiency. There has been little empirical data on the impact of bibliometric rankings on scientific output (Weingart, 2005). However, in Australia a study investigating the implementation of formula based funding (based on the number of publications in peer reviewed journals and linking that to funding) increased the total number of publications but did not increase the 'quality' of the publications as measured by the number of citations (Butler, 2003). An extreme case of overuse of bibliometric indicators is in Finland where it is implied in university evaluation policies that the publication of just one paper in a higher impact journal can boost the budget of a university hospital by about US$7000 (Adam, 2002, p.727). With this in mind, it is no surprise that publishing has become a competitive sport and that institutions are taking an active role in introducing incentive schemes to encourage their scientists to aim for the higher impact journals.

Of the five participating institutes, three offered monetary incentives for publishing in high impact journals. When the scientists were asked about this, the main comment was concentrated on scientists wanting to publish in a high impact journal regardless of any financial return; '*...we should be always striving for the best journals so if it makes people more that this is something that's going to be considered for promotion or bonuses or whatever it probably just makes it in the back of your mind all the time, but I don't think that people are going to change their research fields or journals so that they can get high impact* *factor journals and get their bonus,' QIMR002 (INF).* Scientists are interested in choosing the channel (journal) of communication that delivers their results to the most relevant audience and thus gaining a higher level of visibility in their field. This is in accordance with studies in the literature that found that scientists chose a journal to publish for a number of factors (Gordon, 1984). In addition to the reward it would bring, a main consideration was the communication advantage publishing would bring (Gordon, 1984). This finding was in addition to the confirmation of the reward maximisation model of scientific publishing on which this thesis' quantitative research aspect is based (Luukkonen, 1992). In this study, however, reward was only a minor concern for scientists as they were open and willing to publish in relatively high impact journals regardless of the financial incentives on offer from their institute.

In this thesis, a change was seen in the publishing behaviour over the time period 1999-2005 for these five participating MRIs. The scientists were, in some cases, correct when they reported that they perceived science to be more competitive but a significant change in the log (JIF) over time was only seen for a handful of fields (CHD and MGC). In addition, the level of collaboration as measured by number of authors per article increased linearly over the period 1999-2005. This could be a result of a number of factors, including; the rise of electronic communication which makes collaboration easier for scientists; the access to funding which has been restricted forcing scientists to collaborate more in order to gain access to facilities and results. Another explanation is that the rise of competition in science has forced scientists to include extra authors who are from overseas or affiliated with a high ranking organisation on their papers despite very little input into producing the science. This is a reversal of Hagstrom's (1965) 'gift exchange' theory of scientific exchange where individual scientists donate their findings to the scientific community and in return receive various forms of recognition, usually used for promotions within the community. Scientists have also mentioned that they have feel forced to publish in higher impact journals and wider and more often now than they did 10 or 20 years ago; *'...It also seems to be that there is much more emphasis on publishing in high profile journals so that's obviously made it much harder to practice science, especially in relation to resource allocation,' JCSMR005 (MBD)*.. The publication incentives offered by some institutions do increase this perceived pressure. In addition, the scientists particularly feel constrained that in order to get published in the higher impact journals, they need to collaborate more and have papers with a larger number of authors; *'...papers have become a lot more difficult to produce, you require major teams rather than the input of individuals..I think getting published in Nature or Cell is probably beyond the scope of any one individual, the amount of data that is included in papers and supplementary information is monstrous,' WEHI002 (MBD)*. This has also been seen as one of the key changes for publishing behaviour where the average number of authors per paper was found to be increasing linearly.

This however could not be seen when I controlled for field. For the more competitive MGC and CHD fields, a logarithmic increase in the impact factor over years and between institutions was observed. The same could not be said about the number of authors for the MGC field but could for the CHD and MBD fields. Additionally, a logarithmic increase in the impact factor over time was observed for the Year.CHD interaction when the number of authors was restricted to fewer than 30 and the same was seen for the MGC field. Furthermore, when the number of authors was restricted further to fewer than 10, the YEAR.CHD interaction was lost but the Year.MGC was retained.

The result for the interaction between the log (JIF) over time for the MBD field was surprising; however this can easily be explained by examining the classifications of the participating scientists. The majority of scientists in the bigger, more applied fields such as MGC or CHD also classified themselves as MBD. The area, MBD is a basic science field and in order to do the more applied research (and subsequently the more competitive and more publicly interesting) MBD techniques were required, so it is not so surprising that when an increase in the applied CHD field is observed, a subsequent rise in the MBD techniques used to discover it is also seen.

In relation to the observed increase in collaboration as measured by the number of authors, Gibbons (1999) related this to the increasing number of transdisciplinary endeavours over time. He stated that the demand for this type of knowledge is also coming from policy makers and society in general and new funding criteria and opportunities are being created to attract researchers to Mode 2. In order to deliver on this new societal contract, an increase in the number of participants from an increased number of fields is required. Although this research is unable to comment on the 'quality' of the work being presented in each of the 5110 publications analysed in this study, it can say that scientists are publishing in higher impact journals than the journals in 1999 and can confirm from the interview data that the reasons are competitive. This thesis however cannot conclude with any certainty why that competition has increased. One suggestion is that the very nature of the introduction of quantitative evaluation measures in science has influenced how scientists publish, that is that now scientists know that they are being watched and evaluated, they make more of a concerted effort to publish in higher impact journals. Another suggestion has to do with an increased role of the principle of maximum return in bibliometrics than has previously been thought, that is that scientists will always aim for higher, more influential journals in which to publish their research because of their inherent desire to make their research as visible as possible.

In summary, with the acceleration of ranking using quantitative data, there has been little empirical data on the impact of bibliometrics rankings on scientific output (Weingart, 2005). Despite this, the current study has shown that publishing behaviour has changed over the time period 1999-2005 for these participating MRIs. The scientists were, in some cases, correct when they perceived science to be more competitive for publishing but this was only seen, using publication output, for a handful of specific fields (CHD and MGC) and in relation to collaboration as measured by the number of authors.

6.5.3 It is Difficult to Relate any Change in Publishing Behaviour to the Increased Emphasis in Commercialisation

One of the areas of particular interest to scholars studying the evolution of commercialisation of science and scientific organisations is the potential effect on scientific publishing output. This section will investigate these claims in relation to the results presented in Chapter5 and Appendix III of this thesis and in answer to Research Question 3. Of particular interest in this section is the research concentrating on producing empirical evidence investigating the 'skewing problem' and the 'crowding out' hypotheses. The issue surrounding scientists purposefully withholding results, methods or materials because of commercial and competitive reasons will also be discussed here.

In this thesis, it is difficult to ascertain the effect of the increased emphasis on publishing output. The participating scientists described an increased emphasis on commercialisation; '*...when I started in science, commercialisation was a dirty word whereas* *commercialisation nor is very much highly regarded.' WEHI004 (ATD).* Interviewees also mentioned an increased level of competition in science; *'...if you are to make significant discoveries and publish in the higher impact journals, you need more money, bigger teams and it's really hard,' JCSMR005 (MBD)* that was related to the increased emphasis on commercialisation. The effect these changes have had on publishing behaviour, however, could be attributed to a number of different variables. Nevertheless, it can be said from the results of this study, that there is no negative effect on their publishing output deriving from the increased pressure for scientists to commercialise. Indeed, over the last 7 years, scientific publishing output in some areas (CHD, MGC especially) has thrived under this perceived commercial and competitive environment. A corresponding increase was observed in the number of articles published in high impact journals as well as a higher level of collaboration between national and international research groups for the time period 1999-2005. These results run counter to some of the fears described in the literature that concentrate on how commercial involvement in science would restrict the publishing freedom of science and scientists and that publication would be substituted with patenting as the academic communication mode of choice for scientists.

There are a number of proposed reasons for this observed effect. First, one must consider whether the perceived increase in the emphasis in commercialisation has indeed changed the culture within which these scientists work. This thesis initially assumed that this increased emphasis was a relatively new phenomenon and not one that is already embedded in the culture of these scientific organisations. It is possible, however, that scientists are already looking to commercialise their work and so any outside influences that would potentially increase the expectation to do this would have little effect on how the scientists already work or behave. This was seen in the interviews where a number of scientists viewed commercialisation, not as interference but as an acknowledged method of delivering results to the community; *'I see that what we do gets paid by the taxpayer and taxpayers have an expectation that at the end of the day their tax money is going towards medical research and will produce some sort of medicine or cure, a pill they can pop to sure any disease that comes along,' WEHI007 (SBD).* This was not the opinion of all scientists in this study, with a minority still hoping that commercialisation in science would play a small role when compared to the emphasis of curiosity driven research in developing new scientific results; ' *...I'm not in science for a commercial purpose; I'm in science to discover new things,' JCSMR020 (DNG).* Commercialisation is not the enemy and conversely some scientists see it as a partnership to ensure that their discoveries get to the people who need it the most – their patients.

A second proposed explanation for the data shown in Chapter5 and Appendix III is related to the internal reward system within science. Despite an increased emphasis on commercialisation from government and community expectations, the reward system within science has remained primarily focused on publication and traditional academic outcomes. With this in mind, scientists are working harder to meet these internal, traditional scientific expectations. This would explain the increased publication output, visibility and quantity in the more competitive and applied fields of research such as MGC. However, the same cannot be said for the other fields of research investigated in this study. In order to investigate this further, future research should therefore conduct a study of the participating medical research institute's patent output and compare its growth to the growth (if any) of publications.

The final proposed explanation and the one that will be the focus for the remainder of this section is related to the increased professionalism of the internal BD office. In this study, the institutes with established internal BD Offices (WEHI, GARVAN and QIMR) are significantly higher impact publishers compared to those without internal BD offices (JCSMR and POWMRI). This could also be a result of the differing levels of applied versus basic research being conducted in these institutes. In particular, an institute with a higher level of *basic* medical research may not benefit from the existence of an internal BD Office to the same extent as an institute with a high level of *applied* research. All scientists were still somewhat wary of the potential effect commercialisation could have on their publication output, but those who were open and receptive to the role of commercialisation in research were not only aware of the tradeoffs but knew that with the presence of a professional Internal BD Office, these tradeoffs were negligible. This speaks to the growing professionalism of the internal BD Offices in Australian Medical Research Institutes as it is the BD Office's practices that have changed to adapt to the needs of the scientific community and not the practices of the scientists. This applies also to publishing freedom and opportunity. In contrast to the concerns expressed in the literature, it was found was that the BD Offices not only recognised this problem but had implemented strategies and policies that would negate any concerns the scientists may have about commercialisation. To the credit of the internal BD Office, no evidence of the skewing hypothesis or crowding out between publications or patents was found in this study. In fact, overall, the number of publications increased over the time period 1999-2005, as did the level of collaboration as measured by the total number of authors per journal article. When the participating scientists were asked whether they had either participated in or had experience of withholding of results, materials or methods, it became clear that a certain level of withholding has always been a characteristic of scientific competition; *'People constantly* *fail or are evasive about materials, it's an integral part of competitive science....information is at the heart of science and people tend to keep information to themselves,' WEHI005 (INF)*. Scientists at institutes without an internal BD Office felt this more acutely and were more wary of the potential trade off between commercial involvement and the freedom to communicate with their peers and through publications and participation in conferences, '*...when you try and discuss it [your research] with other people, you can't anymore because people now repeat the same experiments over and over again because no one actually tells you what they have already done,' JCSMR020 (DNG)*. The role of the internal BD Office is a facilitator of commercialisation rather than one that attempts to control or influence the direction of the research. This is further highlighted by the individual institute's scientists being aware of the expertise offered within the Office and in the way that the scientists now accept this expertise as valuable and essential tools in the research process. The scientists with access to an internal BD Office view once daunting aspects of commercialisation such MTAs as now crucial research tools and also tools that can be used to promote their research and develop collaborations with other scientists; '*We have used MTA's for vectors and things. It is actually a good mechanism to stop people passing things around without you knowing it,' WEHI003 (INF)*. This is evidence for the increased professionalism of the BD Office and how having access to this expertise is advantageous for a scientific career. Indeed, this is appreciated by the scientists of each participating medical research institute with an internal BD Office; '*...its becoming lots more streamlined in terms of procedures and forms for viewing potential IP to getting it ratified and getting lawyers to draw up patents if it looks as if it is a viable entity,' QIMR006 (GBI, CHD)*. In summary, the maturation of the internal BD office has facilitated the commercialisation process for scientists to the extent that the fears portrayed in the literature are now negligible. This reinforces the role of the BD Office as one that facilitates the commercialisation process and therefore encourages all scientists to be involved with commercialisation. This view is expressed by the BD Officers who describe this as part of their role within the institute.

In relation to the skewing hypothesis and the crowding out effect, there was no evidence of this occurring in any of the participating medical research institutes. In addition, another expressed role of the BD Office is to ensure that this does not happen. This is both observed and appreciated by the scientists who have, in the past, engaged in commercialisation through their institute's internal BD Office. This therefore indirectly and positively promotes commercialisation as part of the institute's culture and identity.

6.5.4 Scientists' Publishing Behaviour is Minimally Affected by Publication Incentives Officered by their Institutes

One of the more interesting internal policies this study encountered was the delegation of monetary incentives for high impact publishing. The GARVAN, WEHI and QIMR all had some measure of a publication incentive policy in place at the time of this study. This section will investigate the role of these incentive schemes.

In a culture that has been described by the participating scientists as becoming increasingly competitive, institutes, organisations and universities are competing against one another for an increased share of government funding. The distribution of this funding is partially determined by the visibility of a scientist's research through journal publications. With this in mind, it is no wonder that the participating institutes are developing strategies that will both increase the visibility of their research publications, but would also potentially attract additional government funding. Monetary incentive schemes that aim to encourage scientists to publish in higher impact journals would also succeed by reinforcing the reward maximisation theory of publishing.

At the GARVAN Institute, when a scientist publishes in a journal with an impact factor over 10, each collaborating author irrespective of their position in the list of authors was awarded $1000. A similar scheme was in place at both the WEHI and QIMR where the amount of money awarded was dependent on the impact factor of the publication, with the higher impact factor journals earning the authors higher rewards. However, GARVAN 001 sees the role of the monetary incentives distributed by his institute as a 'reward' for research excellence rather than providing an incentive to publish in higher impact journals because scientists already aim to publish in the highest impact journal possible. This view is reiterated by scientists at other institutes with the additional consideration that not all research fields have access to the same amount of high impact journals in which to publish; *'...if you are working in a low publication field like public health/tropical health, the impact factors of the top journals in your field are 3 to 5 or 6 at the most, so you would never get a bonus if you were the best practitioner publishing in tropical or public health,' QIMR002 (INF).* One scientist noted that the existence of publication incentives was unlikely to influence a change in his research field or his choice of publishing journal; *'...we should always be striving for the best journals...I don't think that people are going to change research fields or journals so that they can get high impact factor journals and get their bonus,' QIMR002 (INF).*

The aim of these publication incentives is also to attract more high quality scientists and collaborators to the institute, thereby adding value to the institute's brand and indirectly increasing the visibility of the institute's research publications. GARVAN001 mentions that publication incentives are designed to attract the best and the brightest to those particular institutes; *'by improving the financial reward for scientists, not just in the immediate sense for GARVAN scientists but also permeating outwards to make sure that we raise the remuneration levels for scientists in general because of their value to the community,'*. The overall effect is not as the policy intends, to encourage scientists to seek monetary gain so it is hypothesised that the publication incentives would have had little effect on the publishing output of the GARVAN. In contrast, some scientists in this study suggest that the policy works more like *personal rewards* as the scientist's intention was always to relate their research to the benefit of their patients and no further incentive than this altruism is necessary. The data presented in Appendix III further illustrates that publication incentives have little effect on the publishing behaviour of some fields however a significant difference over time was found for the MGC field. Despite scientists reporting increased level of competition in science, the majority of fields have not changed their publishing output (negatively or positively). This lack of significant change in publishing output can be partially explained by the possibility that both Mode 1 and 2 knowledge production are currently in co-evolution (Gibbons et al., 1994).

In contrast is the role of incentives for scientists to commercialise their work. At GARVAN and WEHI, the commercialisation incentive policy is designed so that the entire institute benefits from these successes. By rewarding the entire institute, including those scientists not involved in commercialisation, the policy attempts to reduce the tension that exists between commercial and traditional modes of production (Etzkowitz, 2003; Leydesdorff & Etzkowitz, 1998).

In summary, publication incentives do little to increase the publication output as scientists already conform to the reward maximisation theory so any additional incentive provided by monetary rewards is moot. Also, as suggested by Luukkonen (1992), publications for scientists serve more roles that just to increase the reward. These include increasing the scientist's visibility to the right audience and this may not always be in the highest impact journal. The existence of publication incentives is unlikely to change this emphasis. Also, because high impact publishing occurs more often in the more competitive fields, publication incentives serve to reinforce this competition on an institute level. This was seen in the bibliometric data in Appendix III which showed no increase in the log JIF over time for the majority of fields. The exception was for MGC which is a highly competitive field and where the potential for high impact publishing is greater than for other, smaller and less competitive fields. With this in mind, it may be concluded that, publication incentives do not act to increase the desire for high impact publishing but rather to reward scientists that do achieve this higher level of visibility. Additional problems with this model are felt by scientists engaged in fields with less opportunity for high impact publishing and the rewards/incentive policies should be reviewed on the institute level to accommodate these field differences.

6.6 Chapter 6 summary

This chapter aimed to discuss in more detail the themes and issues that were explored in the results Chapters 4-5 of this thesis that combined both qualitative and quantitative research methods. By doing this, I aimed to provide answers to the two main research questions and one supplementary question, set out below;

Research Question 1

What are the responsibilities and communication strategies of the internal PR and BD Offices within Australian Medical Research Institutes?

Research Question 2

How do the scientists in these institutes view the role of these Offices and more broadly, communication and commercialisation, in their research?

The supplementary research question, to be considered separately from the two research questions above, is outlined below;

Research Question 3

Has there been any change in scientists' publishing behaviour as a result of the increased level of public accountability in science and/or the introduction of these internal offices?

By addressing these research questions, a complex set of structures employed by medical research institutes in Australia was revealed in order to facilitate public communication as well as the commercialisation of their research results. Considering Research Questions 1 and 2; interviews with the BD and PR officers were triangulated with interviews with the institute's scientists as well as with some bibliometric analysis of the research output of each institution. What was found was that each institute was different in their approach to communication and commercialisation in science. Firstly, all scientists were open to the role of science communication as part of their research responsibilities. The presence of the internal PR Office was seen to be a major factor in influencing this change. The internal PR

Office within each institution employed a variety of techniques to best communicate the institute's research. Most importantly, however, the internal PR Officers acted as advocates for the institute's research programs. As well as the efforts of the internal PR Office, scientists within each institute still act as regulators of their own communication activities.

These activities concentrate on delivering research information to patients and interested members of the public and are closely related to the dual role of the researchers between scientist and practicing physician. For the Internal PR Office, promoting the scientific value of the research is of secondary importance to the publicity angle of the communication. The challenge for the institutes in order to benefit from both modes of communication is to *promote* scientific information sufficiently to raise the *awareness* of the institute and its research without falsely promising a breakthrough cure.

When examining the BD Office, the interactions are far more complex. Only three of the five participating MRIs support an internal BD Office with the remaining two institutes handling their commercialisation activities through external, university affiliated BD Offices. Maintaining this internal representative is important in order to positively influence the opinions of the institute's scientists towards commercialisation. Previous research has identified the integration model as an ideal but unachievable model due to the tensions created between traditional scientific and Mode 2 endeavours. However this tension was not encountered in this study in institutes that maintained an internal BD Office. The role of the increasing professionalism of the office staff, incentives distributed to the entire institutes, the understanding the office has about the needs of the scientists and the willingness of the BD Office to change their methods to accommodate the needs of the scientists (in relation to publishing and withholding results) were identified as major reasons for this change. These results negate the fears expressed in the literature about the introduction of commercialisation in science.

Competition in science was described as a major factor in the changing scientific and academic landscape. To combat this, institutes have implemented monetary incentive schemes to encourage scientists to achieve a higher level of visibility through publication, as measured by the JIF. However, these schemes were shown to have had little impact on the publishing output during the period 1999-2005. Instead, these incentives acted as a reward rather than an incentive, rewards scientists were happy to accept but would not change their choice of journal or research field in order to achieve.

Finally, to address Research Question 3, a statistical analysis of the participating institute's publication output was conducted (Appendix III). Using the JIF as the dependent variable, a number of behavioural characteristics were measured against the JIF to investigate any change during the period 1999-2005, whilst controlling for the field of research. Of particular interest was the linear increase in collaboration (r^2=0.97; $p<0.05$) and a difference in the JIF over time between institutes for the MGC field. Other field differences identified reflected the strength of the field classification method with significant interactions found between the institutes and their field of concentration.

Chapter 7: Reflective Conclusions

7.1 Introduction

In answering the research questions surrounding the topic of how research Institutes have incorporated the concepts of Communication and Commercialisation into their organisational culture, this thesis has revealed a complex set of interactions between scientists and the internal BD and PR Offices. The previous chapter has focused on discussing the themes unearthed in this thesis in response to the two main and a third supplementary research questions. Considering these results, this chapter will investigate the emergent theory of this thesis as well as offer insights for other research institutes that may be either experiencing difficulties with BD or PR involvement of their scientists or who are considering establishing or restructuring their own BD or PR Offices.

The emergent theory of this thesis is outlined below. It concentrates primarily on the evolution of the institutes in adopting Mode 2 models of knowledge production that increases the transparency and social accessibility of the research institute. The theory below also proposes that a main catalyst for the evolution on the institute towards Mode 2 knowledge production has been the introduction and increasing professionalism of the internal PR and BD Offices.

7.2 The New, Socially Reflective Scientific Research Institute

Traditionally, universities and related tertiary organisations have concentrated primarily on the production of knowledge and teaching activities (Krimsky, 2003). According to Krimsky (2003) universities typically focused on four missions; knowledge as virtue, knowledge as productivity, knowledge in service of defence; and knowledge in the service of public interest. The contract between university science and society has been traditionally based on the understanding that universities will provide research and teaching in return for public funding and a relatively high degree of institutional autonomy. Under this contract, the universities, often supported by public research funds, have been expected to generate fundamental knowledge for society and to train highly qualified manpower (Gibbons, 1999). This is no longer the case, with the expansion of higher education being accompanied by a culture of accountability which has had an impact on both teaching and research activities. This is no different for the scientists who work as part of these research and teaching organisations. Recent reorganisation of higher education has allowed research to be conducted under a number of different organisations; private, governments, industry and other semi-independent research organisations such as the institute as defined by this thesis. The institute has allowed groups of scientists from the same or similarly related fields to conduct research together in pursuit of a common goal. These institutes sit astride both traditional research organisations and commercial businesses and hence provide an interesting setting with which to study the evolution and resulting tension between Mode 1 and 2 knowledge production.

The New Production of Knowledge (NPK) (Gibbons et al., 1994), including Mode 1 and 2 theories of knowledge production, has developed some important theories in relation to how public accountability, which can be applied to the evolution of both commercialisation and communication in science. Of particular interest in this thesis are the concerns within NPK of reflexivity, which refers to the public accountability of research and the principle that M2 knowledge is conducted in the context of application. These principles are closely related as both reflexivity and knowledge being conducted in the context of application are dialogic processes where researchers are more aware of the societal consequences of their work and sensibility towards the potential impact of their research. A re-evaluation of the characteristics of NPK was conducted in 1999. Amongst the many additions to the already existing framework was a description of the changes they perceived in various organisations involved in knowledge production. This re-evaluation addressed the major criticisms of the original NPK theory in relation to its lack of empirical foundation and the reliability of the framework. In particular, the concept of 'contextualised science' was introduced which described a setting where society was able to 'speak back' to science. According to the authors, the participation of a wider range of non-scientific actors in the knowledge production process occurred in a theoretical setting known as the 'agora' and that this enhanced the reliability of the NPK framework. According to Gibbons et al. (1994) and later Nowotny et al. (2001), the distinction between science and society, which had been the basis for modern science, was no longer valid. Instead, the public is heterogeneous and comes into contact with the producers of knowledge within the framework of an 'agora' which aims to develop 'inverse communication' between these two groups. This theory emphasises the social relevance of knowledge and lends its theoretical basis to the new range of science communication attempts which insist on 'engagement with the public' and the democratic model of science communication. The increased emphasis in accountability has pressured these once self-governing research institutes to develop policies that will inevitably make them more socially reflexive. For the five participating institutes described in this thesis, this has included the establishment of the internal PR and BD office to help facilitate the process of transparency. This process has been identified by this thesis as an attempt on the behalf of the participating institutes to introduce the *agora* into the minds and practices of their scientists.

This thesis identified two distinct streams of information exchange; the formalised institutional message conducted by the internal PR office which includes media liaison, special events and other large public events; and the informal information exchange between the medical researchers, their patients and interested patient groups. These streams of information are not conflicting but instead reinforced each other. When used cooperatively, the streams of communication produce a publically accessible and transparent research institute that had the capacity to fulfil a variety of public accountability measures. Likewise the culture within the institute is conducive to the public accountability of science and further attempts of public accountability and this revolution has contributed to the overall transparency of the institute.

In relation to commercialisation, tensions about its role in science were softened by the internal BD office that specifically altered their practices in order to accommodate the needs of the scientists. Scientists were aware of the importance of commercialisation in science but were not willing to completely trade their scientific reputation in exchange for commercial success. With this in mind, the willingness of the internal BD Office to accommodate the academic needs of the scientist reduces the tension within the institute.

With the increasing maturity of the Mode 2 activity representatives in science (BD and PR Officers), the increase in the expectation for public accountability in science from funding sources, as well as the willingness of the office professionals to alter their practices to suit the needs of the scientists, Mode 2 activities are being accepted and embraced in these institutes. With this in mind, the production of knowledge within the participating institutes, combined with the level of transparency enjoyed by the scientists, can be described as occurring within an *agora* of science. The next section will explain the process of accommodating the agora into the culture of our five participating institutes.

7.3 Institutionalising the Agora

Influencing change in an organisation is a topic of interest for many researchers due to the inherent tensions this change can cause. Additionally, any change is felt more acutely in a smaller, more specialised institute. It is an additional challenge to change in highly institutionalised contexts with strong traditions and well established norms of behaviour (DiMaggio & Powell, 1983; Kraatz & Moore, 2002) such as some of the older participating institutes such as WEHI and JCSMR. However, some organisations do adapt, survive and prosper. Understanding the differential capability of organisations to change remains a central, ongoing research question in organisational theory (Greenwood & Hinings, 1996). Recent research suggests that understanding variation in organisational response to external pressure requires examining intra-organisational dynamics and the actions of individuals in context (Greenwood & Hinings, 1996) and this is what this study attempted to achieve using both interviews from the Offices and the scientists whilst attempting to understand the scientific repercussions by evaluating the publication output using bibliometric techniques. However, the presence of macro-level pressures does not guarantee that new initiatives will be embraced. The ability of organisations to change depends on the willingness of individuals to adopt supportive norms, routines and behaviours (Whelan-Berry, Gordon, &

Hinings, 2003). Whereas individual behaviour may be influenced by prior experience and by new information gained from physical space proximity or professional relationships that provide an opportunity to observe and learn. Thus, professional imprinting and localised social context are material micro-level influences (Bandura, 1977; DiMaggio & Powell, 1983; Schein, 1985) such as from other scientists. This study attempted to investigate both the micro and macro level influences for commercialisation and communication in science. What was found was that there was little conflict between the scientists and the office professionals. This was due to a number of factors including a common goal (although some tensions were still reported between differing modes of communication), the presence of incentives for the entire institute, the professionalism of the office professionals, the understanding these office professionals had about the scientific needs of the scientists and the ultimately innate desire of the scientists to fulfil their contractual obligations with society.

In the following paragraphs, the results presented in this thesis will be discussed in relation to two of the principles of NPK; reflexivity and conducting research in the context of application. In addition it will describe how these two principles are reflected in the culture of the participating institutes.

According to van Looy, Ranga, Callaert, Debackere, & Zimmermann (2004a) for scientists and science, the ability to balance entrepreneurial activities with scientific excellence depends on the institutional policies deployed. The first principle that I will discuss; Reflexivity, according to Hessels & van Lente (2008), deserves further investigation because it has received less attention in the criticisms of the Mode 2 concept. Despite Weingart (1997) regarding social accountability to be mainly applicable to policy relevant knowledge production and not public awareness/understanding of science, he argues that an institutionalisation of reflexive mechanisms is discernable. Yet, in areas of knowledge lacking an immediate connection to social values and subjective risk perception (high energy physics, astronomy etc) he denies that there is with a need for or a perceivable rise in reflexivity however Hessels & van Lente (2008) also states that this assertion is not supported by empirical evidence. For medical research, however, this is not the case and a rise in reflexivity can be advantageous for scientists and their institutes.

Although some conflict still exists over the differences between awareness and promotion of science communication, this has been partially resolved by the scientists regulating their own communication behaviour by representing and interacting directly with their patients. Previous organisational research has stated that change within an institution is a result of both internal and external pressures (Glaser, 2002). This may be the case for establishing an internal BD and PR office initially; however individual scientists have changed little in the amount of public communication in which they participate and there are a number of explanations for this. Either there is a dysfunction of communication between the individual PR offices and the scientists; or there exists an invisible college of scientists who self regulate their communication behaviour. This is certainly the case for a number of scientists who maintain close relationships with their patients and interested patient groups and are thereby continually conducting their research context of application and producing social robust knowledge as defined by Nowotny et al. (2001). For commercialisation this concept of reflexivity remains. Estabrooks et al. (2008) investigated the expectations of scientists about the role of commercialisation in science and the differences in expectations between basic and applied researchers, especially in relation to societal impact. Like Welsh et al.(2008), Estabrooks et al. (2008) found that science viewed commercialisation positively as its success is seen as having a 'societal impact' beyond knowledge creation and publication (p1860). The same was found in this thesis as the scientists reported that their motivation for engaging in commercialisation activities was the potential benefit such activities would have on their patients and the wider community. Obtaining the desirable level of reflexivity for scientists has been made easier by the willingness of the internal BD offices to adapt their practices to the needs of the scientists. Additionally, the results showed that the scientists described in this thesis were not conducting their research in isolation. In fact, scientists not only described their own altruism as a major determinant of pursuing a science career but are also acutely aware of the potential application of their results to the health of their patients and the wider community. It can therefore be stated that the scientists described in this thesis conduct their research in the context of application, a vital principle of M2 and of the *agora*.

The principle of transdisciplinarity deserves some attention with the increased competition in science also stimulating an increased level of collaboration in science (measured by the number of authors per journal article). It is unsure whether this is across disciplines but scientists did mention that interdisciplinary research was held in higher esteem than homogenous research topics. For the PR and BD offices, in contrast, there is still a major difference in basic and applied research areas where the PR office will target more applied groups as it will be of more public interest.

Bercovitz & Feldman (2008) found that when individuals are faced with a situation where their individual training norms are not congruent with the localised social norms in the work environment, they will conform to the localised rather than individual norms. The success of incorporating Mode 2 activities, through the introduction of the internal BD and PR office, has been both their willingness to alter their practices to accommodate the scientific needs of the institute's scientists and also the shared sense of direction of the institute and its science; towards improving the health of their patients. Institutes and the offices alike acknowledge a scientist's role in conducting research in the context of application as well as the importance of maintaining a good relationship with the broader community. There have been few studies investigating the way in which institutes have adapted themselves to NPK and this lack of evidence highlights the uniqueness of the results of this thesis. Simpson (2004) could not identify a single type of stable organisation styles in relation to the incorporation of Mode 2 knowledge production. Instead she found a dynamic style of organisation that is in a state of endless transition and that this was the most effective and appropriate institutional model for the modern demands of knowledge production in particular relation to the commercialisation in science. Simpson (2004) also mentioned that for one of the institutes, it was unlikely that the institute was able to undergo structural changes to accommodate new government and public expectations. Instead, the institute would find a way of accommodating the contradictions between science and business in order to draw benefit from both. She likened the changes made to accommodate BD in the institute to erosion i.e. slowly chipping away at the institutional structure that was resistant to change. Management also played an essential role in making sense of the complexities of the new and uncertain environment (of greater public accountability). That some of the case study CEOs came from both New Zealand and science backgrounds was, according to Simpson (2004), an advantage as they were both very conscious of the governments' expectations for transformation and the potential for scientific repercussions. These case studies investigated structural changes within scientific organisations but recognised that these structural recommendations were not conducive to good science. Instead, the studies recommend that institutes should place a strong emphasis on the shared valued between science and business.

This thesis focused on how institutes have adopted this change. An additional problem with Mode 2 in previous research is that it placed too much emphasis on the role of the discipline as determinants for scientists' behaviour rather than the individual goals and aims of the scientists. This thesis takes into account both the discipline and the institute as determinants and found that the aims of the scientists are in line with Mode 2 and that access to professional representative of Mode 2 (in particular relation to commercialisation and communication) is a key determinant for influencing change in the opinions of scientists and the culture of their institute and therefore representing an institutionalised *agora*.

7.5 Recommendations from the Results of this Thesis

This thesis recognises that theoretical recommendations made by previous research investigating the incorporation of Mode 2 with scientific organisations have failed. This could be for a number of reasons, however, to ensure the applicability of this thesis research results, the following recommendations are outlined below. In the opening chapter of this thesis, I stated that the results of this study would be used to offer insights for other research institutes that may be either experiencing difficulties with BD or PR involvement of their scientists or who are considering establishing or restructuring their own BD or PR Offices. It is now clear from the results present in this thesis that the recommendations for the PR Office must be made separately to those of the BD Office.

This thesis identified two modes of science communication within the five research institutes; awareness and promotion. Considering the distinct differences between these two modes of communication, future communication attempts should provide a healthy distance between awareness and promotion modes of science communication as tensions can still exist. A scientist's assertion is their ability to engage in the awareness mode should not be made part of the promotion mode of science communication run by the institute. There are many differences between these modes of communication and at first it seems impossible that they can co-exist within the same institute. However, these modes can be used in cooperation in order to successfully communicate the value of scientific research and this is the ideal model proposed in this thesis for the operation of successful science communication. Nonetheless all communication practitioners, scientific or internal PR Office professional, should exercise particular care not to propagate the bald baby effect that was also identified as part of this thesis.

In relation to the BD Office and despite the literature warning otherwise, this thesis recommends that the BD Office is incorporated internally. There are many direct and indirect benefits from this model that were discussed as part of the results presented in this thesis. These benefits can include a more positive collective opinion towards the role of commercialisation in science and an increased level of scientific willingness and participation in commercial activities. Indeed the fears that have been described in the literature, including the skewing of research priorities towards the more applied sciences and the restrictions on scientific publishing can be quelled by the professional behaviour of the internal BD Office. However, it should be kept in mind that one essential component of an institute's internal BD Office is that the Officers should be prepared to alter their practices in order to accommodate the academic needs of the institute's scientists. Adaptation of the BD Office to the needs of scientist can promote involvement in commercialisation and not negatively affect the publishing outcomes and opportunities for the scientists thereby promoting the advantages of commercial involvement and not reinstating the fears described in the academic literature.

Questions remain regarding the reliability and reach of the results discussed in this thesis, especially with regard to how applicable they are to other Australian medical research institutes. However, since the participating institutes in this research represent a variety of different organisational structures and fields within medical science, it is reasonable to assume that these results could be applied to other medical research institutes in Australia. Further research regarding how these results can be applied in other, non-Australian medical research institutes and to other scientific fields (in an organisational setting) is recommended.

These recommendations from this thesis, however, are made in light of the results presented and will ensure that research institutes gain the maximum benefit from the communication and commercialisation of scientific research.

7.6 Summary

In summary, research institutes play a large role in developing the *agora*; the public arena where negotiations and consultations between science and the public take place. Medical research institutes are a special case as medical researchers have a clear and decisive goal for their science in mind and they already conduct their research in the context of application. Developing this *agora* would not, however, be possible without taking into account how the institutes have equipped themselves to deal with this increased public accountability, namely the introduction of the internal office to facilitate commercialisation and communication of science. This internal model is of particular importance as previous research has stated that the internal model was likely to produce tension that would work against the norms of science. This was found not to be the case and in fact both the scientists and the internal offices work to create an *agora* with which the socially reflexive institute can participate. Future studies should consider the extent to which the internal offices are willing to alter their methods and practices to accommodate the needs of the scientists. Previous research investigating the junction between science and business development (BD) has outlined their differences in culture. However, as this study has shown when the cultural norms are compromised on the side of business, science and Mode 2 activities (including communication) are able to work cooperatively internally and within a socially reflexive research institute.

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Appendix I

<u>CONSENT FORM</u>

INSTITUTE:

I .... agree to be interviewed by Gjemma Derrick regarding my involvement in science communication and commercialisation of my research. I have read and understand the following information:

The interviews will contribute to research about the effect of commercialisation of institutions on the ability of scientists to communicate.

My participation is voluntary and interviewees are free to withdraw at any time.

The research will contribute to a PhD thesis and subsequent journal articles.

The names and job titles of interviewees will be withheld in all published work.

All raw data from interviews will be securely stored in locked filing cupboards and on password protected computer, which only Gjemma Derrick has access to, so far as the law allows.

Further questions about the research may be directed to:
Gjemma Derrick
The Centre for Public Awareness of Science
The Australian National University
Canberra ACT 0200
Ph: (02) 6125 2456
Email: Gjemma.Derrick@anu.edu.au

Concerns about the research may be directed to the Human Research Ethics Committee, care of:
Human Ethics Officer
Research Services Office
The Australian National University, ACT 0200
Tel: 02 6125 7945
Fax: 02 6125 4807
Email: Human.Ethics.Officer@anu.edu.au

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Signed **Date**

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Phone Number **Email Address**

Appendix II

This appendix contains a complete transcript of one representative interview. All identifiers have been omitted.

(Tuesday 13th June)

So the first question I would like to ask you is why did you become a scientist? What were your motivations behind that decision?

It's the only thing I ever wanted to do, ever since I was about 7. I was always interested in animals and living things.

Tell me about your career? What was your PhD project?

I started off doing, I left school in grade 10 and did a certificate course in laboratory technics and became a technician. And then went back to university at 21 as a mature aged student did a BSc, the honours and PhD.

What area are you working on at the moment?

Malaria.

How do you think the nature of science and scientific practice has changed since you began your career as a scientist?

Computers totally changed everything. Email. Communication with people overseas. That's a day to day thing rather than a what it was previously.

How have you noticed an increased emphasis in commercialisation?

Oh absolutely. From nothing to a lot of pressure.

Where do you feel that this pressure come from?

Government. Funding agencies particularly NHMRC.

Did you think when you began your career that communication would play a large role?

Communication with other scientists, Yes. With the public? No

Is there more of an emphasis?

Absolutely

In what way? Can you give me an example?

Increased pressure to publish science results. And to have contact with journalists and the media

Have you had any experience with commercialisation?

Depends what level of commercialisation. Yes I have. I have been a director on a biotech company for 7 or 8 years now, but not at the moment. We file patents, we decide not to file patents for some things that would clearly be commercial in other fields. But because our field is not really going to make money you only file patents if you need some type of territory for funding from funding agencies.

Phone rings

Progen is the company, in Brisbane. Companies chasing us.We are interested in infectious diseases and vaccines. So, that increases people chasing us.

Tell me about your experience with the commercialisation of your research. What were the high and the low points?

Low points involve a lot more work that is not necessarily productive. High Points? Not sure that there are any high points. As a director, things went pretty well with one of the compounds, it is now in Phase III actually.

Which compound is that?

It know as PI-88.

Do you see commercialisation in science being more emphasised in the future?

Im not sure it can increase, its pretty well on the radar of every scientist, especially in Medical science. You basically have to have some sort of justification of your works and if you don't have at least the prospect of a patents or potential commercial development then you lose points in terms of getting funding so it has to be on your radar.

Is that good or bad for science in your opinion.

I think it is good for some people and bad for others. I don't think it should be across the board. Some people are made for that and are good at it and they want to find something they can commercialise. Other people don't they just want to do basic research and that doesn't necessarily end up being commercialised. Sometimes it does, but that is the way that basic science works. So there are people who like to do that and if something comes up great but they just want to keep going. And others that are good at commercialising thing. So I think that both situations should be allowed and the government funding agencies are really only trying to push one. Where if you don't have your own start up company, then you are not doing things right.

What did you hope to gain from commercialisation?

You need to be able to protect some things so that you can get funding from agencies such as the Gates foundation. You need some sort of patent protection over the IP.

Money wise you realise that there is not going to be any money in it because Malaria is not really that commercial as it only happens in the developing world.

Have you experienced any barriers to communication of you research? How?

Not really no. We have a business manager who knows what he is doing and doesn't understand the science totally and they probably don't understand that even with Malaria you have to patent even if you won't make any money. So that is probably an issue with us, it is hard to convince lawyers and business managers that we should patent this because potentially it might involve getting funding from the Gates foundation.

Have you experienced any barriers to publication? What were they?

No. I think most companies these days know that publications are important and that so long as you have an initial patent pending then it should be okay.

In your opinion, do you think that it is easier to communicate your research that has been commercialised?

Oh its much easier if it is heading towards a product. Journalists wasn't, one of the questions they ask is "how long before this will be a treatment" which is sometimes a ridiculous question.

Does the commercialised research help promote you as a scientist and researcher? I mean, did communication resulting from you commercialised research promote your research and you as a scientist?

Talking to the general public? I usually talk about a paper that has been published in a high impact journal and if it is commercial or not the journalists still ask about "how is this going to help people?"

Have you ever experienced restricted access to information because of commercial or competitive reasons?

No.

Have you ever restricted access yourself?

No.

Would you ever restrict the access of other scientists?

No

Why is that?

Once it is published it belongs to everyone.

What about patented information?

In terms of MTA's, that true. We have used MTA's for vectors and things. It is actually a good mechanism to stop people from passing things around without you knowing it. So in order for them to give it to someone else they have to tell you that they are giving it to someone else so you know who has it.

Are these considered opportunities for collaboration?

No

Really? Why is that?

If it is unpublished that is reasonable, but if it is already published then that's not reasonable. Some people don't hand them out even when it is published they just don't answer emails, which I think is wrong.

How do you think that commercial involvement affects how scientists communicate?

No. Not in my area because it is pretty open. It is open but the major imperative in keeping things secret is not because of commercialisation is for publication first. I think that comes above anything else.

What do you think are the disadvantages of commercialisation?

Doesn't necessarily lead to making money so it ends up a lot of work for not much gain.

What, in your opinion, is the 'ideal model' for science communication in the future?

I think we have a pretty ideal model now with publication and conferences for our communication with other scientists. With collaborators it is obviously through email. Beyond that I actually think communication is pretty well perfect now.

Really? Even to the Public?

The major impediment is the ability of scientists to explain their research.

How can that be resolved?

It can be taught a little bit but not very much. I think scientists need to be taught to communicate to the lay public.

Do you think that there is a role for a third party in the communication process?

In terms of somebody who contacts me here and organised the process? It certainly helps because if you want to put out a press release then it is better if somebody knows what they are doing. So I think some type of press relations officer is important and we have that here at WEHI.

Do you think that it is necessary for this third party to have a science background?

It helps a lot. They can understand the science better and communicate it better or at least tell the scientists how they can talk about it.

Do you consider yourself a good science communicator?

I've done a lot of media interviews, teaching to teacher, But I don't think I am good. I'm okay but I can improve my level of excitement. My excitement isn't translated well. Need a shot of adrenaline. I'm better at explaining it cause I can formulate the 3 key messages that I want to get across so I can try and explain it well.

How successful do you see this Institute in communicating your research? What works and what needs to be done?

I think on the WEHI side it is okay. The problem is on the journalist side, as they basically want big impact, you can't blame them for that. So they can turn stories into much more than they really are. They don't understand that science is an incremental process and very rarely do you get this huge leap, extremely rare. So everything is a small step and they don't understand that. Well, sometime they do but they don't listen - cause they want a headline so it can end up being different than it should be.

I'm sure that the general public get sick of that type of thing, I'm sure we've cured Malaria about 7 or 8 times, according to the newspapers. So I don't think that is good for science or scientist's credibility and I don't think it is good for journalist though journalists have no credibility to lose.

What can be done to improve this?

The visibility with the general public is not as good as it should be. I don't think the public would have heard about the Walter and Eliza Hall Institute generally before. Places like the Children's Hospital research is easy because they research kid's diseases so its really easy to publicise that. For an institute like us it is perhaps a little harder but I think we do okay but we can certainly improve.

In your opinion, what is it like working at WEHI?

It's the best in Australia but I'm saying that from a biased viewpoint. So from that angle it is obviously very good. The services are fantastic, you can do anything you want.

Is WEHI's success with NHMRC grants consistent?

It's extremely good.

How have you noticed a difference in student expectations in what a career in science will mean?

No I don't think so because I think most people do science because they are interested in it and they don't expect to make huge amounts of money.

What motivates you to communicate your research?

I don't enjoy that terribly much but I'm not sure what motivates me towards that except that it is expected. I prefer not to be interviewed by radio or TV because its high pressure and doing things that I'm not used to with things that are difficult to explain and I'm not trained for it.

Please describe what you consider to be the main successes of your research?

We've done a lot to increase our understanding of how the malaria parasite invades red blood cells, develop resistance to drugs which has implications for developing new drugs. That has been a real buzz for me

Well that is the end of my questions. Is there anything else that you want to add?

Not really. You can email me if you have any other questions

Thank you I will and thank you for you time today it ha sbeen very interesting

Pleasure

-END OF INTERVIEW-

Appendix III

'I certainly have not the talent which some people possess,' said Darcy, 'of conversing easily with those I have never seen before. I cannot catch their tone of conversation, or appear interested in their concerns, as I often see done.'

'My fingers,' said Elizabeth, 'do not move over this instrument in the masterly manner which I see so many women's do. They have not the same force or rapidity, and do not produce the same expression. But then I have always supposed it to be my own fault – because I would not take the trouble of practising. It is not that I do not believe my fingers as capable as any other woman's of superior execution.'

Darcy smiled and said, 'You are perfectly right. You have employed your time much better. No one admitted to the privilege of hearing you, can think of any thing wanting. We both neither of us perform to strangers.'

Pride and Prejudice

Jane Austen pp 136

A.1 Introduction

Publishing is a social behaviour for scientists. The choice of where a scientist will publish their work is not a random decision. Instead, the decision can be determined by factors such as their relationship with a journal, their collaborators as well as the content of the article. Additionally, the BD and PR offices and the public promotion of research may also have an indirect influence on a scientist's choice of journal. It is therefore, not unreasonable to assume that where a scientist will publish his work would be determined by factors such as his field of research, his level of collaboration, his home institute and the year of publication.

Earlier studies have shown a high degree of correlation between collaboration and research productivity (Lee & Bozeman, 2005; Subramanyam, 1983) and between collaboration and financial support for research (Rosenzweig, Van Deusen, Okpara, Datillo, Briggs, &

Birkhahn, 2008). This chapter investigates the relationship between a number of variables and where scientists will publish their work. This aim of this chapter was to track to publication activity of the scientists within the participating institutes and to examine the change in scientific publishing behaviour over 1999-2005. Indeed, the results described in Chapters 4 and 5 of this thesis show that first, the PR and BD Offices pay particular attention to the research outputs from high public impact research areas such as cancer. Similarly, scientists reported in Chapter 5 that their journal choices are restricted by field specific factors.

Bibliometric researchers have been identifying relationships between the impact factor and a variety of publication behaviours for many years. One such finding is the relationship between the impact factor and the number of authors (Subramanyam, 1983). This does not mean that in order to publish in a high impact journal you will require a larger collaboration. It could mean, however, that large collaboration teams will produce more results and that this is rewarded by publication in higher impact journals as measured by the JIF (Journal Impact Factor). The results shown in Chapter 5 indicate that scientists will always aim to publish in the most prestigious journals possible. Further, these results show that, on average, the larger collaborations will publish in the higher impact journals.

This chapter will attempt to map the behavioural publishing concerns expressed in Chapters 4 and 5 by the participating scientists statistically. Since publishing is indeed a social activity for scientists, bibliometrics can be used to highlight these social behaviours.

There are several examples of mathematical relationships identified by bibliometricians. Yitzhaki (1994) published two articles investigating how the length of the 'title' of a journal article was related to, first the number of authors and, second to the length of a journal article. He argued that the length of a journal article's 'title' was related to the level of 'informativeness' of the entire paper. His other paper investigated the relationship between the number of authors and the length of an article's title (Yitzhaki, 2002). Fourteen journals from mathematics, medicine, psychology, economics, philosophy and law were chosen. Even though the study supported results found by Kuch (1978) which explained that multi-authored papers are based on more extensive research than single-authored papers and hence communicate more information and have longer titles, it failed to postulate why this trend is found in each particular journal. In addition, it failed to triangulate their results with social accounts of the scientists that published in these journals.

A scientist's publishing behaviour cannot be explained by using numbers alone. This appendix will scrutinise different relationships in order to determine if there has been any significant change in the publication outcome of science. It should be mentioned that even though these results contribute to the discussion of the interview data in Chapters 6 and 7, they do not related to the central investigation of the evolution of the internal PR and BD Offices within the five participating Medical Research Institutes. However, interview data in Chapter 5 has indicated that scientists personally feel that their publication outcomes have changed in response to the increasing emphasis on commercialisation. It was therefore essential to investigate the validity of these claims using bibliometric techniques.

In this appendix, we will investigate the claims of scientists and office professionals statistically and where the main change, if any, has occurred. This chapter will provide one of the first comprehensive analyses of change in scientific publishing behaviour over the period 1999–2005. The results will further highlight the concerns expressed by the participating scientists in Chapters 4 and 5.

A.2 Background Literature

A.2.1 Bibliometrics: The Rise of the Evaluative Culture

Bibliometrics is the study of scientific publications and their dissemination and use in the scientific community. It offers a powerful set of methods and measures for studying the structure and process of scholarly communication. There are four basic postulates to bibliometrics. They are; that a paper receives at one time at most one citation; an author publishes only one article at a time; a paper does not receive citations prior to its publication; and that the citation link between the two papers is unique. The first two postulates are essential to map and allow the application of point processes and the last postulate is necessary to make quantification of citation impact possible. When the term bibliometrics was introduced in 1969, by Prithchard, Nalimov and Mulchenko it was distinguishable from 'scientometrics'. Pritchard described the term bibliometrics as '*the application of mathematical and statistical methods to books and other media of communication'* (Pritchard, 1969, p.319) and (Nalimov & Mulchenko, 1969) defined scientometrics as '*...the application of those quantitative methods which are dealing with the analysis of science viewed as an information process.' (p.636).* According to these definitions, scientometrics is restricted to the measurement of science communication whereas bibliometrics is designed to deal with a more general information process. Recently, however, the terms have ceased to be separate and are now considered one and the same. For the purpose of my study, however, the terms scientometrics and bibliometrics will be solely referred to as 'bibliometrics'.

Collecting data for the citation index and for bibliometric analysis has been made easier with the existence of the Institute for Scientific Information (ISI) through Thomson Reuters. A citation index is an ordered list of articles each of which is accompanied by a list of citing articles. The citation index works on the principle that every article has an equal likelihood of being cited, it should follow that the more articles a journal publishes, the more frequently the journal will be cited. In 1955, Eugene Garfield proposed a Science Citation Index;' *I propose a bibliographic system for science literature that can eliminate the uncritical citation of fraudulent, incomplete or obsolete data by making it possible for the conscientious scholar to be aware of criticisms of earlier papers' (p610).* He argued that this index could be used to check all the papers that have criticised previous papers and if there were no other use for the index other than the above, then the index would be worth the effort to compile (Garfield, 1955).

Bibliometrics is used extensively to measure the impact and quality of scientific work as well as the intellectual influence of scientists and scholars. In particular; citations are used to measure the cross-fertilization of scholarly ideas from one field to another (Cole, 1970). Although sometimes controversial, bibliometrics has been established as a legitimate method of analysis of scientific activity including the traditional communication methods of publication and referencing. The principle aim of the ISI was initially methodological providing an easy way to derive criterion measures of scientific accomplishment. Prior to its creation, the inability to provide adequate measures of productivity had frustrated researchers (Cole, 2000). Garfield (1963) established the SCI by creating a file of over 1.4 million citations from the 1961 literature, in order to create a computer generated genetics citation index that would provide an evaluation of 1000 geneticists (Garfield, 1963). This new method was labelled the 'critical path method' of evaluating the impact of individual scientific discoveries and the 'critical impact' factor which was used to measure the arborisation of specific papers or ideas through the subsequent literature (Garfield, 1963). Further authors adopted the science citation index as an important indicator of scientific accomplishment in the other fields. Westbrook (1960) has also justifiably used citations as a means of determining the sources of activity. Indeed, it was also suggested that some correlates of a citation measure the level of productivity in science (Bayer, 1966).

A.2.2 The Sociology of Scientific Publishing

Hagstrom (1965), introduced the 'gift exchange' model of scientific exchange in which individual scientists contribute their findings to the scientific community and in return can expect to receive various forms of recognition (Hagstrom, 1965). He explained that publications of scientific works are 'gifts' to journals as neither the scientists nor the institution receive any financial reward for the manuscripts and indeed are sometimes required to aid financially in its publication. Though scientists in Hagstrom's book denied any motive for this 'gift giving' and deny any motivation for the desire to be recognised for their work it is in fact the desire for recognition that induces scientists to publish their results (Hagstrom, 1965). Publishing is therefore recognised as an important part of scientific practice as authors 'give' rather than 'sell' their manuscripts with the expectation that their own work will be reviewed by others hence, improving the scientific relevance of the results (Hagstrom, 1965). Individual scientists thus award recognition in science by citations. This reflects the central values and norms of science but over time will also establish a scientific reputation by the number of times their articles are read and incorporated into further research. In science, imitation is flattery and a good sign of recognition and reputation. In short, Hagstrom (1965) argues that the social structure of the scientific community is based on the central premise of the exchange of information from research in order for it to be reviewed by peers (Hagstrom, 1965). Franck (1999) supported Hagstrom's theories by stating that success in science is rewarded by 'attention'. Attention was gained by publication in a renowned journal, the research being presented to the 'right public' or reviewed by eminent reviewers. A scientist achieves full membership in the scientific community by gaining the attention of fellow scientists in what is termed 'scientific income' (Franck, 1999).

Hagstrom (1965) also developed a number of scientific profiles based on traditional scientific communication activities such as; published articles or books; meetings of societies; informal contacts with others at different institutions but in the same type of work; informal contacts with departmental colleagues; graduate students; and people of different disciplines or non-scientists. Hagstrom (1965) concluded that different scientists and the contexts in which they work permit wide variations in communication practices (Hagstrom, 1965). Although Hagstrom could not have envisioned the transition of science to become an enterprise with a large amount of business connections, he did indicate that a scientist's publication activities, although only in relation to the culture of science, would be the result of their environment.

The Cole brothers provided the first quantitative analysis for the sociology of science (Cole, 1970; Cole, 1968; Cole, 1970b, 1967, 1981). Counting the number of citations received by a number of papers by the 1996 scientific citation index, the Cole brothers were able to provide a justification for using publication rates as a quantitative basis of the sociology of science and also provide indicators of a scientist's research activity as a measure of their publication activity. They looked at the citations received by the same papers at an earlier point in time and a time closer to their publication. This was used to compare the extent to which papers that were utilised at time 2 to when they were utilised at time 1. Using this method, Cole et al. (1968) was able to investigate the extent to which the work of a sample of 120 physicists is familiar to the entire community of university physicists. Citations were used as a measure of quality and weighed citations were used for other factors in determining the visibility of scientists and other forms of their recognition. For scientists, successful communication was determined by the extent that ideas are read, written up, circulated and effectively utilised. With this in mind, Cole et al. (1968) stated that there was a distinct difference in a scientist's visibility and a scientist's awareness (Cole, 1968). This was one of the first times that citations were used systematically as a measure of scientific quality or impact with relatively large samples of scientists; *'Just as some men can easily be seen (visibility) others are in a position where they can easily see (awareness)' (p10).* Visibility was therefore defined as the extent that a physicist is known by his colleagues, whilst awareness was defined as the extent to which social characteristics of the individual, or the context in which he works, affect the extent to which they know of the work of other scientists (Cole, 1968).

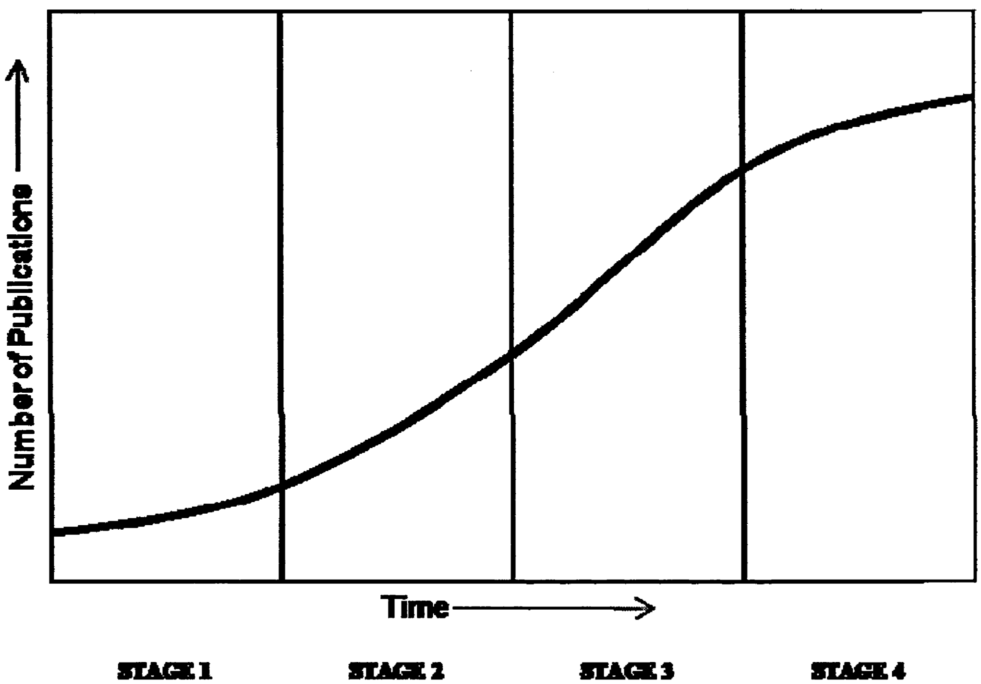
One hundred and twenty physicists were studied with the aim of determining how 'visible' and 'aware' they were. The visibility score was measured as a percentage of respondents who said that they were familiar with the physicists' work. Factors, such as the number of papers published, and the number of citations to their work and the number of awards for scientific work each one had received, were used in the recognition process. It was determined that publication of high quality work increases the visibility of the scientist although the publication of scientific papers does not assume that the author will gain visibility (Cole, 1968). There was also a high correlation between a scientist's visibility and the prestige of the highest award that he has received and likewise with his ranking by the scientists within his department (Cole, 1968). In regards to age though, it was determined that visibility increase with age and peaks in a scientist's early sixties. However the data suggested that age has no affect among scientists who produce high quality work and that physicists will continue to have a high visibility nearing, or even in, retirement as long as they continue to produce high quality publications (Cole, 1968). Awareness was measured in a similar way to the visibility score; a physicist awareness score is the number of men whose work the respondent knows. A scientist with high awareness is one who has distinctive personal attributes or is located in a position that enables him to have great knowledge of the work that is being done in his field. The data indicated that awareness is high in all sectors of the population studies (Cole, 1968). Variables such as age, rank of department and quality of work made only minor differences in awareness and it was concluded that the communication system in physics, via publication in scientific journals or by citations, operates efficiently (Cole, 1968).

De Solla Price (1963) proposed that a small proportion of scientists accounted for a very large proportion of the published scientific literature. His hypothesis about the contribution of scientists to the published literature proved accurate and the Cole brothers took this further by explaining variations in scientific productivity and whether rewards were principally determined by the quality of the performance (Cole, 1967). For this study, Cole & Cole (1967) altered the SCI so that it took into account that science in changing rapidly and that it is difficult to track citations if they will only appear in papers 5 years after their initial publication. The weighted citation method takes into account scientists that have made their most important contribution at different times since papers seem to have a half-life of no more than five years and that at least half the citations in any year are to work published in the five preceding years (Cole & Cole, 1967). Based on research that stated that physics publications in the last 5 years are 17 times more likely to be cited today than research of more than 20 years ago, the weights for each citation were calculated where citations to work 20 or more years before where given a weighting of 17 and citations to work 0-5 years before were given a weighting of 1 (Cole, 1967). In addition, the average number of weighted citations to a physicist's research in his three most heavily cited years was used as the measure for quality. As a result, four types of physicists were identified; Type I - The Prolific Physicist, who produces a large quantity of papers that are of a good quality; Type II - The Mass Producer, who publish a large quantity of papers of low quality; Type III – the Perfectionist who publish a comparatively small quantity of papers but that are of a very good quality; and Type IV – the Silent Physicists who produce relatively few papers that are of little quality to the field. The study determined that the quantity and quality of research by physicist tended to be related (Cole, 1967). When there is an inconsistency between quantity and quality of work – as in the cases of the 'mass producers' and the 'perfectionists', quality proves to be a more significant correlate of the amount of recognition accorded by research physicists. This was the case for the three forms of recognition studied including honorific awards, appointments to top-ranking departments and having one's research known in the national community of physicists.

This study laid the foundation for further studies of the progression of science. One in particular, the Ortega hypothesis, became the object of further studies by the Cole brothers. The Ortega hypothesis states that a large numbers of pedestrian scientists contribute substantially to the advance of science through their research (Cole, 1970). An alternate hypothesis stated that there are relatively few great scientists that are responsible for the great discoveries of science and that the National Academy members and the Nobel Prize winners are the real 'pedestrian' scientists of history. With the use of data from a random sample of American physicists and examining their citation practices the data showed that the physicists who produce important discoveries depend almost wholly on the research produced by a relatively small number of scientists (Cole, 1970b). Even physicists removed from centres of research make considerable greater use of the work produced by scientists at the leading academic departments and by those others who have produced high quality work than the work produced by their colleagues at lesser universities and colleges. While the data indicated that the research of most physicists is used sparingly, it also suggested that the work of scientists who publish less distinguished research is used by the most eminent physicists and are just as likely as non-eminent colleagues to use this less distinguished research (Cole, 1970b).

Many other papers contributed to theories of bibliometrics (Bradford, 1985; Lotka, 1926; Zipf, 1949) but in 1963 Derek deSolla Price published his book 'Little Science, Big Science' where he presented the first systematic approach to the structure of modern science applied to the sciences as a whole and at the same time laid the foundation of modern research evaluation techniques. In particular, his models of growth of scientific knowledge, which were inspired by the reading of a complete set of the *Philosophical Transactions of the Royal Society,* secured a place for Derek deSolla Price as the founding father of bibliometrics. Price is also famous for his exponential growth figure of the number of scientific journals and abstracts. In contrast, his logistic curve means that the growth of numbers of new publications is passing through the following stages: (1) a preliminary period of growth in which the absolute increments are small although the rate of increase is large but steadily decreases; (2) a period of exponential growth when the number of publications in a field doubles at regular intervals as a result of the constant rate of growth that produces increasing amounts of absolute growth: (3) a period when the rate of growth declines but the annual increments remain approximately constant: (4) a final period when both the rate of increase and the absolute increase decline and eventually approach zero, Figure 2.1. Price argued that in 1961, basic science was currently in the second phase of growth but that, as a result of shortages of resources and manpower, it will eventually enter the third and fourth stages (Crane, 1972; De Solla Price, 1961; Garfield, 1973).

Figure 2.1 Stages of growth in the scientific literature as defined by Price (1961)



In his classic 1965 paper, Derek deSolla Price described the unique relationship that is given by the citation of one paper to another in its footnotes or bibliography. He calculated that in any given year about 35 percent of all existing papers are not cited at all, and another 49 percent are cited only once (n=1). Despite the originality of his work, Price (1965) was criticised for vigorously opposing Kuhn's (1962) central idea about the revolutionary nature of science structures. Reviews in Nature described Price's work as a *'search for the Philosopher's stone'* other criticism's focused on Price's methodological inadequacy, his bias towards the English language and omitting the quality of research in his models by assuming that the papers are undifferentiated and all authors are homogenous (Fernandez-Cano, Torralbo, & Vallejo, 2004). Nonetheless, his book *Little Science, Big Science* since its publication about 40 years ago, has been cited more than 1500 times indicating the extent to which it influenced the course of history, in the development of such disciplines as sociology of science, bibliometrics, science policy studies and now science communication.

A.3 Methods

A.3.1 Bibliometric Analysis

A.3.1 The Science Citation Index (SCI)

Recently, collecting data for the citation index and for bibliometric analysis has been made easier with the availability of the Institute for Scientific Information (ISI) through Thomson Reuters (Thomson ISI). A citation index is an ordered list of cited articles each of which is accompanied by a list of citing articles. The citing article is identified by a source citation, the cited article by a reference citation. The citation index works on the principle that if every article has an equal likelihood of being cited, it should follow that the more articles a journal publishes, the more frequently the journal will be cited. The Institute for Scientific Information (ISI) in the United States has published the Science Citation Index (SCI) since 1961. It counts the citations of individual papers based on the list of references of all papers in journals that are indexed by the SCI itself. Today, the Citation Index is available online along with the yearly Journal Citation Reports which provide the JIF and other yearly indictors on each journal listed by Thomson ISI. Using this source, information about each journal, for each year, was collected and added into the publication database.

It should also be mentioned here that Web of Science (WoS) and Thomson ISI was used in preference to either Google Scholar or Scopus. The main reason for this decision was the use of the Journal Citation Reports which is published yearly by Thomson ISI. Additionally, as the focus of the bibliometric analyses in this study was the JIF being a measure of visibility within the scientific community, the use of Scopus or Google Scholar was therefore not appropriate in this study.

A.3.2 The Impact Factor

For a detailed discussion about why the JIF is used in this study as a measure of scientific visibility and for a specific description of how the JIF is calculated, please refer to Chapter 2: Literature Review of this thesis.

A.3.2 Database Creation

The full publication lists from each institute from 1999-2005 (n=5110) were obtained through each participating institute's Annual Reports and websites. In some cases, full publication lists were provided by the participating institute.

A.3.2.1 Institute's Annual Reports

Annual reports from the years 1999-2005 were collected from each participating institute. Medical Research Institute's annual reports contain information regarding funding, peer reviewed journal articles published, books published, collaborations and community outreach activities engaged by the institutes each year. The annual reports also provide valuable information about the types of research being conducted at the institute and the direction and vision of the institute's Directors and other laboratory leaders.

Finally, the annual report was used in order to prepare for the interviews whilst visiting the institute. The annual report, in this regard, was additionally an important tool with which to understand the institute professionally and familiarise myself with the aims and goals of each organisation. This was therefore an important tool with which to frame the analysis of the interview and bibliometric analysis.

A.3.2.2 Publication Lists

A total of 5110 publications were collected from all participating institutions for the period 1999-2005. These publications were then identified as either articles, reviews, editorials and letters. Any review articles were discounted from the publication lists. This was done for two reasons; firstly review articles are usually published in higher impact journals and have a higher level of citations (Weale, Bailey, & Lear, 2004) and secondly, usually do not contain any original research data (Gorman, 2005). Thus, inclusion of reviews would not correctly represent the dissemination of scientific research results and will therefore skew the results. For this reason, review articles were omitted from the publication list. Therefore, only articles were used in the bibliometric analysis of this study. In the past, a complicated algorithm weighing the various characteristics of an item was used to identify whether an article was a review article, a letter to the editor or a proper article. This system used a 'points' system where points were allocated according to the amount and type of information the article contains. For example, an article with no authors loses one point and an article with two or more authors receives one point. Similarly, if an author address is provided the item receives another point. Other weighing criteria include page length, number of references and page overlap, which occurs when two or more items share the same page (Garfield 1987).

Fortunately, this extensive procedure was not needed to identify types of articles for this study. Instead, Pub Med was used to determine the type of publication. PubMed is an international database available via the NCBI Entrez retrieval system, was developed by the National Centre for Biotechnology Information (NCBI) at the National Library of Medicine (NLM), located at the U.S. National Institutes of Health (NIH). PubMed provides access to citations from biomedical literature. With this in mind, Entrez PubMed was a simple database to use in order to confirm information about a particular publication, in particular whether the article was classified as a research article, review or editorial. Once the type of article was determined, the list was adjusted so that only articles remained and that the reviews, editorials and letters were listed separately. Information about the article including the number of authors and number of pages was collected prior to retrieving bibliometric information.

Using the specific yearly Journal Citation Reports provided by Thomson ISI, the Journal Impact Factor (JIF), Immediacy Index and the Cited Half Life was recorded for each publication. Additionally, the number of authors (AUTHORS) for each publication was recorded and the publication was given a field classification. More information on the assignment of field classifications can be found in the section below. Each publication was also coded according to its year of publication (YEAR), which institute the authors belonged to (INSTITUTE) as well as the length of an article (PAGES). This was done for each publication collected and recorded for the database. The dependant variable for all calculations was the Journal Impact Factor (JIF).

The publication window was set at 1999 until 2005. Records of publications prior to the year 1999 of each participating institute were difficult to obtain. This could have been for a number of reasons including, as seen in Chapter 4, the professional communication offices are a relatively new endeavour for the MRIs and accurate publication lists and annual reports were not produced until the late 1990's. In addition, for the purposes of this study, the aim of this section was to monitor changes in a scientist's publication activity in response to external pressures such as commercialisation. In 2000, Australia's first policy regarding science and innovation, *Backing Australia's Ability I,* was launched. Since its inception, this altered the way that funding is allocated and consequently the priorities of scientific research. With this in mind, choosing a reference year prior to the inception of the *Backing Australia's Ability Policy* ensures the accurate recording of the scientific publication behaviour in response to the policy and, in addition provides a useful tool to describe the state of science. The year 2005 was chosen as the last year mainly for reasons of convenience. The *Journal Citation Reports (JCR)* is released from Thomson Scientific in July the following year. For example, the JCR for the year 2003 was released in July, 2004. Due to the time constraints of the project, 2005 was chosen as the end year. Another reason for the careful selection of the appropriate publication window is the issue of a suitable citation window in order to see any significant change in publishing behaviour. Butler (2001a, 2001b) recommends a minimum citation window of 3 years, stating that this is sufficient time to detect any significant change in publishing behaviour. With this in mind, the 7 years from 1999-2005 would be sufficient to measure any change in publishing behaviour that would have been stimulated by the introduction of the policy.

Publications published in journals that were not listed by Thomson ISI were excluded from all calculations. The reason for this exclusion was based on the criterion that a journal needed to be 'visible' enough to be listed by ISI in order to contribute to any results of this thesis. The number of negligible publications that failed to meet this criterion totalled 53 over the 5 participating institutes for the period 1999-2005.

For each publication; the year, the institute, the journal, the number of authors and number of pages was recorded. Using the Journal Citation Reports supplied from Thomson Scientific, data on each journal in which a paper was published was recorded.

A.3.2.3 Field Classification

The problems with the ISI Web of Knowledge/Web of Science field classification system have been well-documented in the literature (Leydesdorff, 2009). These problems reflect that the field classification system is based on the journal and its subsequent citations links with other journals. This citation cluster is then recognised as a 'field' and then labelled as such by ISI. This study, however, recognises that no external party understands the research as well as the involved scientist. For this reason, this study specifically asked the researchers to classify their own research publication outputs.

Each journal article was therefore assigned a field classification code. The field classification referred to which laboratory or laboratories produced the article. The different field classifications and their definitions are listed below in Table A.3.2.3.

Table A.3.2.3
Field Classification and Definitions used for the Internal and Publication Data Presented in this Thesis

Abbreviation	n	Field Classification Description
CHD	552	Cancer And Haematology (Including Cancer Research)
DNG	843	Neurobiology (Neuroscience)
IMM	716	Immunology (Basic Immunology)
MBD	627	Molecular Biology (Basic Molecular Biology)
EPI	101	Epidemiology
INF	695	Infection And Immunity (Infectious Diseases, Vaccines)
GBI	551	Genetics And Bioinformatics (Basic Genetics And Bioinformatics)
ATD	331	Autoimmunity and Transplantation (Asthma, Diabetes)
JPS	26	Ćoint Proteomics (Wehi Specific)
HBP	45	High Blood Pressure
MGC	337	Molecular Genetics of Cancer (Including Applied Genetics)
SBD	104	Structural Biology
OTHER	249	Other Miscellaneous Research Areas

The field classification was originally based on the WEHI method of classifying each division in their Annual Report. For the other Medical Research Institutes, each laboratory was classified according to their research area into one of the above field classification codes. To classify each journal article, authors were identified by belonging to one of the laboratories that were previously classified into different fields. An example of the procedure used to classify papers into the above fields is demonstrated below. For example, for the journal article:

The authors identified as belonging to the participating institution and their corresponding laboratories are; Daly RJ of the laboratory, Signal Transduction and Cancer Research Program; and Henshall SM of the laboratory, Prostate Cancer Research Program.

Daly RJ, Hu G, Parmer J, Lyons RJ, Kairouz R, Head DR, Henshall SM (2002) The docking protein Gab2 is over-expressed and oestrogen regulated in human breast cancer.

The classification of the first laboratory would be CHD and MBD since both Cancer and Haematology and Molecular Biology related research takes place in this laboratory. Therefore the Field Classification for this first author would be CHD and MBD. The second laboratory, the Prostate Cancer Research Program, would be classified as CHD as the main focus of that laboratory's research is Cancer and Haematology. Therefore the field classification of this paper would be CHD, MBD. This formula for classifying articles was continued for all journal articles collected from each participating institution over the years 1999-2005.

A.3.3 Variables

For the purposes of this study, the dependant variable was the Journal Impact Factor (JIF). The independent variables included the number of authors (#AUTHORS), the number of pages (#PAGES), the institute (INSTITUTE), the field of research (ATD, CHD...etc) and the year of publication (YEAR). A full list of the variables being taken into consideration is given below in Table A.3.3.

Table A.3.3
List of variables under investigation

	Variable	Description
1	#PAGES	Total length of the article in pages
2	INSTITUTE	The institute that the authors belong; either JCSMR, WEHI, GARVAN, POWMRI or QIMR
3	JIF	Journal Impact Factor (Average number of citations per article of that journal in a given year)
4	FIELD	The field classification of the authors and thereby the article. Full list of fields in Section 3.3.8.1
5	#AUTHORS	Total number of collaborating authors per article
6	YEAR	The publication year of the article

A.3.4 Collaboration Measure

Co-authorship (or collaboration) is a valuable measure of communication patterns within the scientific field. Collaboration links scientists across subject fields and in turn this network of collaboration facilitates communication between scholars. Previous research has concentrated on the value of collaboration in terms of being published in higher impact journals and linking authors through a co-authorship pattern. However, collaboration is evidence of an even larger social phenomenon that forms the basis for the internal scientific exchange of ideas. The number of authors was an important variable to include in the calculations as it represented a measure of the degree of collaboration on the individual paper. However, past research has concentrated on developing sophisticated formulae for the measurement of collaboration.

The Collaborative Index (CI) is used to measure the mean number of authors per paper. The CI differentiates among levels of authorships and is very easy to calculate. Among its disadvantages is the fact that it is not easily interpretable as a quantitative measure as it has no upper limit and it also gives a non-zero weight to single authored papers that involve no collaboration. The Collaborative Index is written as;

$$CI = \frac{\sum_{j=1}^{k} j f_j}{N}$$

F_j = the number of j-authored papers published during a certain period of time

N = the total number of research papers published during a certain period of time

However, it is obvious from the formula that it is difficult to compare separate papers across a scientist's career and across scientific disciplines. A scientist may, as seen in Chapter 5, be involved in several different collaboration networks and may publish papers with varied levels of co-authorships. This CI gives one numeric indicator of a scientist's level of collaboration, without taking into account any social influences affecting a scientist's collaboration choice. According to Subramanyam (1983), the mathematical difficulties with the CI can be easily overcome using an additional *Degree of Collaboration.* Without getting into the complex mathematical derivations of the DC, the formula is shown below:

$$DC = \frac{N_m}{N_m + N_s}$$

N_m = number of multiple-authored research papers in the discipline published during a year

N_s = number of single-authored research papers in the discipline published during the same year

A preliminary study investigating the usefulness of the DC reinstated previous research that suggested that the degree in collaboration is higher, for example, in biochemistry than in chemical engineering. As that in both biochemistry and chemical engineering, collaborative research papers were supported by grants to a larger extent than were single authored papers. The confirmation of these previous results by using the DC, supported evidence suggesting it is a efficient measure of collaboration. However, according to Subramanyam (1983), both the DC and CI, gave a fair indication of the extent of collaboration within a discipline, although some problems still do arise. In order to avoid this, a single measure that incorporates some of the merits of both the CI and the DC was developed. This formula known as the Collaboration Co-efficient (CC) is outlined below:

$$CC = 1 - \frac{\sum_{j=1}^{k} (1/j) f_j}{N} \qquad 0 < CC < 1$$

F_j = the number of j-authored papers published during a certain period of time

N = the total number of research papers published during a certain period of time

K = the greatest number of authors per paper

This formula, developed by Ajiferuke (1988), assumes that the mean number of authors per paper (the Collaborative Index) (Lawani, 1980) or the proportion of the multiple-authored papers (the Degree of Collaboration) (Subramanyam, 1983) are inadequate as a measure of the degree of collaboration within a discipline. Both of these measures are thus combined to produce one Collaboration Coefficient. However, for the purposes of this study, the above Collaboration Coefficient cannot be used. The reason is that the CC is based on the assumption that each paper carries with it a "single credit" that is shared between its authors. For example, if the paper has 2 authors, then each author gets 1/2 credit and if the paper has 3 authors, then each author gets 1/3 credit for the paper. Therefore; If we have χ authors =

$1/\chi$ credit per author, hence the range of credit per author can receive is $E[1/\chi]$ $0 < \text{credit} < 1$.

In relation to studies involving communication, there is an obvious problem with using this formula and that is that it assumes that an author who publishes alone, (i.e. 1 author = 1 credit per author) deserves more credit than an author as part of a large collaboration, (i.e. 5 authors = 1/5 credit per author). When investigating science communication, large collaboration groups can represent international and cross-institutional collaboration. Therefore, a paper with 10 authors requires more *science communication* than a paper with 1 author. For this reason, this study use author counts to measure the extent of collaboration between scientists assuming that χ authors = χ credit per authors and hence the range of credit per author is $E[\chi]$ $1 < \text{credit} < \infty$.

A.3.5 Data Analysis

For the analysis, GenStat v9 was used for all statistical calculations (Nelder, 2006). The figures were produced in either GenStat v9 or SPSS v16, depending on the type of calculation and the quality of the figures produced in each program (Nelder, 2006). Additionally, where indicated, some simple analysis was done in SPSS v16 in preference to GenStat v9.

A.3.6 Statistical Modeling

Analyses of the variables were fitted to generalised linear models and were done using Genstat v9. I used least-squares regression with the journal impact factor (JIF) as the dependant variable to explore associations. The F-test was used to calculate the level of significance and I included variables in my multivariable models only if their level of significance was $P<0.05$ or if they subsequently altered the significance of another variable in the model. A variable was considered statistically significant if it had a P-value<0.05 in the final multivariate model.

A.4 Results

A.4.1 Total Number of Publications Over Time is Variable for Each Institute

Before, classifying each article by its field of study, we analysed the change in the number of publications from each institute over time. The results can be seen in Table A.4.1.

Table A.4.1
Number of Publications over Time for each Institute

Institute	1999	2000	2001	2002	2003	2004	2005
WEHI	162	208	193	213	200	202	179
POWMRI	82	67	107	80	101	79	111
JCSMR	171	204	200	167	181	150	88
GARVAN	50	63	95	91	107	98	137
QIMR	124	204	228	229	200	242	307

As can be seen above, both WEHI and QIMR continually publish more articles per year than the other institutes. In addition, GARVAN has seen a significant increase in their number of publications in 1999 (50) and 2005 (137). Publication number however, is not sufficient to measure the publishing behaviour of scientists; the JIF is taken into account when measuring this in the next few sections of this chapter below.

A.4.2 Average Impact Factors Show No Significant Difference Over Time

The impact factors for each year and then each institute were calculated, graphed and are shown in Figure A.1A and Figure A.1B.

Figure A.1A – Boxplot of Average Journal Impact Factor (JIF) over time

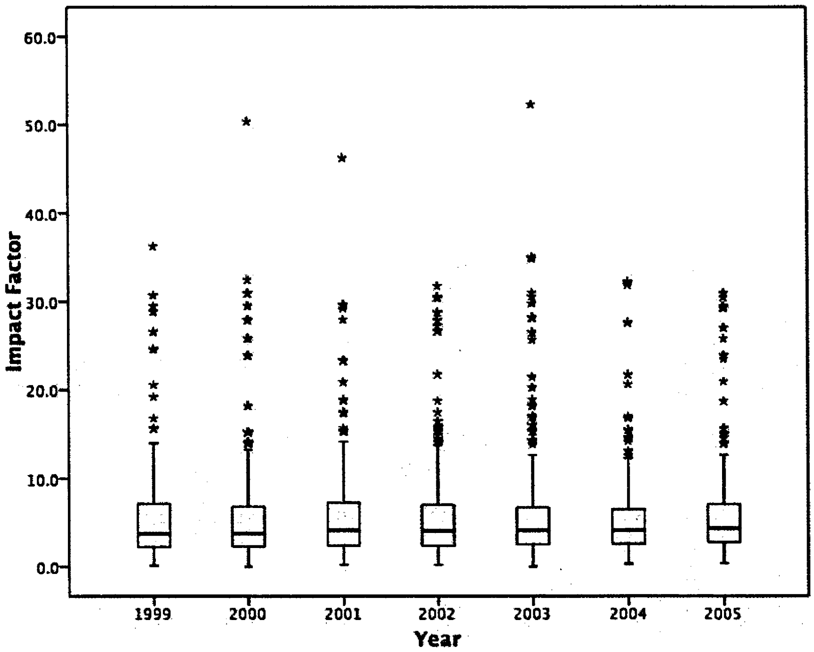
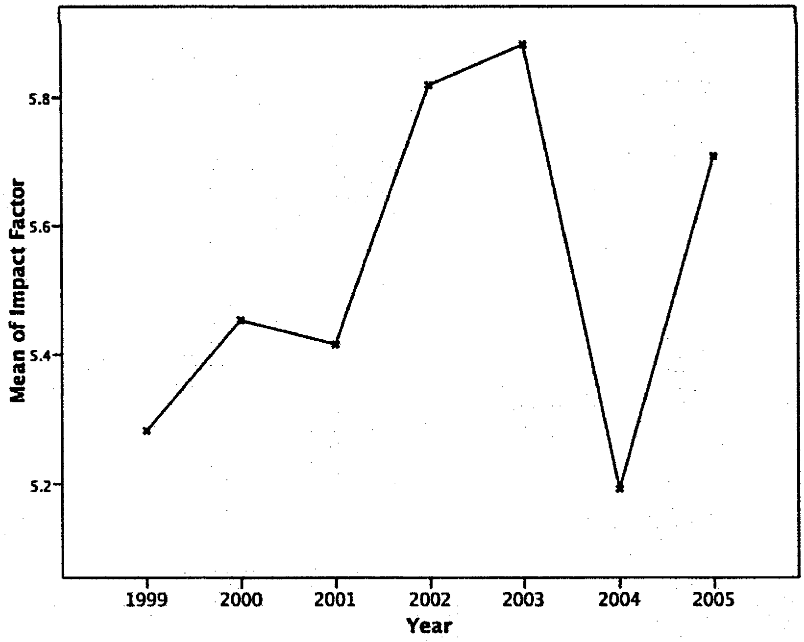


Figure A.1B – The mean JIF for each year. Using one-way ANOVA, no significant difference was found (F=1.56; P = 0.15)



A box plot for the average JIF for each year was calculated and is shown in Figure A.1A; the means of the JIF over time is also shown in Figure A.1B. One way ANOVA showed no significant difference for the JIF over time (F=1.56; P = 0.15). However a significant difference between the average JIF between institutes was found using one-way ANOVA (F = 57.14; P = 0.0001 (P < 0.05). In particular, using a Tukey HSD test, significant differences in the average JIF was found between all institutes except between JCSMR and QIMR. The results are tabulated in Table A.4.2 below;

Table A.4.2
Differences between the average JIF between Institutes

Institutes	P-value	S.Error
GARVAN/JCSMR	0.006	0.27
GARVAN/POWMRI	<0.001	0.32
GARVAN/QIMR	<0.001	0.26
GARVAN/WEHI	<0.001	0.27
JCSMR/POWMRI	<0.001	0.29
JCSMR/QIMR	0.252	0.22
JCSMR/WEHI	<0.001	0.23
POWMRI/QIMR	<0.001	0.27
POWMRI/WEHI	<0.001	0.28
QIMR/WEHI	<0.001	0.28

As can be seen, there was very little difference between institutes overall, however, WEHI did consistently have higher average impact factors when compared with POWMRI and, surprisingly QIMR. A two-sample t-test was used to determine the significance of the difference between each institute's average JIF for each year. The results of these tests are discussed in more detail below.

For 1999, each institute showed significantly different results except for QIMR and JCSMR. Using the two-sample t-test the null hypothesis could not be rejected (F=1.18; P=0.37).

In the year 2000, each institute showed significantly different results expect for the GARVAN and the WEHI (F=1.31; P=0.20) and no significant difference was found between the average JIF for the QIMR and JCSMR (F=1.17; P=0.33). Significant differences were found between WEHI and all other institutes as well as POWMRI for all other institutes.

For 2001, both JCSMR and QIMR still showed no significant difference between their average JIF for 2001 (F=1.27; P=0.13) again. Additionally, no significant difference was seen for the average JIF of GARVAN and QIMR (F=1.44; P=0.08). All other institute combinations showed significant differences in their average JIF for 2001.

In 2002, no significant difference for average JIF was found again between JCSMR and QIMR (F=1.15; P=0.40). In addition, no significant difference was seen between the GARVAN Institute and WEHI (F=1.31; P=0.19) or JCSMR (F=1.41; P=1.10)

Significant differences were found for all institutes in 2003 except between JCSMR and QIMR, mirroring the trend from the previous 4 years (F=1.14; P=0.44).

For 2004, significant difference was still not seen between JCSMR and QIMR ($F=1.02$; $P=0.91$). Additionally, no significant differences was seen between GARVAN and JCSMR ($F = 1.23$; $P = 0.30$), WEHI ($F=1.29$; $P=0.21$) or QIMR ($F=1.25$; $P=0.22$). All other combinations were significantly different.

Finally for 2005, all combinations were significantly different except for QIMR and JCSMR who, as seen for the previous years, still showed no significant difference in their average JIF for 2005 ($F=1.08$; $P=0.63$).

The significantly lower ($P<0.05$) average impact factors for POWMRI for all years suggests a field bias in the results. The results comparing the 5 participating MRI's taking into account the field of the study are considered in the general linear models detailed below.

A.4.3 The Average Number of Authors per Article is Increasing Linearly over Time

The average number of authors over time was calculated in order to determine whether the level of collaboration has significantly changed over the time period 1999-2005. ANOVA was used to test the strength of each line and its corresponding formulae. The results are shown in Figure A.2

Figure A.2A – Boxplot of the number of authors per article for each year.

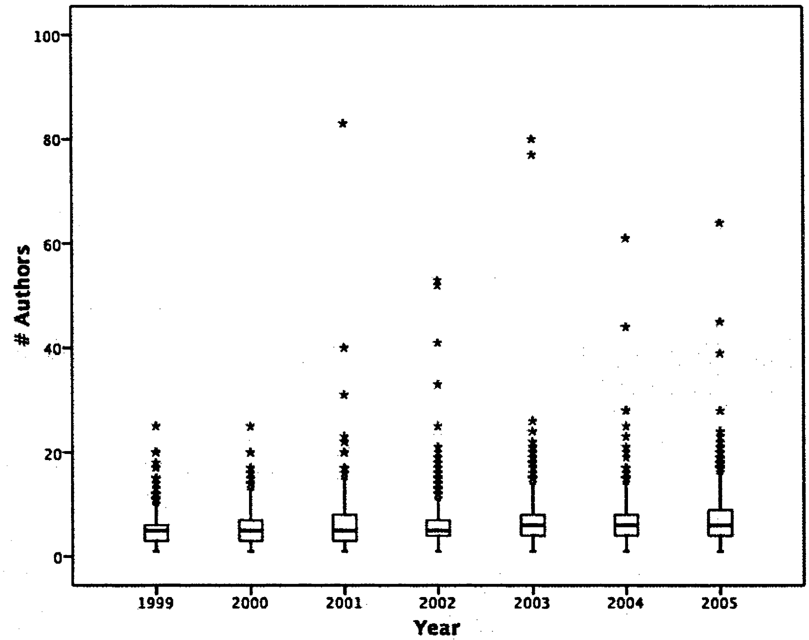
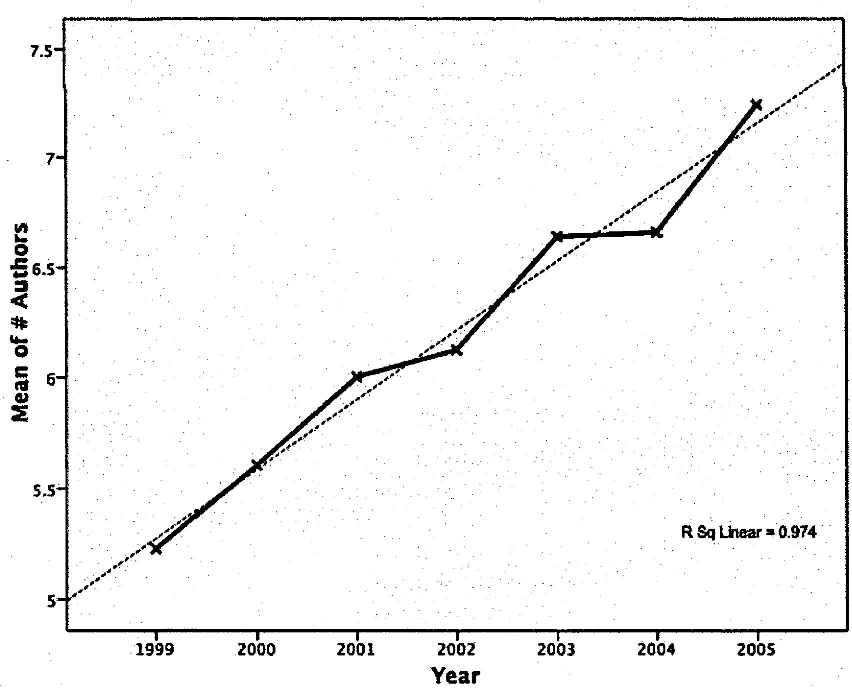


Figure A.2B – Further analysis of the mean number of authors per article showed a linear increase over time (r^2=0.97; P<0.05)



In Figure A.2A, the average number of authors per article for each year (1999-2005) was graphed. Using one-way ANOVA, a significant difference between years was found ($F=12.93$; $P<0.001$ ($P <0.05$). Further analysis using a Tukey HSD test determined a significant difference between the number of authors per article for 1999 and 2002 ($P=0.02$; $P <0.05$), 2003 ($P<0.001$; $P<0.05$), 2004 ($P=0.0001$; $P <0.05$) and 2005 ($P<0.001$; $P<0.05$). No significant difference was found between the number of authors per article for 1999 and 2000 and 2001.

There was also a significant difference between the number of authors per article for 2000 and 2003 ($P=0.003$; $P<0.05$), 2004 ($P=0.002$; $P<0.05$) and 2005 ($P<0.0001$; $P<0.05$). A further significant difference was found between the number of authors per article for 2005 and 2001 ($P<0.001$; $P<0.05$) and between 2005 and 2002 ($P<0.001$; $P<0.05$).

Further analysis of the mean number of authors per article (1999-2005) shown in Figure A.2B showed a linear increase ($r^2=0.97$, $P<0.05$) over time. Despite these encouraging results, it was particularly difficult to draw comparisons between institutes and fields due to the nature of the distribution, although using one way ANOVA a significant difference between the institutes for the number of authors per article was found ($F=48.1$; $P<0.001$; $P<0.05$). A log transformation was used to further investigate the nature of the results of this study; the relevant distributions are discussed later in this chapter.

A.4.4 Regression Analysis and Interaction Models

It was necessary for our general linear model analysis to transform our dependant variable, the Journal impact Factor (JIF), into a log (JIF) for distributional reasons. A number of different terms showed varying degrees of interaction however only the most significant interactions will be described below. For the terms in the model that were not significant, further refinement became evident. In this section, a variety of different models are investigated in order to measure the significant of a number of difference factors and terms. Only the more significant and relevant interactions will be discussed for single, 2- and 3-factor interactions.

A variety of models were constructed with variables from the data that exhibited differing degrees of success. The results are graphed in and displayed in Figures described below. After all terms were fitted, the model with the added residual was tested using non-orthogonal analyses of variance. The predicted means for the strongest and most significant interactions were then calculated.

To test the null hypotheses of the following interactions, t-tests and ANOVA were used to test for significance.

A.4.4.1 Modelling General Interactions

The model used to investigate the following factors and to calculate the predicted means for this section is shown in Figure A.3.

Figure A.3 – Modelling general interactions. Interactions that are discussed in the text are indicated with a ♣

	Change	d.f.	m.s.	v.r.	F pr.
♣	+ Year	6	1.0279	3.56	0.002
♣	+ INSTITUTE	4	25.7123	89.04	<.001
	+ ATD	1	2.4058	8.33	0.004
	+ IMM	1	27.2149	94.25	<.001
	+ DNG	1	0.1780	0.62	0.432
	+ GBI	1	1.4616	5.06	0.025
	+ INF	1	16.0336	55.53	<.001
	+ MGC	1	20.1641	69.83	<.001
	+ CHD	1	6.6739	23.11	<.001
	+ JPS	1	0.1904	0.66	0.417
	+ SBD	1	0.3734	1.29	0.256
	+ HBP	1	2.2353	7.74	0.005
	+ MBD	1	12.0259	41.65	<.001
	+ EPI	1	0.1781	0.62	0.432
	+ OTHER	1	0.0085	0.03	0.864
	+ Year.INSTITUTE	24	0.3314	1.15	0.281
	+ INSTITUTE.ATD	3	0.7349	2.54	0.054
	+ INSTITUTE.IMM	3	1.2183	4.22	0.005
♣	+ INSTITUTE.DNG	3	0.6596	2.28	0.077
♣	+ INSTITUTE.GBI	2	2.0790	7.20	<.001
♣	+ INSTITUTE.INF	3	3.7252	12.90	<.001
♣	+ INSTITUTE.MGC	3	3.1261	10.83	<.001
	+ INSTITUTE.CHD	3	0.9006	3.12	0.025
	+ INSTITUTE.JPS	0	*		
	+ INSTITUTE.SBD	1	0.6882	2.38	0.123
	+ INSTITUTE.HBP	2	0.2649	0.92	0.400
♣	+ INSTITUTE.MBD	2	2.0965	7.26	<.001
	+ INSTITUTE.EPI	1	0.9935	3.44	0.064
	+ INSTITUTE.OTHER	3	0.1819	0.63	0.596

Figure A.3 (continued)

♣	+ Authors	1	64.4900	223.34	<.001
♣	+ Authors.INSTITUTE	4	2.5060	8.68	<.001
	+ Authors.ATD	1	0.2345	0.81	0.368
	+ Authors.IMM	1	0.4176	1.45	0.229
	+ Authors.DNG	1	0.1509	0.52	0.470
	+ Authors.GBI	1	0.6945	2.41	0.121
	+ Authors.INF	1	0.0025	0.01	0.926
	+ Authors.MGC	1	0.8131	2.82	0.093
♣	+ Authors.CHD	1	2.0837	7.22	0.007
	+ Authors.JPS	1	0.0901	0.31	0.576
	+ Authors.SBD	S	1.3012	4.51	0.034
	+ Authors.HBP	1	0.6458	2.24	0.135
♣	+ Authors.MBD	1	2.5560	8.85	0.003
	+ Authors.EPI	1	0.0384	0.13	0.715
	+ Authors.OTHER	1	0.1040	0.36	0.548
	+ Authors.INSTITUTE.ATD	3	0.5207	1.80	0.144
	+ Authors.INSTITUTE.IMM	3	0.4009	1.39	0.244
	+ Authors.INSTITUTE.DNG	3	0.7257	2.51	0.057
	+ Authors.INSTITUTE.GBI	3	0.0319	0.11	0.954
	+ Authors.INSTITUTE.INF	3	0.6004	2.08	0.101
	+ Authors.INSTITUTE.MGC	2	0.2113	0.73	0.481
	+ Authors.INSTITUTE.CHD	3	0.3316	1.15	0.328
	+ Authors.INSTITUTE.JPS	0	*		
	+ Authors.INSTITUTE.SBD	1	0.2532	0.88	0.349
	+ Authors.INSTITUTE.HBP	2	0.1728	0.60	0.550
	+ Authors.INSTITUTE.MBD	2	0.0014	0.00	0.995
	+ Authors.INSTITUTE.EPI	0	*		
	+ Authors.INSTITUTE.OTHER	3	0.3189	1.10	0.346
	Residual	3923	0.2888		
	Total	4046	0.3650		

Firstly, for the variable, YEAR, a significant interaction was found and the results of which were tabulated below in Table A.4.4.1A. Using the YEAR 1999, as the test reference, the null hypothesis for this interaction was described as there would be no significant difference in the log (JIF) over the period 1999-2005. As can be seen from the below table, using ANOVA to test for significance, P=0.012 (P<0.05) and the null hypothesis was rejected.

Table A.4.4.1A
Significant Interaction between the JIF and the Year of Publication

Log (JIF) = YEAR

Year	Predicted Means	S.Error	t(3940)	n	P-value
1999	1.742			442	
2000	1.730	0.108	0.71	551	
2001	1.723	0.107	1.32	592	
2002	1.754	0.107	1.33	618	
2003	1.777	0.103	0.00	566	
2004	1.720	0.104	0.98	617	
2005	1.762	0.098	0.43	714	P=0.012
TOTAL				4100	

The same method was used to investigate the interaction between the log (JIF) between each institute. The results of this analysis are described in Table A.4.4.1B below. The null hypothesis was therefore described as there being no significant difference in the log (JIF) between institutes. This interaction was of particular interest due to the difference in field concentrations between the institutes. For example, POWMRI specialises in the Neuroscience (DNG) field which has a potential impact factor range that is smaller than for some other, more popular fields such as Molecular Genetics of Cancer (MGC) or basic

Cancer (CHD) fields. As can be seen in the table below, for the INSTITUTE interaction $P<0.001$ ($P<0.05$), lending evidence to reject the null hypothesis of there being no difference in the log (JIF) over INSTITUTES.

Table A.4.4.1B
Significant Interaction between the JIF and the Institute

Log(JIF) = INSTITUTE

Institute	Estimate	S.Error	t(3940)	n	P-value
GARVAN	Reference category			534	
JCSMR	-0.334	0.226	-1.48	895	
POW MRI	-0.188	0.137	-1.37	452	
QIMR	-0.377	0.215	-1.76	1207	
WEHI	0.150	0.220	0.68	1012	P<0.001
TOTAL				4100	

Further from the above analysis, a combination of the YEAR and the INSTITUTE was tested for significance against the log (JIF), unfortunately ($P=0.495$, $P>0.05$) so significant interaction could be determined. There were, however, a number of two-factor interactions did exhibit significance and are described below in the next section.

A number of different two-factor interactions were tested using the regression models. The significant interactions are described below. As was described in the Chapter 5 results section, a number of scientists commented on how a potential publication would be limited by the field that it belonged. This difference could be seen in the different range of journal impact factors of each field. For example, a scientist in the molecular biology (MBD) field would aim to publish in different journals than a scientist in the applied Cancer (CHD and

MGC) field. This also means that the scientists in the applied cancer field would have a higher probability of publishing in a journal with a high impact factor than a scientist in a less applied and smaller field. In particular, each of our participating institutes specialises in a different field and their publication rates would differ accordingly. This theory was tested below by examining the difference in publication behaviour for each institute over each of our defined fields. Only the significant interactions are reported below.

The interaction between the variables INSTITUTE and a number of different fields was tested against the log (JIF). The GARVAN Institute was used in each situation as the reference category, additionally, in many of the interactions described below, POWMRI will not exhibit any results, and this is because the POWMRI does not involve research in any areas other than the neuroscience (DNG) area. For this reason, the interaction for INSTITUTE.DNG will also be described below.

Firstly the interaction for INSTITUTE.GBI was tested using the GARVAN as the reference category. The null hypothesis was described as there would be no difference in the log (JIF) between institutes in the GBI field. The results of the interaction are described in Table A.4.4.1C below;

Table A.4.4.1C
A Significant Interaction between the JIF and the Institute for the GBI Field

Log(JIF) = INSTITUTE.GBI

Institute	Estimate (95% CI)	S.Error	t(3940)	n	P-value
GARVAN.GBI	Reference category			77	
JCSMR.GBI	0.212	0.211	1.00	137	
POWMRI.GBI	*	*	*	0	
QIMR.GBI	0.199	0.209	0.95	189	
WEHI.GBI	-1.188	0.217	-0.87	158	P=0.001
TOTAL				561	

A significant interaction was determined for the relationship log (JIF) = INSTITUTE.GBI (P=0.001, P<0.05) and the null hypothesis was rejected.

Likewise we tested the interaction in the Infectious Diseases (INF) field against the log (JIF) using the GARVAN as the reference category. The results of the analysis are shown below in Table A.4.4.1D.

Table A.4.4.1D
A Significant Interaction between the JIF and the Institute for the INF Field

Log(JIF) = INSTITUTE.INF

Institute	Estimate (95% CI)	S.Error	t(3940)	n =	P-value
GARVAN.INF	Reference category			17	
JCSMR.INF	0.323	0.350	0.92	127	
POWMRI.INF	*	*	*	0	
QIMR.INF	-0.100	0.337	-0.30	388	
WEHI.INF	-0.072	0.345	-0.21	162	P<0.001
TOTAL				694	

The null hypothesis was described as there being no difference in the log (JIF) between the institutes in the INF field however, as can be seen $P<0.001$, $P<0.05$ so the null hypothesis was rejected.

Next the interaction between institutes in the MGC field was tested. The MGC field (Molecular Genetics of Cancer, including applied genetics) field has been described by our participants as a particularly competitive scientific field and one of great public interest. Again, using the GARVAN as the reference category, the null hypothesis was described as being no difference in the log (JIF) between institutes in the MGC field. The results obtained can be seen in Table A.4.4.1E below;

Table A.4.4.1E
A Significant Interaction between the JIF and the Institute for the MGC Field

Log(JIF) = INSTITUTE.MGC

Institute	Estimate (95% CI)	S.Error	t(3940)	n =	P-value
GARVAN.MGC	Reference categeory			10	
JCSMR.MGC	-0.145	0.621	-0.23	81	
POWMRI.MGC	*	*	*	0	
QIMR.MGC	0.074	L.608	0.12	87	
WEHI.MGC	0.139	0.577	0.24	166	P=0.008
TOTAL				344	

With P=0.008, P<0.05, the null hypothesis was rejected.

The Molecular Biology field (MBD) was another field of interest. Molecular Biology, though not a field that is known publishing alone in high impact journals, nevertheless is a field that is used as a tool for the more applied and high impact fields. Interestingly enough then a significant interaction was detected for the variable: INSTITUTE.GBI. There were also no detected values for WEHI; this was because the WEHI did not record any MBD field papers for the period 1999-2005. As a result, the main interaction categories therefore were between the QIMR, JCSMR and GARVAN. The null hypothesis was described as there is no difference in the log(JIF) between institutes in the MBD field. The results are described below in Table A.4.4.1F and as can be seen the level of significance of the interaction was P=0.002; P<0.05, so the null hypothesis was rejected.

Table A.4.4.1F
A Significant Interaction between the JIF and the Institute for the MBD Field

Log(JIF) = INSTITUTE.MBD

Institute	Estimate (95% CI)	S.Error	t(3940)	n =	P-value
GARVAN.MBD	Reference category			151	
JCSMR.MBD	-0.102	0.199	-0.51	258	
POWMRI.MBD	*	*	*	0	
QIMR.MBD	0.077	0.193	0.40	218	
WEHI.MBD	*	*	*	0	P=0.002
TOTAL				627	

Up until now, POWMRI has been left out of the two-factor field interactions due to the institute's specialisation in Neuroscience (DNG). Therefore, the interaction between the institutes in the DNG field was tested and the results show in Table A.4.4.1G. The null hypothesis was described as there being no significant difference in to log (JIF) between institutes in the DNG field.

Table A.4.4.1G
Interaction between the JIF and the Institute for the DNG Field was found to be not Significant

Log(JIF) = INSTITUTE.DNG

Institute	Estimate (95% CI)	S.Error	t(3940)	n =	P-value
GARVAN.DNG	Reference category			114	
JCSMR.DNG	0.469	0.228	2.06	216	
POWMRI.DNG	0	0	1.00	452	
QIMR.DNG	-0.230	0.667	-0.35	6	
WEHI.DNG	-0.163	0.236	-0.69	55	P=0.243
TOTAL				957	

Unfortunately, this interaction did not appear significant (P=0.243; P>0.05) and so the null hypothesis failed to be rejected. This is good news for POWMRI as the institute's lack of 'high impact' fields such as Cancer and Immunology appears to have put the Institute at a disadvantage compared to our other participating institutes. For the DNG field at least, POWMRI appears to be comparable with the other participating institutes.

A.4.4.2 Author Interactions

As described in the methods section of this chapter, the number of authors of an article will be used for the purposes of this analysis as the measure of collaboration. This will be used in preference to the various collaboration indices developed by past authors and described in the methods section of this chapter. The number of authors per paper will therefore will be used as a measure or the level of communication within the scientific community. With this in mind it would be of particular interest to test the interactions of the number of authors per paper (AUTHORS) with a variety of other variables including the different fields, years and institutes. Only the most significant interactions are described in this section.

To firstly test the single variable (AUTHORS) interaction per paper, the null hypothesis was described as that there would be no difference in the number of authors per paper and the log (JIF). Using regression analysis and the t-test to test for significance, the null hypothesis was then rejected ($t(5109)=0.68$; s.e=0.997; $P<0.001$).

The interactions between the log (JIF); the number of authors per paper in a variety of different fields was then investigated. The most significant interactions were evident for the variables; AUTHORS.CHD ($t(5109)=-0.13$; s.e=-0.0023; $P=0.03 (P<0.05)$) as well as for the variables AUTHORS.MBD ($t(5109)=0.61$; s.e=0.0189; $P=0.001$ ($P<0.05$)) . In both cases the null hypothesis was rejected.

Finally, the other author interaction of note was for the variable AUTHOR.INSTITUTE. For this interaction, the null hypothesis was described as there being no difference in the number of authors per paper and the log (JIF) for each of the participating institutes. The results of this generalised linear model are shown in Table A.4.4.2 below and the model including this interaction is shown in Figure A.4.

Table A.4.4.2
A Significant Interaction between the JIF and the Number of Authors per Paper between Institutes

Log(JIF) = AUTHOR.INSTITUTE

Institute	Estimate (95% CI)	S.Error	t(3940)	n =	P-value
GARVAN.AUTHORS	Reference category			533	
JCSMR.AUTHORS	0.439	0.0275	1.60	895	
POWMRI.AUTHORS	0.0088	0.0104	0.85	452	
QIMR.AUTHORS	0.0169	0.0225	0.75	1207	
WEHI.AUTHORS	0.0012	0.0245	0.05	1012	P=0.005
TOTAL				4100	

The interaction was determined by the F-test to be significant (P=0.005; P<0.05) and so the null hypothesis was rejected.

Using the same model, significant interactions were also found for the average number of authors per article (AUTHORS) (F=253.6, P<0.001) as well as for the average number of authors per article for the CHD field (F=7.27, P=0.007) and for the MBD field (F=9.10, P=0.003). Predicted means using the model described were not calculated.

A.4.4.3 Further Author Interactions using a New Model

Another model was constructed in order to investigate the variable interactions further. A number of different combinations between the institutes, the fields and the number of authors per paper were tested against the log (JIF). Unfortunately, using log-generalised linear models, the only additional significant interaction found was for the number of authors per paper between institutes in the field of Autoimmunity and Transplantation (ATD). The results of which are described below in Table A.4.4.3.

Table A.4.4.3
A Significant Interaction between the JIF and the Number of Authors per Paper for the ATD Field

Log (JIF) = AUTHORS.ATD

Institute	Estimate (95% CI)	S.Error	t(3940)	n =	P-value
GARVAN.ATD	Reference category			79	
JCSMR.ATD	0.0610	0.0349	1.75	76	
POWMRI.ATD	*	*	*	0	
QIMR.ATD	0.0303	0.0486	0.62	18	
WEHI.ATD	0.0224	/numbe	0.79	160	P=0.04
TOTAL				333	

The null hypothesis was therefore rejected (P=0.04; P<0.05) as there appears to be a signification interaction for this variable (AUTHORS.ATD).

The residual for the above regression model as its interactions was determined to be 0.309. In an attempt to reduce the residual amount, another regression model was formulated that included only the significant interactions described above and the individual field values.

Unfortunately, limiting the number of interactions was not successful in reducing the regression residual (v.r=0.3164).

Figure A.4 – Further author interactions using a new model

CHANGE	df	ssq	vr	Fpr
YEAR	6	5.04	2.66	0.014
INSTITUTE	4	107.5	84.94	<0.001
ATD	1	3.55	11.23	<0.001
IMM	1	16.67	52.71	<0.001
DNG	1	0.02	52.71	<0.001
GBI	1	2.31	7.31	0.007
INF	1	16.45	52.01	<0.001
MGC	1	10.32	32.65	<0.001
CHD	1	10.84	34.26	<0.001
JPS	1	0.07	0.25	0.617
SBD	1	0.18	0.59	0.441
HBP	1	2.37	7.49	0.006
MBD	1	10.84	34.28	<0.001
EPI	1	0.27	0.85	0.356
OTHER	1	0.16	0.50	0.479
AUTHORS	1	59.75	188.86	<0.001
AUTHORS.INSTITUTE	4	4.85	3.84	0.004
RESIDUAL	4035	1276.62		
TOTAL	4063	1527.87		

A.4.5 Restricting the Number of Authors does Yield some Additional Significant Interactions

The range of authors per paper in some fields was vast. One paper in particular recorded 200 authors. These extreme values for the number of authors per paper had the potential to skew any resulting patterns in the regression models. For this reason, two alternative models were proposed below; one where the number of authors per paper was restricted to those papers with authors less than 30; and the other where the number of authors per paper was restricted to less than 10. The results are presented and discussed briefly below.

A.4.5.1 Restricting the Number of Authors <30

Keeping the log (JIF) as our dependant variable, the relationship with the number of authors per paper restricted to a maximum of 30 authors was examined. The F-test was used to determine the significance of the accumulated components of the model. The results of the model are presented in Figure A.5.

As can be seen in Figure A.5, there were a few significant interactions not described in this chapter yet. For the individual fields, there was no change in significant interactions found by restricting the number of authors per paper to <30. This was the same for the interactions involving the number of authors per paper and the institute, as well as for the institute combined with a number of fields. Of the new significant interactions, of most interest was the variable, INSTITUTE.DNG ($p=0.038$; $P<0.05$). This interaction was previously reported as not being significant; however the null hypothesis for this interaction can be rejected when the number of authors is limited to a maximum of 30 authors per paper. Additionally, a similar change in significance was seen for the interaction; INSTITUTE.SBD ($p=0.048$; $P<0.05$). This interaction may be related to the specialty Structural Biology (SBD) department located at the WEHI.

Finally significant interactions were observes for the variable YEAR.MGC ($P<0.001$; $P<0.05$) and for YEAR.CHD ($P=0.014$; $P<0.05$). Previous significant interactions were observed for both the AUTHORS.CHD and the INSTITUTE.MGC variables however, by restricting the number of authors per paper to a maximum of 30, the null hypothesis of these two interactions can now be rejected. The residual value for this model was calculated at 0.307

A.4.5.2 Restricting the Number of Authors <10

Another model which restricts the total number of authors per paper to a maximum of 10 was investigated. The F-test was again used to test the accumulated level of significance of the model as well as to calculate the residual amount. The results can be seen in Figure A.6.

Figure A.5 – Restricting the number of authors to <30 does yield some additional significant interactions.

VARIABLE	df	ssq	vr	Fpr
♣ AUTHORS	1	91.9629	299.49	<0.001
YEAR	6	1.7109	0.93	0.473
AUTHORS.YEAR	6	6.6780	0.37	0.900
INSTITUTE	[illegible]	97.9252	79.73	<0.001
ATD	1	3.2666	10.64	0.001
IMM	1	14.1905	46.21	<0.001
DNG	1	0.2265	0.74	0.390
GBI	1	1.8312	5.96	0.015
INF	1	11.0873	36.11	<0.001
MGC	1	5.8920	19.19	<0.001
CHD	1	3.2825	10.69	0.001
JPS	1	0.0122	0.004	0.842
SBD	1	0.6004	1.96	0.162
HBP	1	2.8839	9.39	0.002
MBD	1	8.1113	26.42	<0.001
EPI	1	0.0093	0.03	0.862
OTHER	1	0.0939	0.31	0.580
INSTITUTE.ATD	3	1.8840	2.05	0.105
INSTITUTE.IMM	3	1.9916	2.16	0.090
INSTITUTE.DNG	3	2.5872	2.81	0.038
INSTITUTE.GBI	3	5.8081	6.30	<0.001
INSTITUTE.INF	3	8.7388	9.49	<0.001
INSTITUTE.MGC	3	3.0125	3.27	0.02
INSTITUTE.CHD	3	1.9751	2.14	0.093
INSTITUTE.JPS	0	0	*	*
INSTITUTE.SBD	1	1.2008	3.91	0.048
INSTITUTE.HBP	2	0.4318	0.70	0.495
INSTITUTE.MBD	2	3.3861	5.51	0.004
INSTITUTE.EPI	1	1.1494	3.74	0.053
INSTITUTE.OTHER	3	0.2473	0.27	0.848
YEAR.ATD	6	0.8979	0.49	0.818
YEAR.IMM	6	3.2578	1.77	0.102
YEAR.DNG	6	2.9575	1.61	0.141
YEAR.GBI	6	2.5256	1.37	0.222
YEAR.INF	6	1.0432	0.57	0.758
YEAR.MGC	6	7.2215	3.92	<0.001
YEAR.CHD	6	4.8878	2.65	0.014
YEAR.JPS	4	0.4396	0.36	0.839
YEAR.SBD	6	2.8625	1.55	0.157
YEAR.HBP	6	1.6886	0.92	0.482
YEAR.MBD	6	1.8879	1.02	0.407
YEAR.EPI	6	1.5040	0.82	0.557
YEAR.OTHER	6	1.9464	1.06	0.387
YEAR.INSTITE	24	5.8567	0.79	0.748
RESIDUAL	3889	1194.19		
TOTAL	4049	1050.34		

Figure A.6 – Restricting the number of authors to <10 does yield some additional significant interactions.

	CHANGE	df	ssq	vr	Fpr
	AUTHORS	1	31.47	104.9	<0.001
	YEAR	6	1.66	0.93	0.475
♣	AUTHORS.YEAR	6	4.59	2.55	0.018
	INSTITUTE	4	96.61	80.50	<0.001
	ATD	1	2.48	8.27	0.004
♣	IMM	1	12.23	40.78	<0.001
	DNG	1	0.04	0.14	0.712
	GBI	1	0.76	2.55	0.111
	INF	1	6.56	21.89	<0.001
	MGC	1	8.08	26.95	<0.001
	CHD	1	2.32	7.75	0.005
	JPS	1	0.07	0.24	0.624
	SBD	1	0.53	1.77	0.183
	HBP	1	3.69	12.31	<0.001
	MBD	1	5.84	19.47	<0.001
♣	EPI	1	0.001	0.00	0.953
	OTHER	1	0.13	0.44	0.506
	INSTITUTE.ATD	3	1.61	1.80	0.146
	INSTITUTE.IMM	3	0.97	1.09	0.354
♣	INSTITUTE.DNG	3	2.96	3.29	0.02
	INSTITUTE.GBI		4.31	4.79	0.002
	INSTITUTE.INF	3	6.67	7.41	<0.001
	INSTITUTE.MGC	2	3.12	5.20	0.006
	INSTITUTE.CHD	3	0.66	0.73	0.532
	INSTITUTE.JPS	0	0.00	*	*
	INSTITUTE.SBD	1	1.64	5.48	0.019
	INSTITUTE.HBP	2	1.26	2.11	0.121
	INSTITUTE.MBD	2	3.75	6.26	0.002
	INSTITUTE.EPI	1	1.33	4.42	0.036
	INSTITUTE.OTHER	3	0.32	0.36	0.785
	YEAR.ATD	6	1.41	0.79	0.581
	YEAR.IMM	6	2.74	1.52	0.166
	YEAR.DNG	6	2.25	1.25	0.276
	YEAR.GBI	6	2.05	1.14	0.336
	YEAR.INF	6	1.02	0.57	0.758
	YEAR.MGC	6	9.02	5.01	<0.001
	YEAR.CHD	6	2.50	1.39	0.213
	YEAR.JPS	4	0.80	0.67	0.613
	YEAR.SBD	6	2.82	1.57	0.152
	YEAR.HBP	6	0.78	0.44	0.853
	YEAR.MBD		1.18	0.66	0.685
	YEAR.EPI	6	1.17	0.65	0.687
	YEAR.OTHER	6	1.08	0.60	0.730
	YEAR.INSTITE	24	5.38	0.75	0.806
♣	RESIDUAL	3320	996.07		
	TOTAL	3479	1236.08		

As was seen when the number of authors was restricted to a maximum of 30, the level of significance for the interactions for INSTITUTE.DNG was increased (P=0.02; P<0.05). Likewise other interactions involving a specific field and the institute were observed when the maximum number of authors per paper was restricted to <10.

A new interaction that was not seen before; both when the number of authors was not restricted as well as when the number of authors was restricted to a maximum of 30, was the interaction for the variable AUTHORS.YEAR. The null hypothesis was described as there is no difference between the number of authors (maximum number of authors is restricted to 10) per paper over the period 1999-2005. The results show (P=0.018; P<0.05) that the null hypothesis can be rejected.

A new interaction was also seen for the Immunology (IMM) field (P<0.001; P<0.05) and for the interactions between the institutes in the epidemiology (EPI) field (P=0.036; P<0.05). For both variables, the null hypothesis was rejected. The residual for this model was calculated to be 0.3.

These new interactions observed between different fields and the institute may reflect the nature of publishing within that particular field. For example, for SBD, the impact factor value may be restricted by the number of journals willing to publish a Structural Biology paper; however the number of contributing authors is not limited. At the WEHI, there is a dedicated structural biology department that maintains collaborations with other WEHI departments in the more competitive areas such as immunology and cancer. By collaborating with these departments, the number of authors per paper would be increased however the potential impact factor of the journal would not. By restricting the number of authors to below 30 and then 10, a more structured pattern of publishing behaviour can be seen for more fields.

A graph of the relationship between the log (JIF) and the number of authors; where the maximum number of authors per paper was restricted to 10. The residual (v.r=0.30) was added to this model.

A.4.6 Further Models Confirm the Significant Observations described above

Another model was contrasted to confirm the significant interactions observed above in previously contrasted models. At first only single-factor interactions and two-factor interactions that were seen to be particularly significant in the previous sections were added to the model. ANOVA and the F-test were then used to calculate each factor's level of significance to the model as well as to calculate the residual value.

Figure A.7 shows the first of the additional models. The most significant change in the model's significant occurred for the variable INSTITUTE. The residual value for this model was calculated at 0.29 which is an improvement on the previously described interactions. Using REML analysis, we predicted the log (JIF) means for each institute. The results are presented in Table A.4.6A below;

Another model was constructed by using a combination of single and two-factor interactions. This model uses the F-test and ANOVA again to determine the significance of a variety of interactions. The model is shown in Figure A.8. These models, however, failed to significantly reduce the residual (v.r=0.29) and additionally returned the same level of significance, predicted means and standard error as the model show in Figure A.6.

Figure A.7 – Modelling further interactions Part 1

	CHANGE	df	s.sq	v.r	F.pr
	YEAR	1	3.55	12.01	<0.001
	AUTHORS	1	97.39	328.68	<0.001
	YEAR.AUTHORS	1	0.02	0.09	0.760
♣	INSTITUTE	4	92.19	77.78	<0.001
	ATD	1	2.77	9.36	0.002
	IMM	1	25.16	84.94	<0.001
	DNG	1	0.05	0.18	0.675
	GBI	1	0.80	2.71	0.100
	INF	1	11.21	37.86	<0.001
	MGC	1	13.94	47.05	<0.001
	CHD	1	1.36	4.59	0.032
	JPS	1	0.07	0.24	0.626
	SBD	1	0.55	1.87	0.172
	HBP	1	2.65	8.96	0.003
	MBD	/r	9.81	33.13	<0.001
	EPI	1	0.004	0.01	0.906
	OTHER	1	0.03	0.12	0.732
	GBI.INSTITUTE	3	7.56	8.51	<0.001
	INF.INSTITUTE	3	7.26	8.17	<0.001
	MBD.INSTITUTE	2	1.62	2.74	0.065
	YEAR.MGC	1	0.30	1.01	0.314
	AUTHORS.ATD	1	1.05	3.56	0.059
	AUTHORS.IMM	1	0.23	0.79	0.376
	AUTHORS.DNG	1	1.69	5.70	0.017
	AUTHORS.GBI	1	1.81	6.13	0.013
	AUTHORS.INF	1	0.05	0.18	0.674
♣	AUTHORS.MGC	1	0.54	1.83	0.176
	AUTHORS.CHD	1	1.89	6.40	0.011
	AUTHORS.JPS	1	0.0008	0.00	0.959
	AUTHORS.SBD	1	1.67	5.64	0.018
	AUTHORS.HBP	1	1.02	3.46	0.063
	AUTHORS.MBD	1	1.45	4.91	0.027
	AUTHORS.EPI	1	0.13	0.44	0.507
	AUTHORS.OTHER	1	0.26	0.89	0.345
♣	YEAR.INSTITUTE	4	1.17	0.99	0.410
	RESIDUAL	4000	1185.26		
	TOTAL	4046	1476.65		

Figure A.8 – Modelling further interactions Part 2

	CHANGE	df	s.sq	v.r	F.pr
	YEAR	1	100.66	344.59	<0.001
	AUTHORS	6	2.46	1.40	0.209
	YEAR.AUTHORS	6	2.59	1.48	0.180
	INSTITUTE	4	91.83	78.59	<0.001
	ATD	1	2.84	9.75	0.002
	IMM	1	25.38	86.89	<0.001
	DNG	1	0.05	0.18	0.676
	GBI	1	0.83	2.86	0.091
	INF	1	10.82	37.05	<0.001
	MGC	1	13.82	47.34	<0.001
	CHD	1	1.23	4.24	0.04
	JPS	1	0.07	0.27	0.604
	SBD	1	0.52	1.80	0.180
	HBP	1	2.71	9.30	0.002
	MBD	1	9.69	33.20	<0.001
	EPI	1	0.0005	0.00	0.967
	OTHER	1	0.029	0.10	0.751
	GBI.INSTITUTE	3	7.34	8.39	<0.001
	INF.INSTITUTE	3	7.16	8.17	<0.001
♣	MGC.INSTITUTE	3	12.07	13.78	<0.001
	MBD.INSTITUTE	▯ ▯	2.04	3.50	0.030
♣	YEAR.MGC	6	3.75	2.14	0.046
	AUTHORS.ATD	1	0.76	2.62	0.106
	AUTHORS.IMM	1	0.15	0.53	0.468
	AUTHORS.DNG	1	1.52	5.21	0.022
	AUTHORS.GBI	1	1.97	6.78	0.009
	AUTHORS.INF	1	0.02	0.09	0.760
♣	AUTHORS.MGC	1	0.51	1.77	0.183
	AUTHORS.CHD	1	2.15	7.37	0.007
	AUTHORS.JPS	1	0.03	0.13	0.714
	AUTHORS.SBD	1	1.49	5.10	0.024
	AUTHORS.HBP	1	0.95	3.25	0.071
	AUTHORS.MBD	1	1.31	4.51	0.034
	AUTHORS.EPI	1	0.14	0.49	0.486
	AUTHORS.OTHER	1	0.57	1.98	0.159
♣	YEAR.INSTITUTE.MGC	36	13.15	1.25	0.145
	RESIDUAL	3950	1153.87		
	TOTAL	4046	1476.65		

TABLE A.4.6A
Predicted means for the Interaction between the JIF and each Institute
For the model;

$JIF = e^{INSTITUTE}$ (0.026<s.err <0.044)

Institute	Predicted Means
GARVAN	1.735
JCSMR	1.655
POWMRI	1.511
QIMR	1.557
WEHI	1.867

The final model was calculated by adding a 3-factor analysis between the Year and institute for the MGC field. This was of particular interest due to the interview results described in Chapters 4 and 5 where scientists, BD Offices and the PR Offices all described the MGC field as highly competitive and of particular public interest. It was therefore hypothesised that the publication behaviour within that field would have been affected over time to reflect that in-field competition. Additionally, the interactions for AUTHORS.MGC, INSTITUTE.MGC, YEAR.MGC and YEAR.INSTITUTE were of interest. There variables were therefore added and tested with the model presented in Figure A.4.6C.

As can be seen from Figure A.4.6C, the null hypothesis failed to be rejected for the interactions; AUTHORS.MGC as well as for the 3-factor interaction; YEAR.INSTITUTE.MGC. However, the null hypothesis can be rejected for the interactions; INSTITUTE.MGC ($P<0.001$; $P<0.05$); and YEAR.MGC ($P=0.04$; $P<0.05$). Using REML variance component analysis, the following means for the significant interactions using the model can be predicted. The results are shown in Table A.4.6B and C below.

Table A.4.6B
Predicted means for the Interaction between the JIF for each Year for the MGC Field

For the model;

$JIF = e^{YEAR.MGC}$ (0.0319<s.err<0.1256)

YEAR	PREDICTED MEAN MIN < x < MAX (95% CI)
1999	1.783 < x < 2.251
2000	1.811 < x < 2.079
2001	1.807 < x < 1.922
2002	1.825 < x < 2.133
2003	1.864 < x < 2.127
2004	1.812 < x < 2.011
2005	1.866 < x < 2.141

Table A.4.6C
Predicted means for the Interaction between the JIF and the Institute for the MGC Field

For the model;

$JIF = e^{INSTITUTE.MGC}$ (0.0281< s.err < 0.5508)

INSTITUTE	PREDICTED MEAN MIN < x < MAX (95% CI)
GARVAN	1.919 < x < 2.159
JCSMR	1.830 < x < 1.873
POW MRI	1.709 < x < *
QIMR	1.747 < x < 1.935
WEHI	2.010< x < 2.490

A.5 Summary of the Results Presented in Appendix III

This chapter attempted to analyse the publication output of our five participating institutes in order to investigate any change in publication behaviour during the period 1999-2005. Likewise this chapter investigated whether any change in publishing behaviour could be reasonably attributed to the increased emphasis of communication and commercialisation in science and/or the establishment and presence of the internal PR and BD offices.

In order to investigate this, the journal impact factor (JIF) was used as the dependent variable (n = 5110) and was tested against a number of author behaviour variables including the field of research, institute, year and level of collaboration (as measured by the total number of authors per paper). One of the first discoveries in relation to the publishing behaviour of our scientists in our participating institutes was that despite the total number of papers changing over time, there was no significant change in the average impact factor over time. In contrast however, the average number of authors per paper was found to be increasing linearly over time with the level of collaboration being significantly higher in 2005 when compared to 1999.

For distribution reasons, the range of the JIF values was very large, the next stage of the study looked at a range of interactions with the log (JIF). It was hoped that by taking the log (JIF), that some of the more subtle interactions would emerge. To do this, a number of different models were constructed in order to investigate the level of significance of a number of interactions and their combinations. The first model showed a significant interaction between the log (JIF) and the year of publication (P=0.012), a relationship that was not observed to be significant in the above described linear models. This therefore showed that using the log (JIF) that there was a significant difference in the average JIF over time. A significant interaction was also found between the log (JIF) and institute, showing a significant difference in the average JIF between the five participating institutes (P<0.001). This result is not surprising as each institute specialises in different fields of research and, from what will be explained below, significant differences in the log(JIF) was also observed between fields. This partially explains any difference in the log (JIF) between institutes.

When different fields were analysed in relation to the institutes, only a few interactions proved significant. In particular the log (JIF) was found to have significant interactions with publications in the GBI (INSTITUTE.GBI; P=0.001), the INF (INSTITUTE.INF; P<0.001), the MGC (INSTITUTE.MGC; P=0.008) and the MBD (INSTITUTE.MBD; P=0.002) fields. The result for the MBD field was surprising however is explained by the use of MBD techniques in many applied scientific fields such as MGC and GBI that were also found to have significant interactions in with the log (JIF) in the model. In addition, despite the POWMRI being specifically tailored to neuroscience research programs, no significant interaction was observed between the log (JIF) and the institute in the Neuroscience field (INSTITUTE.DNG). Despite this, a significant interaction was observed between the logs (JIF) and the institute in the INF field (INSTITUTE.INF) which is interesting considering QIMR's specialisation in that field.

Next, the level of collaboration using the number of authors per article was analysed using the log (JIF). Firstly, a new model was constructed in order to specifically investigate these interactions. The log (JIF) was found to significantly interact with the number of authors per article (P<0.001) as well as showed a significant difference in the number of authors per article between institutes (INSTITUTE.AUTHORS; P=0.005). Next, the pattern of co-authorship was investigated within different fields with significant relationship between the log (JIF) and the number of authors per article for the CHD ($P<0.05$) field, the MBD ($P<0.05$) field and the ATD (P=<0.001) field. This result again is interesting in that both the CHD and ATD are highly competitive as well as labour intensive fields requiring more results and larger teams in order to achieve high impact publishing thereby accounting for the significant interaction with the number of authors. In addition, as was the case with the significant interactions for the institute and the fields described previously, the significant result for the MBD field can be explained by this basic field often being used by the more applied fields such as CHD, MGC and ATD. Interestingly, the same model identified a significant relationship between the log (JIF) and the number of authors between institute for papers published in the ATD field ($P=0.05$).

The distribution of the number of authors for this study was very diverse with the number of authors per article ranging from 1 to 200 authors per paper. To identify further interactions that many only occur in papers with a limited number of authors, two extra models were constructed. The first model investigated the interactions present for publication with 30 or less authors per paper and the second model investigated interaction for publication with 10 or less authors per paper.

For the first model, restricting the number of authors to 30 or less, resulted in additional significant interactions between the log (JIF) and the institute in the SBD ($P<0.005$), MGC ($P<0.001$) and DNG ($P<0.05$) fields. These results were surprising as these interactions had not previously been observed. In particular, the significant difference between the log (JIF) and the papers published at each institute in the DNG field is interesting because of the POWMRI's specialisation in the neuroscience (DNG) research. This relationship was not seen to be significant when the analysis was not limited to papers with 30 or less authors. This could be explained by the POWMRI not collaborating with scientists from other, nor-DNG fields. Different fields of scientific research result in different culture of collaboration. Other institutes may have a higher probability of collaborating with scientists from both the DNG and other fields such as CHD or MGC which bring to the paper different collaboration cultures. This would result in a higher number of authors per paper in institutes supporting a variety of fields (such as the GARVAN, WEHI, JCSMR or QIMR) thereby skewing the results. When the publication analysed is restricted to those with author numbers under 30 however, a difference between the institutes in the DNG field is observed. Additionally interactions under this model was also observed for papers in the MGC (YEAR.MGC; $P<0.001$) and CHD (YEAR.CHD; $P=0.014$) fields over time and the log (JIF).

The next model analysed restricted the publications further to those with 10 or less authors per paper. The following additional interactions that were not observed in the previous model were detected. Of interest were the significant interactions between the log (JIF) for papers in the DNG field across institutes, further demonstrating the validity of the explanation provided above when the papers were restricted to those with 30 or less authors. This is of particular interest as the level of significance for this interaction was increased ($P=0.02$) where the analysis was restricted to those papers with 10 or less authors. Additionally, this model observed a number of interactions not observed in the previous, non-restricted models. This included a significant interaction between the log (JIF) and the number of authors over time (AUTHORS.YEAR; $P=0.018$) as well as for publication in the IMM ($P<0.001$) and EPI ($P=0.036$) fields.

A final model was constructed to confirm the interactions observed above as well as to calculate the estimated means for the more significant interactions. This model recorded a residual of 0.29, which is smaller than for previous models published (Lokker, McKibbon, McKinlay, Wilczynski, & Haynes, 2008). With this smaller residual amount, the estimated means were calculated for each institute as a result. This estimated means showed the WEHI as the highest performing institute which is not surprising considering that the calculations were not controlled for field. The WEHI specialises in immunology (IMM) and Cancer (CHD. MGC) fields of research which are traditionally high impact publishing fields thereby explaining the significantly higher estimated means for the WEHI as well as explaining why POWMIR with its specialisation in the lower impact, DNG (neuroscience) fields, scored a significantly lower estimated means.

Finally, estimated means were calculated for a number of interaction in the MGC research field which is a field that is both highly competitive and of a high level of public interest. In particular, the measurements for the YEAR.MGC category shower that the range determined for the year 2005 was significantly higher than the range for 1999. This result suggested that the JIF of the journal chosen to publish in 2005 has a significantly higher JIF than the choice of journal in 1999. However, this result must be considered in relation to one possible limitation of this study that relates to the increasing size of the ISI. It is possible that this result is not reflective of the scientist's choice of journal but rather a by-product of the increase in the JIF of all journals chosen by scientists generally. With more papers and journal being indexed by ISI over time (*Thomson Reuters - Web of Science and Science Citation Index*, 2009), the JIF has been generally increasing for all indexed ISI journals. It could be that the scientist's choices of journals have not changed as this result suggests s but rather the JIF of the journals have been increasing. This is a major, recognised limitation of this study. Although this would not be a limitation in the analyses that compare our participating institutes during the same period of time. For the INSTITUTE.MGC estimated means, the values for GARVAN and the WEHI were significantly higher than the other institutes in the MGC field. POWMRI, expectedly, reported a lower result here due to the very small number of MGC papers in their total publication list 1999-2005. This low number of MGC papers also explains the lack of upper limit (maximum) reported for POWMRI. WEHI was the highest performer in the MGC category however this is not surprising considering WEHI's strong history and specialisation in this research field.

A.6 Appendix III Summary

In summary, linear models were not sufficient to observe and map relationships between the JIF and behavioural publication variables. However, when the distribution was transformed to a log model a number of interesting relationships were observed. In particular, a number of significant interactions were observed between the level of collaboration (AUTHORS), between institutes, within research fields and over time. In addition, it was necessary to examine the more subtle relationships by restricting the publications examined to those with author numbers under 30 and also to publications with 10 or less authors per paper. When models were constructed for these author limitations, a number of more subtle significant interactions were observed including a significant relationship between the log (JIF) between institutes for the DNG field. This interaction was previously not observed in the unrestricted models, suggesting that the presence of the more competitive and high impact fields within an institute may also affect the pattern of co-authorship for each publication. The results of this chapter together with the results of the two results chapters (Chapters 4 and 5) will be discussed together and at length in Chapter 6: General Discussion.