Creative Research Environments

**Environmental Factors Affecting Creativity
in Agricultural Research in Australia**

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Foreword

This report examines the nature of creativity and presents the views of agricultural scientists and their managers on factors affecting creativity in research.

These factors include how the work is conceived, funded, managed, and communicated and applied. It is thus a valuable resource for all those interested in improving research outcomes.

The report concludes by proposing several principles whose application would remove existing constraints on creativity in agricultural research without diminution of the relevance and accountability of the work.

This report, a new addition to RIRDCs diverse range of almost 400 research publications, forms part of our Human Capital, Communications & Information
Systems R&D program, which aims to enhance human capital and facilitate innovation in rural industries and communities.

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Peter Core
Managing Director
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Preface

A splendid concert pianist and singer, Jeannie Campbell, once told me that "a truly good scientist is an artist, a truly good scientist is creative". Is that true? Does it matter? What is creativity? How is creativity associated with the research environment, research management, the agency providing financial resources, and the rewards?

Creativity may be as simple as a good idea, or an idea differing from the prevailing conventions and directions. There are numerous examples of creative genius. Kary Mullins thought of the Polymerase Chain Reaction (PCR), now such a key and pervasive component in molecular biology, during a drive along a Californian mountain road one evening in 1983. Thomas Huxley's comment on Darwin's theory of evolution says it all: "How extremely stupid not to have thought of that!".

Other strokes of genius have been based on fortuitous errors, which then led to research which changed the field for ever. Examples include the discovery by Chris Polge of the cryoprotective properties of glycerol for freezing cells. A mislabelled bottle inadvertently led to the testing of glycerol for successfully freezing sperm. The bottle labelled as glycerine eventually had to be reanalysed to determine its true chemical composition. Glycerol remains as only one of five "cryoprotectants" known to date that enable cells to survive freezing. The cloning of "Dolly" the sheep was recognised recently as the scientific advance of the decade. The testing of cell lines for that purpose included an adult mammary gland cell line as a "negative control" (not supposed to work), and led to the birth of Dolly.

All these good ideas are based on creative thinking. They are derived by scientists trying to solve a problem based on interesting observations and predictions that are not ordinary or conventional. This creative process survives despite the pressures on researchers to conform to the conventional ideas of the time, ie judgements on grant applications and scientific manuscripts are predicated on the expected and conventional progress of experiments published in the accepted journals. It could be argued that the very design of grant applications prevents creativity or at least does not promote it

Creativity is also a key element of intellectual property (IP) and the capture of IP is a major consideration of commercial, corporate and public research funding agencies and companies. Given the potential for very substantial reward for the capture and utilisation of IP in information technology, medicine and biotechnology, the need to nurture and foster creativity ought to be a primary consideration for funding bodies and companies. There is a new world of IP trading and rights that can be driven more by fantasies rather than by truly creative scientific advance, by the world of "spin doctors" and "vapour traders". Their influence needs to be separated from the work of the hard-core creative scientists and artists who actually make a difference to the communities and industries with whom they work.

Individuals and groups appear to experience different influences and barriers to creativity. The individual depends on infrastructural support, including finance, space and materials. Reward involves recognition of individual creativity. In groups, skilled management is needed to ensure direction, productivity, accountability and minimisation of the disappointment, disagreement and anxiety that may occur in groups where a number of creative individuals are striving for recognition.

Given that one of the key elements for creativity is sheer enjoyment, management needs to protect key creative members of the group from concerns such as job security and any intra-group problems. Competition with other groups can be useful in aiding recognition and reward. Often the problem is to

ensure, however, that the leaders of the group retain vision, stability and dependability as they often absorb difficulties of behalf of the group.

Some recognition of the research environment by outside influences such as granting agencies would be helpful for the creative process, as would some flexibility in the institutional regulations. For example, some individuals don't work best in the conventional 9 - 5 hour span. Indeed, the formalities of "normal working hours" may inhibit creativity. As many important observations and insights occur outside conventional work hours and work places, these opportunities need to be maximised. I have heard this often as an argument for visiting the pub after work and I wouldn't dismiss the importance even of those interactions for the creative process.

Alan Trounson

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Executive Summary

> Our goal in *Creative Research Environments* is to foster
> creativity in agricultural research and development.

The OECD defines research and development (R&D) as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications. This definition of R&D is adopted widely, in Australia and elsewhere. However, the creative essence of R&D is seldom recognised. Creativity is the accepted life-blood of music, literature and the arts but it is rarely associated with science. For instance, the Industry Commission made scant mention of creativity in its 1995 wide ranging report on R&D. None of the seven broad guidelines proposed by the Commission for R&D policy design covered creativity. Similarly the need for creativity in R&D went unrecognised at a conference in Melbourne in 1996 on Global Agricultural Science Policy for the Twenty-First Century.

Creative Research Environments seeks to fill this gap by examining the nature of creativity, what drives people to be creative and which environmental factors affect creativity. Our work has relevance generally to R&D. However, our particular focus is agricultural R&D, which has a number of distinctive characteristics. For instance, agricultural R&D is conducted principally in and is funded by public sector institutions. Agricultural R&D is conducted predominantly by male scientists, many of whom have been trained in agriculture or a related domain. Agricultural R&D is also geographically dispersed. These and other institutional and cultural features suggest there may be a need to foster creativity more actively in agricultural R&D. Agricultural R&D policies and strategies throughout the 1980s and 1990s have probably accentuated that need.

In the 1980s and 1990s agricultural R&D policies and strategies reflected the paradigms held almost universally within the public sector of competition, accountability and economic growth. Public funding of R&D evolved from a grant format to become direct investments in outcomes. This evolution was associated with institutional changes aimed at increasing the relevance of agricultural R&D and the accountability of scientists, and few would question that there was a need for those changes. Agricultural scientists are now far more dependent than in the past on competitive project based funding. The greatest influence on the direction of research is provided by industry based R&D corporations. These corporations are funded by levies on industry and by taxes on the community generally. They are dominating purchasers of research and development within their legislatively defined charters. The corporations are governed by public sector accountability requirements. Against this background it is timely to examine whether our principal R&D resource, the creativity of scientists and other individuals in the community, is being adequately nurtured.

Chapter 1 provides a definitional context and a snapshot of the nature of the creative process. A systems view of creativity is adopted, where creativity is portrayed as arising from the interaction between the problem solver and his or her domain and with the college or field of those who act as gate keepers to ideas in that domain. For agricultural R&D the principal gate keepers are scientific peers, research leaders and managers, research funders and industry personnel.

Creativity contributes to the various components of innovation and is embedded in (but not restricted to) R&D. Creativity is an important component of all processes leading to innovation. While definitions of R&D place emphasis on it as a systematic process, creativity also arises across the innovation spectrum from intuition, organisational learning and serendipity. Any description of the processes of creativity also highlights the importance of imagination and analogical thinking. While

conscious systematic elements dominate the preparation, elaboration and evaluative components of the creative process, sub-conscious imagination and intuition are critical during incubation and insight (the movement from not knowing to knowing).

In Chapter 2, we present three concepts from the literature and integrate them to provide an understanding of what it is that drives people to be creative. That understanding is a prerequisite to identifying ways to foster creativity.

To be creative people need to be motivated by intrinsic factors such as the interest, enjoyment, satisfaction and challenge of the work itself. Whether someone interprets a motivating factor as being intrinsic or extrinsic, depends upon the psychological meaning of that factor for the individual rather than any objective features of the event. The second layer of the picture is to understand what drives the motivated person to be creative It is the urge to control one's consciousness. When someone is totally immersed in a challenge and in control of the information flowing to the consciousness he or she experiences a deep satisfaction and the activity at hand becomes autolytic, that is, an end in itself. This state of flow reinforces the important intrinsic nature of motivation.

The personal, domain and field factors affecting creativity are described in the second part of Chapter 2. Of particular interest to this study are factors in the work environment. With the qualification that different people (or the same person in different circumstances) may respond differently to the same environmental factor by-and-large the factors conducive to creativity are those that strengthen capability, motivation and opportunity. The environmental situation is well described by the following synthesis of responses of over 200 R&D scientists in North America to the question:

> *"The biggest obstacle in my job environment to my creativity is ....* lack of time, lack of freedom, abundance of quick negative criticism, distractions from creative thought, lack of encouragement, lack of acceptance of new ideas, ineffective meetings, overly cautious management styles, red tape, lack of appreciation of creative accomplishment, lack of suitable rewards, limited resources, overload of work, interruptions, demands of others, need to be productive rather than creative, limited communication, paper work, lack of skills".

Chapter 3 presents information gathered from scientists in Australia. Researchers and research managers voice concerns about the way agricultural research and development is funded, managed, and executed. They believe that higher risk projects are neither proposed nor funded because of their lower probability of success and the over-emphasis on gaining short term commercial outcomes. They also believe that research funding committees lack familiarity with the state of science and that both the committees and research organisations are risk adverse. Researchers are concerned that creativity is being constrained by research funders who prescribe research processes, by inappropriate accountability mechanisms, poor leadership and a virtual absence of encouragement for, or recognition of, creativity. State government researchers and managers were scathing about policies which limit international travel and participation in conferences.

Chapter 4 outlines the importance of creativity generally, to agriculture at large and to agricultural R&D. Creativity shapes our culture and the maturation and complexity of the individual. Creativity is also a major contributor to global competitiveness and hence to national prosperity. The chapter suggests that there is a need to look creatively at the issues in agriculture, to reconstruct the 'problem', to gain insights and to transform those insights into creative products and processes.

Agricultural R&D is characterised as a substantial activity, conducted almost exclusively within public sector institutional and cultural settings, dominated in direction and strategy terms by research and development corporations operating as dominating purchasers of services and generally not open to private sector R&D providers. Agricultural R&D in Australia is fragile, given its heavy dependence on public sector policies and institutional capabilities. Many of the agricultural and

agricultural R&D features described in Chapter 4 together with the views of scientists and their managers in Chapter 3, lead to the conclusion that a more creative agricultural R&D culture would be in the interests of agricultural researchers, agriculture and the nation generally.

As part of our work on *Creative Research Environments* we convened a workshop involving participants from industry and the scientific and creative arts fields. Edited transcripts of relevant workshop discussions are included at the end of each of the first four chapters. Chapter 5 is comprised of abstracts of five invited papers on creativity, while Chapter 6 provides edited transcripts of the plenary discussions.

The papers from Elke Neidermüller-Hughes and Zara and Troy Swindells-Grose remind us how important it is that individuals take control of their own creativity. Merilyn Sleigh draws on her extensive experience to highlight the similarities and differences of managing and conducting research in the public and private sectors. Graeme Russell critiques the impact of education on creativity. In the final paper Wendy Craik identifies how industry and others could foster creativity in agricultural research and development.

The need for researchers and representatives of the field to foster creativity in agricultural research and development in interactive and co-ordinated ways is a constant and important theme in the discussions reported in Chapter 6. Equally important are the differences in the views provided by people from different backgrounds highlighting the potential for new and better mechanisms for managing research to arise from a broader mix of people than has been involved in the past.

The concluding chapter proposes a structural and conceptual framework within which to foster creativity in R&D. The structural component of the framework highlights a systems approach to creativity, leading to the important implication that the potential for improved creativity in R&D lies not only with scientists but also with R&D leaders, managers and funders from both industry and the research organisations. It also points to the importance of creativity, both in R&D and elsewhere, throughout all the innovation processes, leading to the judgement that creativity should be fostered throughout the basic to applied spectrum of R&D. Conceptually the framework comprises the three elements briefly described previously and discussed in Chapter 2.

Five principles for promoting creativity in agricultural R&D are proposed in the final chapter of *Creative Research Environments*. They are simple principles, indeed stunningly so, given the complexity of the creative process and of the institutional cultures within which agricultural R&D operates.

The five principles are:

GOALS Creativity is fostered by setting both creativity and productivity goals but not by prescribing R&D processes to attain them.

BOUNDED FREEDOM Creativity is affected by the psychic balance experienced by the researcher or field participant between what she/he seeks to achieve and what the organisation or group desires her/him to achieve.

RECOGNITION Creativity is enhanced by reward and recognition, as long as it is experienced as an appreciative and/or informational event and not as a means to control or manipulate.

SOCIAL INTERACTION Appropriate peer and social interaction is an essential prerequisite to creativity.

LEADERSHIP The development and communication of insightful organisational visions and leadership help foster creativity.

1 HOW CREATIVITY HAPPENS

In this first chapter we explore how creativity happens. This can only be the beginning of the journey for many aspects of creativity are complex and somewhat indeterminate.

Although our understanding of how creativity happens is discussed only briefly, we do not wish to leave the impression that the picture is simple. In fact, throughout this work we need to remind ourselves that one of the defining characteristics of creative people is a high tolerance for ambiguity combined with an urge to transform chaos into organisation. In our attempts to turn chaos into organisation, we should recognise, and in fact celebrate, the complexity of creativity, while ensuring that our understandings lead to improvement in people's capacity to express their creativity.

DEFINING CREATIVITY

In a review of the definitions of creativity Repucci (1988) identifies at least fifty definitions of creativity which he classified into six groups, each described in terms of the outcomes and processes of creativity. For instance in his outcome group he includes Harmon's definition of creativity **as any process by which something new is produced** and he includes in the process group Ghiselin's definition of creativity **as the process of change, of development, of evolution in the organisation of subjective life.** It is sobering to note however that after three decades of studying creativity, Torrance (1988) began a paper on the nature of creativity with the statement that creativity defies precise definition.

Defining processes as creative on the basis of the product they produce has considerable functional utility but neither explains the processes nor the situations wherein the processes operate but fail to generate a creative product. In any event what is a creative product? What is deemed not to be creative today may at some future point be judged otherwise, what one person judges to be creative, another may not. In other words a person may perform creative processes without there being a contemporaneous recognition of a resultant creative product.

According to Amabile (1982) a product or response is creative to the extent that appropriate observers independently agree that it is. "Appropriate observers" are those familiar with the domain in which the product was created or the response articulated. Thus, creativity can be regarded as the quality of a product or response judged to be creative by appropriate observers, and it can also be regarded as the process by which something thus judged is produced.

From a study of creativity seen through the lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham and Gandhi, Gardner (1993) summarises the situation as follows:

> One begins with a set of individuals of varying abilities, talents, and proclivities, each engaged in work in a particular domain. At any historical moment, that domain features its own rules, structures, and practices, within which the individuals are socialised and according to which they are expected to operate. Such individuals address their work to the field, which in turn examines the various products that come to its attention. Of the many individuals and works that undergo scrutiny by the field, only a few are deemed worthy of sustained attention and evaluation. And of those works that are appreciated at a given historical moment, only a subset are ever deemed to be creative - highly novel, yet appropriate for the domain. The works (and the workers) so judged come to occupy the most important spot in the dialect: they actually cause a refashioning of the domain. The next generation of students, or talents, now work in a domain that is different, courtesy of the achievements of highly creative individuals. And in this manner the dialect of creativity continues. Creativity lies not in the head (or hand) of the artist or in the domain of

practices or in the set of judges: rather, the phenomenon of creativity can only - or, at any rate, more fully - be understood as a function of interactions among these three nodes.

This systems approach to understanding creativity is encapsulated in Csikszentmihalyi's definition of creativity as **any act, idea or product that changes an existing set of symbols rules and procedures (a domain) or which transforms an existing domain into a new one** (Csikszentmihalyi 1996). In this systems view, creativity results from the interaction of domains of knowledge and action, fields of persons who decide whether a new idea, product or process should be included in the domain and persons whose thoughts or actions change a domain or establish a new domain. These various definitional elements are embedded also in the understanding of creativity as **the capacity to produce new or original ideas, insights, restructurings, inventions, or artistic objects which are accepted by appropriate people as being of scientific, aesthetic, social, or technological value** (after Vernon 1989).

Clearly, in our exploration of ways to enhance creativity we need to address the characteristics not only of creative people but also of the domains and fields which are able to recognise and diffuse new ideas arising from people acting creatively.

INNOVATION, CREATIVITY AND RESEARCH AND DEVELOPMENT

Definitions of creativity need to be related to both those of innovation and research and development.

Rickards (1985) defines innovation as the process through which new and valuable ideas are put into practice leading to systems-wide adjustments. A similar approach is adopted by Sheehan, Pappas, Tikhomirova and Sinclair (1995) in their description of innovation as the process by which firms or other economic units assemble, from a wide variety of internal and external sources the know-how necessary to enhance their competitive position. Both these approaches embrace organisational and managerial improvements as well as the introduction of new products and devices. They differ however in that Sheehan et al restrict innovation to having an economic purpose, whereas Rickards is less restrictive.

Rickards (1991) proposes that the distinction between creativity and innovation might be best conceptualised by considering innovation as a multi-faceted social phenomenon, whereas creativity might be considered as a personal phenomenon. This view could presumably not be reconciled easily with Csikszentmihalyi's tripartite systems view of creativity which in fact requires the creative product to have an impact on the respective domain; that is, it is analogous to innovation.

Definitions of research and development are generally based on those adopted by the OECD (see OECD 1994) where research and development is defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including the knowledge of man, culture and society, and the use of that stock of knowledge to devise new applications.

OECD countries divide research and development into the following categories:

Pure basic research: experimental or theoretical work undertaken to acquire new knowledge without looking for long term benefits other than the advancement of knowledge.

Strategic basic research: experimental or theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries.

Applied research: original investigation undertaken in order to acquire new knowledge, directed primarily towards a specific practical aim or objective.

Experimental development: systematic work, drawing on existing knowledge gained from research and/or practical experience, directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

The emphasis in these definitions on experimental and systematic work is characteristic also of agricultural research and development. The predominance of the scientific paradigm in agricultural research and development further emphases experimentation. As a consequence a misperception has developed that creativity in research and development arises only from experimental and systematic work. On the contrary, as discussed later in this chapter, insightfulness may rely heavily on intuition and imagination. A related, and equally mistaken, belief holds that all innovation has its genesis in systematic investigation. However innovation occurs throughout organisations and is not restricted to research and development. Innovation may have its genesis also in organisational learning, intuition and serendipity.

To reiterate the key points:

- creativity is the generation of new and useful ideas, processes, products and devices, accepted by the field as being relevant to an existing domain or which lead to the development of a new domain
- the expression of creativity is dependent upon the characteristics of creative people and of the relevant domain and field
- creativity occurs throughout the interactive and iterative processes of innovation, including the conception, development and application of technological, organisational and managerial improvements which may or may not have an economic purpose, and
- research and development contributes to innovation but not exclusively so with much innovation arising from experience, organisational learning, accident and intuition.

THE CREATIVE PROCESS

It is generally but not universally recognised that particular cognitive or knowing processes, called creative processes, lead to the generation of creative ideas or products. These processes have been described by Csikszentmihalyi (1996) as follows:

- preparation: becoming immersed in a set of problematic issues that are interesting and arouse curiosity.
- incubation: enabling ideas to churn around below the threshold of consciousness.
- insight: moving consciously from not knowing to knowing.
- evaluation: deciding whether the insight is valuable and worth pursuing.
- elaboration: expanding and justifying the creative idea, product or process.

These stages may overlap in function or in time. They may proceed from varying starting points and their relative contributions to the creative process may vary among problem solvers and among environments.

Preparation

We begin with some comments on preparation and incubation but then concentrate chiefly on insight for the remainder of the chapter.

During the preparation phase the problem to be solved emerges from either personal experience, the requirement of the domain and/or the field of influence of teachers, peers, persons in industry and the community generally. In many instances the form of the problem reflects the influence of each of these sources.

Whatever may be the factors leading to an identification of the problem, creativity is unlikely to be demonstrated unless the problem solver experiences a phase of internalisation or immersion in the problem.

Really important breakthroughs in science appear to come from reformulating old problems or discovering new ones rather than by just solving existing or presented problems. Csikszentmihalyi (1996) recounts how Darwin was commissioned to travel on the *Beagle* around the coast of South America to describe the plant and animal life he encountered. This he did but his puzzlement with the differences between species led to the concepts of differential adaptation and natural selection and, eventually to the concept of the evolution of species.

One of the most fundamental questions we must address is the extent to which we foster the development of the psychic energy in the problem solver for presented problems. We need to ask whether or not our emphasis on prescribing goals, outcomes and methodological steps leads to a premature and possibly false construction of the problem, a failure in the problem solver to identify with the problem, and an inappropriate use of non-insightful procedures.

Incubation

It is important to let problems simmer for a time below the threshold of consciousness. Many will identify with the following comments from creative scientists as quoted by Csikszentmihalyi (1996):

> *I am fooling around not doing anything, which probably means that this is a creative period, although of course you don't know until afterward. I think it is important to be idle - people who keep themselves busy all the time are generally not creative. So I am not ashamed of being idle.*

> And, *I will tell you one thing that I found in both science and technology. If you have a problem, don't sit down and try to solve it. Because I will never solve it if I am just sitting down and thinking about it. It will hit me maybe in the middle of the night, while I am driving my car or taking a shower, or something like that.*

Both cognitive and psychoanalytic accounts of what happens during incubation assume that some form of information processing keeps going on in the mind even when we are not aware of it. Cognitive theories, unlike the psychoanalytic, do not attribute any direction to this subconscious thought. However even though sub-conscious thinking may not follow rational lines it nevertheless follows patterns established during conscious learning. The knowledge of the domain and the concerns of the field have been internalised and become part of the way our minds are organised.

Insight

New ways to foster creativity in research may arise when we understand insight, for this is the kernel of creativity.

The components of the insight experience are open to much debate. However the reality probably is that the presence and relative importance of the various facets of insight vary between problem types, people and environments. Different problems elicit or constrain varying insight processes, and problem solvers may use different processes to solve the same problem. Generally however insight involves a cognitive restructuring leading to a representation of the problem.

Schooler, Fallshore and Fiore (1996) after reviewing various presentations of insight, defined insight as being the sudden transition from a non-solution state to a solution state. In other words insight is the process whereby one moves from not knowing to knowing.

Schooler and his colleagues list the causes of blocks to achievement of insight as being:

- over-emphasis of irrelevant clues: in other words the more the problem solver spins his or her cognitive wheels, the deeper the rut in which he or she finds him or herself in.
- under-emphasis of relevant clues: a failure to see the clue occurs through not recognising the relationships between the problem and the information acquired in the past or by not mentally searching the right place, for instance, when not understanding the domain.

Such impasses may be overcome by improving solving recognition or by searching for a new problem. Improving faulty recognition can come about by de-emphasising the inappropriate problem elements, by (for instance), delaying in order to forget, or by changing the physical or psychological context, for example by routine activities such as showering or walking. These strategies assist in removing mental obstacles to insight. Improving recognition may also be achieved by accessing more appropriate problem elements by, for instance, encountering new information, by allowing cues to surface from the unconscious or by a combination of both whereby the environment may set in action unconscious retrieval processes that ultimately bring to the consciousness a cue that can prompt recognition of the solution. These concepts explain why insights occur frequently when the creator gives up on a particular problem and turns to other activities.

Simonton (1996) maintains that information processing below the threshold of awareness is far from sophisticated and that, in all likelihood, the unconscious mind is simply the repository of some rather primitive associations that can form linkages that the conscious mind would deem preposterous. Once these intuitive insights emerge the conscious mind then gets involved in verification and elaboration. However the line between consciousness and unconsciousness is not hard and fast. Simonton quotes the Nobel laureate Max Planck attributing to great scientists " a vivid intuitive imagination, for new ideas are not generated by deduction but by a creative imagination".

In contrast to this "thinking by association" approach, Mayer (1996) lists five interrelated views holding insight to be:

- completing a coherent structure linking the problem and the goal (the schema view)
- looking at the problem in a new way by reorganising the visual information, the decisive step, according to Kohler (1969) being a restructuring of the given material
- mentally redefining and clarifying the problem, such as reformulating the givens or the goal
- removing mental blocks, for instance by removing functional fixedness, or
- focusing on the structural relations, rather than the surface features, of one problem and then applying them to another.

The overlapping thread in many of these non-association views is that problem and/or goal representation through one or more forms is a central feature of insight. In fact, Dominowski and Dallob (1996) characterise insight as a form of understanding of a problem and its solution that can result from restructuring, i.e. a change in a person's perception of a problem situation. This generalisation has significant implications for the management of R&D, for it highlights the importance of the scientist being able to reformulate the problem and hence to have undergone a process of immersion and possibly a period of incubation. It also lends support to the suggestion by Finke (1996) that techniques for generating preinventive forms (see next paragraph) and for exploring their creative possibilities might facilitate creative thinking in scientific training, a component he observes as being seldom emphasised.. However it should be noted that the representation process generally only applies to situations in which the problem solver does not know what to do to achieve the goal, viz to insight problems, and then not universally so.

Searching Mind-spaces

The first step in searching for a new problem representation is the recognition that one is lost, for example, when one accepts an unexpected finding as valid and rejects existing theory. Finke, Ward and Smith (1992) propose a two stage model of divergent insight involving the generation of preinventive structures or mental representations and the exploration and interpretation of these representations. Reflecting these generation and exploratory phases they termed their model the Geneplore Model.

The generative processes include a retrieval, re-association and synthesis of existing forms, an analogical transfer where there is a transfer of relationships between contexts and a categorical reduction where a familiar structure is mentally reduced to more primitive forms. The resultant preinventive structures can take the form of visual patterns, object forms, mental blends, category exemplars or mental models. Such structures promote creative insight and discovery, particularly if the following are true: they are novel, ambiguous leading to a variety of possible interpretations, possess a sense of meaningfulness or deeper significance, possess emergent features, possess incongruities or are divergent in that they may have different uses within a variety of contexts.

The exploratory processes include attribute finding, conceptual interpretation, functional inference, contextual shifting, hypothesis testing and searching for limitations. Attribute finding refers to the systematic search for emergent features, for example the search for unusual or unexpected features in a preinventive association of ideas. Conceptual interpretation refers to the finding of a theoretical interpretation of a preinventive structure or more generally to the application of one's knowledge to the task of creative exploration. Functional inference refers to the process of exploring the potential uses of a preinventive structure and hence is important in evaluating and testing mental models. Contextual shifting is considering a preinventive structure in a new or different context. Preinventive structures can also be explored for their possible value in testing hypotheses or solving problems and they can be searched for limitations to provide insights into which ideas or approaches will not work.

Perkins (1996) provides an interesting perspective on human insight in comparing it with the phenomenon of biological evolution, each involves a long search, a precipitating event and a rapid culmination of events. He maintains that these generative breakthrough events or episodes of sudden innovation may occur in any creative system, including that of biological evolution.

Perkins visualises a creative system as a process of search through a space of possibilities or a "possibility space". There are two extreme kinds of topography possessed by possibility spaces. The first is a Homing Space of a clue rich character enabling relatively easy resolution of the problem through convergent thinking by people expert enough to know the signs. The second is a Klondike Space, of vast relatively clueless regions in the midst of which occur small pockets rich with clues where rapid progress can be made. Typical earmarks of insights or more generally, generative breakthrough events such as suddenness are consequences of Klondike topography and may have little to do with intelligence.

Perkins describes insights and evolution as being generative breakthrough events each having common features - except that evolution, as it is traditionally understood, does not possess the feature of improved understanding. However human processes of search are often well adapted to the topographies of Klondike spaces and these processes are described as being insightful in that they are well adapted to cope with search in a Klondike space, with insight being the consequence of insightful searching of Klondike spaces. More insightful systems make more discoveries. In contrast, evolution as classically conceived by Darwin would appear to lack this insightfulness. It is a brute-force process. However, some modern concepts of evolution suggest that evolution may be smarter than Darwin imagined and that genes in their passages from generation to generation may function in an insightful way (*see* Wesson 1991).

Common features of these insightful events according to Perkins are that they follow a period of preparation or search, disclose something which was previously hidden, begin with a precipitating event, and are achieved rapidly. Perkins believes there is little evidence to support the concept of incubation, the period of inactivity between preparation and insight during which progress is somehow made nevertheless. He thus dismisses the possibility of reasoning proceeding subconsciously during periods of incubation. However the frequently cited situation where insights occur during times of distracted relaxation raises doubts about whether the role of the subconscious should be so summarily dismissed.

One feature of the search through a possibility space is that the goals may shift as the search proceeds and the aim of the search process becomes that of finding a state of the search space that satisfies the current state of the evolving goal. Getzels and Csikszentmihalyi (1976) found sudden shifts in goals to be a hallmark of what they term problem finding, a trait related to creative productivity. Similarly the possibility space may change during the actual course of the search either from the recognition of pre-existing knowledge or the discovery of new knowledge. This evolution of the possibility space might be what underpins the evolution of research goals and the related practice of "skunking", that is progression along research pathways outside the boundaries of established programs.

Schooler, Fallshore and Fiore (1996) list the attributes they associate with the ability to find alternative approaches to problem solving:

- perseverance - trying out many approaches
- risk taking - the balance of low and high risk projects
- playfulness - analogical and combinatory play
- broad knowledge - enabling connections; and
- the ability to recognise analogies - they represent one of the central sources of insight.

The constraint for insightful problem solving is to see where to go whereas the constraint for non-insightful problem solving is to move successfully to a readily perceived or prescribed destination. These problems require differing skills, logical argument being predictive of non-insightful problem solving but not of insightful problem solving. Non-insightful problem solving places demands on the solver's ability to maintain an inner representation of the problem and the goal. However an excessive or inflexible premature prescription of a problem may limit problem representation and therefore the power of insight. Verbalisation can also cause an over-emphasis on reportable processes, rather than the non-reportable processes frequently associated with insightful problem solving.

Studies of simulated scientific research (in vitro) and actual scientific research (in vivo) have been conducted by Dunbar and his colleagues at McGill University, Montreal and are summarised by Dunbar (1996). These studies demonstrate that the generation of alternative hypotheses to explain inconsistent evidence required the setting of new goals, but that such a conceptual reconstruction rarely occurred without social interaction with other scientists. Analogical reasoning, the process of reasoning from parallel cases, was an important source of knowledge and conceptual change and might arise from the same (local) domain from a similar (regional) domain, or from a different (long-distance) domain. Furthermore, the social structure of the research team was found to be crucial as to whether analogical reasoning was used. Social interactions and cognitive representations interact to produce conceptual change when surprising findings occur, when the researcher believes these findings are not due to error and when the researcher's interpretation of the findings is challenged by others. Dunbar concludes that members of a research group should have different but overlapping research backgrounds and that analogical reasoning should be encouraged in part by providing opportunities for researchers to interact and discuss their work.

SUMMARY

What principal lessons can we draw from our understanding of creativity?

First, creative products are both novel and useful and their generation involves creative people, domains and fields.

Second, creative people need to draw on both conscious and sub-conscious processes involving both intuitive and logical thinking.

Third, creative people need adequate time to explore possibility spaces and, in circumstances requiring insightful processes, there is likely to be a need for a re-representation of the problem.

Edited Transcript: 'How Creativity Happens'[1]

Craik: With the push for greater accountability over the past ten years or so, is there now more or less creativity in research?

Gleeson: It is an important question but we have no hard data to help us answer it. Productivity in terms of, for instance, projects completed may have risen but certainly researchers believe their potential to be creative has diminished; and possibly in the future we will need more creativity irrespective of what the recent trend has been.

Trounson: If the environment affects creativity and the focus is moving on to accountability, then creativity might be being constrained.

McDonald: Many scientists have a pre-disposition to be non-compliant and are hell-bent upon not being constrained by the environment. The symptom is a hatred of the manager.

Trounson: So the environment doesn't affect creativity?

McDonald: I think it is very, very important to establish the right environment but don't underestimate the capacity of dedicated scientists to ignore the accountability requirements.

Kerin: How appropriate is the analogy between the conditions for creativity for artists and scientists?

Gleeson: The literature and our limited information from discussions with artists lead me to suggest that artists and scientists have much the same requirements and concerns. Perhaps the most striking differences are in relation to education and funding. During formal education the creativity of artists seems to be more challenged and hence possibly more developed than it is for scientists. The other difference is that artists are often funded for the creative work they have produced whereas scientists tend to receive funding for work in progress. The importance of this difference will depend very much on the psychological impact of the funding arrangement, hence it is likely to vary greatly between individuals.

Hamblin: Some people feel so constrained that they reject the mainstream institutional arrangements and establish their own circumstances in which they are able to be creative. They redefine the external environment.

Trounson: Those situations are unlikely to be sustainable unless they are able to obtain resources.

Hamblin: Possibly, but not all creative people follow the flow of resources.

Woods: The degree to which people are driven by the 'job' of being an artist or scientist as distinct from it being a personal obsession is likely to be an important factor.

Pini: Is there anything particular about the Australian psyche that differentiates Australians in relation to creativity?

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[1] *Presenter - Tony Gleeson : Chairperson - Alan Trounson*

Gleeson: I am not aware of any information on that issue. More generally the similarities between cultures seem to greatly outweigh any differences. However there is information suggesting that rural children in the United States are less creative than those brought up in urban environments.

Fawns, Mac: So far we have been speaking of creativity in relation to problems but is creativity really dependent on recognition of problems? I'm sure it also has an element of spontaneity.

Trounson: Perhaps that is the only way to survive?

Gleeson: That is an important issue and I'm unsure about how to answer it. However one of the characteristics of creative people is their ability to identify good problems and at least for problems requiring insightful solutions, the reconstruction of the problem is crucial to its solution.

Drinan: In your presentation you seem to be making a distinction between the creativity that leads to incremental change and that which leads to quantum leaps. Is that a correct interpretation?

Gleeson: I've not got a definite view on whether there is such a distinction. I'd prefer to think about it not in incremental change and quantum leap terms, but rather in relation to whether or not it is an insightful problem, that is a problem for which the problem solver doesn't know how to move to a solution. And whether the output is an incremental one or a quantum leap is a secondary issue (in relation to the nature of creativity).

Trounson: Can you characterise creative people? The popular impression is that they can be difficult.

Gleeson: We will touch on that tomorrow but it is not a principal focus of this project. I've basically accepted the tenet that the vast majority of people who are in positions to do certain things have the intelligence and personal creativity more than sufficient to do the job, so long as the environment is conducive to them so performing. On the specific of your question, the short answer is 'yes'. Creative people are complex and yes, they can be difficult, but not necessarily so!

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2 ENVIRONMENTAL FACTORS AFFECTING CREATIVITY

This chapter is concerned principally with developing an understanding of what drives people to be creative and the conditions conducive to creativity.

The following findings of an analysis by Csikszentmihalyi and his colleagues of the narrative accounts of creative individuals provide a link between these questions and our previous discussion of insight:

- insight is part of an extended mental process preceded by periods of conscious preparation and subconscious incubation and followed by periods of conscious evaluation and elaboration. The length of this process is usually much greater for problem-finding, compared to problem solving,
- problem-finding insights are characterised by the synthesis of information derived from more than one symbolic domain,
- the processes that come before and after insight are heavily dependent on social interaction, in the form of face-to-face encounters,
- to achieve a problem-finding synthesis, the following prerequisites must be met:
  (1) thorough knowledge of one or more symbolic domains;
  (2) thorough immersion in an endeavour that practises the domain;
  (3) focus of attention on a problematic area of the domain;
  (4) ability to internalise information relevant to the problematic area;
  (5) ability to let the relevant information interact with information from other domains at a subconscious level, where parallel processing takes place;
  (6) ability to recognise a new configuration emerging from this interaction that will help resolve the problematic situation; and
  (7) evaluation and elaboration of the insight in ways that are understandable and valuable to the field.

DRIVERS OF CREATIVITY

One of the tenets underpinning this work is that we need to understand what drives people to be creative. Three concepts in the literature, if considered together, go some way to achieving this goal.

First, the concept of intrinsic motivation as described for instance by Teresa M. Amabile.

> *People will be most creative when they feel motivated primarily by the interest, enjoyment, satisfaction and challenge of the work itself - not by external pressures.*

The second and linking concept is Deci and Ryan's cognitive evaluation theory:
> *The impact of an event is determined not by the objective characteristics of the event but by its psychological meaning for the individual.*

The third is the concept of flow as described by Csikszentmihalyi:
> *Flow is an optimal state of inner experience achieved when consciousness is harmoniously ordered.*

These concepts point to the importance of the motivational state of the creative person and they provide a framework within which to consider how creativity might be enhanced.

Hennessy and Amabile (1988), in a review of the literature on the effects of external stimuli on motivation and creativity, observe that as early as 1954 Carl Rogers talked about the "conditions for creativity" and the importance of setting up situations of psychological safety and freedom, providing an environment in which external evaluation is absent. Hennessy and Amabile support the suggestion made by Lepper and Greene (1975) that the intrinsically motivated person feels freer to take risks because those risks carry virtually no liability save any which is self-imposed. They conclude that motivation, broadly assessed quality of performance and creativity are reduced by surveillance, understanding the task to be a means to an end rather than an end in itself, deadlines and prior, actual and expected evaluation.

The importance and the delicate state of the motivational orientation of creative people is well illustrated by a study reported by Amabile (1985) in which creative writers were asked to write a poem after having completed one of two questionnaires about their reasons for writing, the questionnaires comprising questions all either intrinsically or extrinsically oriented. The control group was asked to write a poem without completing a questionnaire.

The writers in the control group and the intrinsic questionnaire group wrote poems judged fairly high on creativity whereas those in the extrinsic questionnaire group wrote poems judged to be much lower in creativity than the poems produced by either of the other groups. As stated by Amabile people who had been writing creatively for years and who had long-standing interests in creative writing suddenly found their creativity blocked after spending barely five minutes thinking about the extrinsic reasons for doing what they do.

As dramatic and universal as the adverse effects of extrinsic stimuli on creativity seem to be, the picture is not always a simple one. For instance, other studies by Amabile and her colleagues indicate that children at least can be trained to treat reward not as an element that detracts from intrinsic interest but as something that can add to overall motivation. Such complexities can be explained by the cognitive evaluation theory of Deci and Ryan (1985). Deci and Ryan maintain that the impact of an event on motivational processes is determined not by the objective characteristics of the event but rather by its psychological meaning for the individual.

Deci and Ryan categorise external events as being informational, controlling or amotivating. Informational events such as the provision of choice and positive feedback provide relevant information without any pressure to attain a particular outcome and they may increase or decrease intrinsic motivation. Controlling events such as rewards, deadlines and surveillance are perceived to be seeking a particular outcome or a specific behaviour, and intrinsic motivation is undermined. Amotivating events such as negative feedback, lower one's assessment of being able to master certain situations, for instance through lowering self esteem, and again intrinsic motivation is undermined.

How an event will be perceived is a function of the nature of the event and of one's own sensitivities and past experiences. People who do not perceive themselves to be in a controlling situation, for instance most researchers seeking funding, will be more inclined to interpret events as controlling than will those less dependent on such funding. Certainly, in our examination of the conditions likely to be conducive to research creativity it will be useful to reflect on Hennessy and Amabile's general conclusion that fluctuations in an individual's level of creative output must be examined in the light of environmental influences on motivation and environmental effects must be examined in the light of an individual's perceptions of these influences.

We can understand, that to be creative, people need to be motivated and that the influence of certain factors on motivation may differ between individuals, depending on their psychological response to those factors. However, to understand what drives the motivated person to be creative, we need to

look for a more innate urge. This is the urge, to use Csikszentmihalyi's terminology, to experience the state of flow.

Individuals experience flow when they are in control of their own consciousness, or at least when they understand that such control is possible. They are totally immersed in a challenge. They control the information flowing into their consciousness. The opposite state to flow is inner chaos, leading to existential dread, or the fear of there being no meaning to life.

Creative people interviewed by Csikszentmihalyi listed nine main elements to describe the flow experience. They describe clear goals every step of the way and immediate feedback to their actions. The challenges and skills required to meet the challenges are well balanced and concentration is fully focused on the activity so that action and awareness are merged. There is no worry about failure and self-consciousness disappears. In flow the sense of time becomes distorted so that the sense of how much time passes depends on what is being done. Under these circumstances the activity becomes autolytic, an end in itself.

It is not surprising that all the creative people interviewed by Csikszentmihalyi, whether engineers, chemists, writers, musicians, business people, social reformers, historians, architects, sociologists or physicians, agreed that they do what they do primarily because it is fun.

If one clear message emerges from our understanding of creativity it is that if creative people do not enjoy their work, they will not be creative.

CONDITIONS FOR CREATIVITY

Our presentation of the conditions for creativity is within the overall framework of the creative person-domain-field interactive systems view of creativity as described by Csikszentmihalyi (1996), and outlined in Chapter 1. Most of the observations on creative people are drawn from the writings of Tardif and Sternberg (1988) and Amabile, Coni, Coon, Lazenby and Herron (1996).

Creative People

Creative people are those who experience the world in novel and original ways, whose perceptions are fresh, whose judgements are insightful and who may make important discoveries that only they know about (Csikszentmihalyi 1996).

The characteristics of those people generally fall into three categories: cognitive characteristics, personality and motivational qualities, and special events or developmental experiences (Tardif and Sternberg 1988). The cognitive characteristics can be categorised as traits, abilities and processing styles but neither the personality or the developmental characteristics are so easily categorised.

Table 2.1:   Cognitive Characteristics of Creative People

Traits	Abilities	Processing Styles
• relatively high intelligence • originality • articulateness • good imagination • able to recognise 'good' problems in their field and apply themselves to these problems while ignoring others.	• capacity to think metaphorically • flexibility and skill in making decisions • independence of judgement • ability to cope well with novelty • logical thinking skills • internal visualisation • ability to escape entrenchment • ability to find order in chaos.	• using wide categories and images of wide scope • preference for non-verbal communication • preference for building new structures • questioning norms • being alert to gaps and novelty • use existing knowledge as a base for new ideas.

Table 2.2: Personality and Motivational Characteristics of Creative People

• a willingness to confront hostility and take intellectual risks • perseverance • a proclivity to curiosity and inquisitiveness • an openness to new experiences and growth • a driving absorption • discipline and commitment to one's work • high intrinsic motivation • task-focus	• a certain freedom of spirit that rejects limits imposed by others • a high degree of self-organisation setting one's own rules rather than those set by others • a need for competence in meeting optimal challenges • often withdrawn, reflective, and internally preoccupied, yet having an impact on the people who surround them • a tolerance for ambiguity • a broad range of interests	• a tendency to play with ideas • a valuing of originality and creativity • an unconventionality in behaviour • experiencing deep emotions • intuitiveness • seeking interesting situations • opportunism • exhibiting tension between self-criticism and self-confidence • exhibiting tension between socially withdrawing and socially integrating tendencies.

Table 2.3:   Developmental Characteristics of Creative People

• being a first born • having survived the loss of one or both parents early in life • experiencing unusual situations • being reared in a diversified, enriching, and stimulating environment • being exposed to a wide range of ideas	• liking school and doing well • developing and maintaining excellent work habits • learning outside the class room • having many hobbies • being an omnivorous reader • forming distinct and closely knit peer groups yet perhaps also exhibiting marginality	• having a future career image and definite role models, and mentors • exerting sustained effort and hence enjoying an enduring reputation • having contributions that demonstrate precocity and longevity • publishing early and getting good jobs at the initial stages • demonstrating voluminous productivity

Tardif and Sternberg typify the creative person as being one in conflict, a theme followed by Csikszentmihalyi who characterises creative people by their complexity or ability to move from one extreme to the other as the occasion requires. For example, creative individuals:

- have a great deal of energy but they are also often quiet and at rest
- are smart yet naive
- are playful yet disciplined
- highly imaginative yet have a strong sense of reality
- oscillate between extroversion and introversion
- are humble yet proud
- possess psychological androgyny, being able to be aggressive and nurturant, sensitive and rigid, dominant and submissive
- are both conservative and rebellious
- are passionate and objective, and
- have been exposed to suffering but also enjoyment.

Creative people are unlikely to be creative unless they:

- are lucky to be in the right place at the right time, as not all circumstances are equally stimulating
- have access to domain(s), field(s) and data base(s), and
- are oriented to do that for which they are well suited and to do so early in life.

The following classification of factors in the work environment which affect creativity is drawn from Amabile et al, (1996):

Organisational Encouragement:
- encouragement of risk taking and of idea generation, a valuing of innovation from the highest to the lowest levels of management.
- fair, supportive evaluation of new ideas
- reward for and recognition of creativity
- collaborative idea flow across the organisation and participative management and decision making.

Supervisory Encouragement:
- goal clarity

- open interactions between supervisor and subordinates
- supervisory support of a team's work and ideas
- lack of rigid formal management structures, conservatism and internal strife.

Work Group Encouragement:
- diversity in team members' backgrounds
- mutual openness to ideas.
- constructive challenging of ideas.
- shared commitment to projects.

Autonomy:
- relatively high autonomy in the day-to-day conduct of the work.
- sense of ownership and control over their own work and their own ideas.
- perceived choice in how to go about accomplishing tasks.

Resources/Pressures
- resource allocation (within limits) to a project is directly related to the project's creativity levels. Apart from the obvious practical limitations that extreme resource restrictions place on what people can accomplish in their work, perceptions of the adequacy of resources may affect people psychologically by influencing their beliefs about the intrinsic value of the projects they have undertaken.
- some degree of time and resource pressure can have a positive influence if it is perceived as arising from the urgent, intellectually challenging nature of the problem itself.

Ryhammar and Brolin (1991) state that there is little empirical research on the conditions conducive to creativity in research environments. However there is some collaborative support (Amabile 1983, Gran 1981) for the findings of Pelz and Andrews (1976) that the most important social-psychological factors are:

- a high level of worker responsibility for initiating new activities
- a low level of interference from administrative superiors
- a high stability of employment, and (interestingly)
- a large degree of power to hire research assistants.

Shalley (1991) examines the effects of productivity goals, creativity goals and personal discretion over the processes adopted to solve problems of a sample of 270 undergraduates enrolled in a business administration course. The principal findings were that:

- subjects given a creativity goal exhibited higher levels of creativity irrespective of the type of productivity goal or the level of personal discretion over the work process
- assignment of only one goal detrimentally affected achievement of the other goal, and
- assignment of a productivity goal or low discretion adversely affected creativity when no creativity goal was assigned.

In 1986, Glassman from the University of North Carolina reported on responses of over 200 R&D scientists to each of three questions:

When I am creating I feel ... excited, fulfilled, joyful, good, enthusiastic, insightful, stimulated, enjoyable, intense, fun, happy, delighted, good, satisfied, useful, energetic, alert, challenged, worthwhile, and energised. Less than 5 percent were "stressed, frustrated, anxious, disturbed.

The biggest obstacle in my job environment to my creativity is ... lack of time, lack of freedom, abundance of quick negative criticism, distractions from creative thought, lack of encouragement, lack of acceptance of new ideas, ineffective meetings, overly cautious management styles, red tape, lack of appreciation of creative accomplishment, lack of suitable rewards, limited resources, overload of work, interruptions, demands of others, need to be productive rather than creative, limited communication, paper work, lack of skills.

I need the following from my job environment to be more creative ... more time, more freedom, less red tape, less paper work and routine jobs, more resources, more respect as a professional, more recognition for novel ideas, better rewards for innovation, better communications on problems, encouragement for originality, fewer meetings, better team work, fewer penalties for failure, fewer interruptions, more supportive atmosphere, realistic schedules.

The principal conclusion reached by Glassman was that time to be creative and freedom of choice on what to work on and how to accomplish goals are considered to be very important. This is similar to the conclusions reached by Amabile (1984). However, Farris (1973) and Pelz and Andrews (1976) found that scientists who are moderately controlled were found to be the most effective in organisational terms.

Habits of managers which interfere with creativity include (not in any order):

- too much or too little control
- not expecting subordinates to be creative
- rationing resources rather than seeking new creative opportunities
- not tolerating ambiguity
- moving to closure too quickly
- over-emphasising reason and logic coupled with a belief that fantasy and intuition are a waste of time
- using inappropriate problem solving strategies
- not allowing creative people to individualise their working conditions
- promoting external rewards and goals as motivators, rather than the personal enjoyment and challenge of creative work
- failing to allow time for ideas to incubate and mature in the hidden complexities of creative thought
- not questioning why or how things can be improved
- playing it safe and not taking risks
- not allowing bizarre ideas or impossible intermediate ideas to exist in the early stages of creative thinking
- dominating meetings
- not encouraging creativity training
- not making it clear that creativity is wanted
- committing to an early idea too soon
- using quick negative criticism to stifle an idea
- insisting that a new, fragile idea run the gauntlet of the team's negative thinking before it is taken seriously and developed, and
- not allowing the time needed for effective creative problem solving

In simple terms it appears that creativity will be fostered when R&D managers give a clear idea of the desired end product, and let people set their own goals and run their own programs. However, creativity is not the only consideration. Factors such as institutional objectives and the particular circumstances of the researcher or research team also affect the design of any optimal approach to research leadership and management.

DOMAINS AND FIELDS

The creative person-domain-field systems view of creativity has several implications for creativity in research and development, the most important being that we need to consider the influences on and the characteristics of the domain and the field, as well as those relating more directly to the creative research person.

A domain is a set of symbolic rules and procedures such as those of mathematics, music and legal systems, nested in culture, containing the symbolic knowledge shared by a particular society. Creativity is affected by the narrowness of the domain, the manner by which the domain information is sorted and accessed (for instance as words, equations, rhythm or pitch) and the breadth and depth of interest in a domain (Csikszentmihalyi 1996). Research creativity will diminish unless teachers, industry representatives and research leaders and managers actively promote and extend existing domains and, enable new domains to emerge as needed.

A field consists of all the individuals who act as gatekeepers to the domain, including, for instance, teachers, industry people, administrators of R&D funds, journalists and other communicators, scientific editorial panels and referees. Fields can affect creativity by:

- being reactive or proactive in stimulating and supporting novelty
- being well or poorly versed in the domain
- choosing the size of the filter for new ideas, (too open or closed a filter is counter productive), and by
- being well connected (or not) to the rest of the social system from which they can channel support for their domain.

The struggle for recognition results in strong competition between units of information for acceptance by the field which has a limited attention and is forced to be highly selective. Field members need to recognise that they themselves need to be creative in how they execute their various gatekeeper roles.

Gardner (1993) hypothesises that creativity results from an individual's capacity to exploit or create misfits or asynchronies between him or herself, the domain and/or the field. The capacity of persons within the field to identify such asynchronies may be reduced owing to the higher order hierarchical positions normally held by these people.

Domains and fields can affect each other for the knowledge base may restrict the field, or the field may not be competent to represent the domain.

SUMMARY

People possess an inner urge to create. The expression of this urge may be influenced by the creative capabilities of others and the environment within which they operate.

Creative people are characterised by complexity and individuality and the psychological meaning of environmental influences may differ, both between individuals and over time. Creative people are influenced by their immediate work environment and by the people responsible for determining the entry of ideas and products into the relevant domain.

Within this framework Lewis and Dehany's view on managing creativity and innovation in a government research environment seems appropriate:

"You manage it by setting it free" through, for instance, the following actions:

- signal support for trying new ideas and approaches
- respect individuality in people and their approaches
- free scientists of administrative burdens, and
- promptly fund good ideas from discretionary funds.

Edited Transcript: 'Environmental Factors Affecting Creativity'[2]

Dickman: We will need to limit this discussion to bring us back on to the schedule.

Craik: There have been many comments about the need for time to be creative. However, there is a lot of self-responsibility required and we should allocate whatever time we think is necessary for creativity.

Gleeson: Yes. That point was put strongly (by the facilitator) at the focus group discussions, particularly those with research managers. But the view was that the in-tray treadmill prevented such self-determination. It seems to me that organisations should recognise that individuals need to allocate time for these activities and expect them to do so.

Craik: Maybe people at the top need to lead by example.

Fawns, Kate: We are all creative people and to varying degrees we need to exhibit discipline to be creative. I don't have a problem with setting goals but we are imposing a structure on our goal setting before we need to. Allowing time in our daily life is important, to see things in a new light. This needs time, so you can perceive things.

Trounson: It is getting worse, with the speed of communication.

Fawns, Kate: That's true and so we need that time (to think) even more.

Borell: There is a duality between the need for solitude and the need to interact.

McDonald: Having just been through the experience of trying to open up an organisation, I can attest to the high level of frustration that can be associated, at least initially, with a lack of direction. Left alone, people can go back to a very comfortable position. We need to learn more about how to manage these processes.

Hamblin: Picking up Tony Gleeson's points: first, the need for constructive criticism, which is a very un-Australian thing in my experience. Second: the concern and anxiety of people on short term funding and their apparent reluctance to be critical. Is this to do with hierarchical structures? And there are gender and age features.

Gleeson: Possibly the solution is to increase the pool of persons not permanently tenured so that there are more opportunities for good people to go, or to stay. So my inclination is to open up the employment system rather than rely on long term tenure.

Dickman: We must stop at that point.

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[2] *Presenter - Tony Gleeson : Chairperson - Vicki Dickman*

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3 THE VIEWS OF AGRICULTURAL RESEARCHERS AND THEIR MANAGERS

FOCUS GROUPS

Establishment

A focus group discussion approach was used to obtain the views of agricultural researchers and research managers on how their workplace environments stimulate or constrain creativity. Two focus group discussions with researchers and one focus group discussion with research managers were conducted in each of three major public sector agricultural research and development institutions. The institutions, the place of the discussions and the number of participants other than facilitators are outlined in Table 3.1.

Table 3.1:

Institution	Researchers		Research Managers
New South Wales Department of Agriculture	Sydney *(n=9)*	Orange *(n=9)*	Orange *(n=10)*
Queensland Department of Primary Industries	Toowoomba *(n=8)*	Rockhampton *(n= 8)*	Brisbane *(n=5)*
CSIRO	Brisbane *(n=7)*	Brisbane *(n=8)*	Sydney *(n= 4)*

With the exception of the research manager group in New South Wales Agriculture the names of potential focus groups participants were selected from organisational staff lists provided by each institution. The selection was guided by a desire for the participation of as many different disciplines and industries as possible. Potential participants were telephoned, briefed on the purpose of the project and invited to participate. Confirmation of arrangements for the discussions was sent to each invited participant. Three people who subsequently became aware of the project also participated. New South Wales Agriculture extended an invitation to research managers to participate in the focus group discussion. These persons were not contacted by project personnel prior to the discussion but were informed of its purpose when invited to participate.

Conduct

Each discussion was of two hours' duration and was structured around the nature and drivers of creativity and the environmental factors affecting it. All discussions were facilitated by the same project person, with one other of three project people attending as an observer for five of the nine discussions.

Participation in Focus Group Discussions

Everyone invited to attend the focus group discussions did so, with the exception of two, one of whom was unavoidably delayed overseas. Participants in each focus group were involved actively in discussion at the point of expiry of the two hours allocated.

Profile of Focus Group Participants

Focus group participants completed a short profile questionnaire. The collated data are presented in Appendix II. In summary the data show that the majority of participants were highly qualified, experienced people and occupied permanent positions. Most were involved in a range of research related activities. Researchers were heavily dependent upon external funding from the rural research and development corporations. Most researchers and their managers related to only one of a range of industries or to resource management but to many end users. Approximately 60% of researchers and 80% of research managers judged their involvement with end users as very active or active. No researcher judged their environment to be very conducive to creativity.

Information Capture & Verification

Each of the discussions was recorded and transcribed. The transcriptions were verified by the facilitator against the recordings. The facilitator produced a synopsis of each transcription comprised of statements to reflect the general views of the discussion group and selected extracts taken directly from the transcript. The synopses were sent to participants so that they might judge whether they reflected the essence of the discussions. Responses from participants generally supported the validity of the facilitator's interpretations and included editorial amendments, as presented in Appendix III. A second project researcher produced a synopsis for each of the three focus group discussions attended by both herself and the facilitator. These synopses did not differ in substance from those produced by the facilitator.

The facilitator produced a summary of the discussions with all research managers and a summary of the discussions with all researchers using the synopses of the transcripts. These summaries are presented in Appendices IV and V.

A third project researcher examined the summaries produced by the facilitator and compiled an integrated statement of the views of scientists and their managers. Several minor differences in emphasis were resolved between the project researcher and the facilitator through an interactive process resulting in an agreed integrated summary of the discussions.

INTEGRATED SUMMARY OF DISCUSSIONS

The focus group discussions with both researchers and research managers were structured loosely around these questions: what is creativity? what drives creativity? and what environmental factors encourage or constrain creativity? Responses to the first two questions are reported upon under a similarly phrased heading whereas the reporting on the environmental question is categorised according to the principal issues arising in the discussions: leadership, funding and direction, management and administration, communication, teams and training, and recognition.

Consistency of View

One of the insights provided by the interest in systems approaches over the last twenty years has been a recognition that how the view is seen depends on where the viewer is located and his or her previous

experiences. The participants in the focus groups of researchers and research managers conducted within this project came from a number of organisations and different research areas, yet on many points they held a remarkably consistent view of what constitutes creativity and which environments enhance it. In this summary we present the shared view except where there is some notable point of difference. Quotes illustrating shared views are taken directly from the transcripts of the discussions.

The Nature And Drivers Of Creativity

There is general agreement that creativity concerns:

- generating innovative solutions (not producing a brick, but inventing a brick, or inventing a new brick with new values)
- mind work (drawn from subconscious ideas intermingling)
- work that is pre-useful (that is, you do it before you can know that it will be useful)
- exploration beyond conventional boundaries.

Creative work is messy, at the limits of normal thinking, and cannot be done in a structured way, yet it depends on extensive knowledge of a relevant domain and the field reality. It is often stimulated by putting together teams of appropriate personnel.

> *... it is a balance between trying to go in one direction to get something done as a team, but then making sure you are out on the edge enough in a sense where thought patterns and other processes are really breaking down.*

Creativity is looking for new answers to existing problems or for new problems to be solved.

> *There is much creativity in problem formulation, as much as in the problem solving area.*

It requires time and space to explore for insights with a flexible mind. It is important that the ideas are not judged or constrained too early in their conceptualisation, and that the processes by which an outcome is to be achieved are not overly prescribed or inflexible. There has to be a permission to explore beyond the next pre-planned step, or once a creative idea has occurred, to consider how it might add to or change existing knowledge.

> *Sometimes you don't know at the time that it is going to be useful, but five years down the track that may be something that is extremely useful to industry, and that is why you need a balanced portfolio of your strategic work and your basic research ... you really do.*

There is considerable variation between researchers as to how they respond to particular organisational cultures and processes. However almost universally, at least from the perspective of the research scientist, an important driver of creativity is the fun, the buzz, the excitement of a new discovery.

> *For me it is a sense of discovery, I get a real buzz out of that.*

A problem is internalised to become a personal challenge, which is solved by a new discovery or insight into the why or how. It is the new discovery that is really exciting, really joyful. Research managers did mention enthusing staff, but did not focus on the joy of discovery. Many of the responses from research managers indicated a focus on the needs of researchers and the research system, rather than their excitement at their own or their staff's creative discoveries. Research managers obtained satisfaction from enthusing and developing individuals, providing solutions to clients, creating good working environments and seeing how the science fitted into a broader picture.

Managers expressed their rewards in terms of satisfaction, whereas researchers chose the more passionate expressions of buzz, joy and excitement.

A second key driver of creativity is the worthwhile nature of the work of solving problems. A researcher perspective was that creativity can be driven by the challenge of a self-identified problem or that an industry problem can be internalised to become a personal intellectual challenge and an opportunity to visibly contribute and do good.

> *What makes my heart beat faster about science is solving problems that I find difficult.*
> *That's essentially what it comes down to.*

The research managers also focused on the opportunity to solve problems, but by contrast, were more likely to see their role as fitting research into the context of other organisational activities and into the boundaries imposed by organisational policies and procedures.

The third key driver of creativity in research identified by researchers and research managers alike is an environment which fosters creative ideas and supports people to develop and implement them. Such an environment was described as having an ethic of open and exciting exploratory discussions (including scientists and non-scientists) and providing the opportunity to share an idea with others and see it adopted. It is an environment that is ready to accept new ideas, providing the opportunity for the joy of the discovery to be shared and its implications appreciated.

> *So you have got to have the basic training, you have got to have the knowledge,*
> *then you have got to have the work environment that creates, that allows for the*
> *development of new approaches, different ideas too.*

Research managers invariably focused on the creativity related needs of researchers and generally were reluctant or indeed unable to discuss their own creative needs.

> *I think that, going back to our roles as managers and directors, always the challenge*
> *is to create the environment for the individual to have the opportunity for him or her*
> *to develop that creativity.......Where the creativity occurs is at the bottom line.*

Factors which discourage or preclude creativity include the setting of short term and/or narrowly defined targets, often through the processes employed by research funders and organisational arrangements which are conservative and inflexible. Research managers noted that government organisations were affected by a risk averse political climate and that industry could be overly focused on quick solutions to current problems. They believed that there is insufficient diversity of thinking.

> *The problem we have got sometimes is that funding bodies and certainly hierarchical*
> *departments are quite conservative."*

The result is "bounded" creativity with insufficient resources (especially of time) to follow up creative ideas, and a lack of opportunity for creative people to participate across activities and beyond the strict boundaries of funded projects.

> *... you have very little leverage to follow that line of thought to see whether it goes*
> *down a blind alley or not. That's part of what research and creativity is all about.*

The support to publish may also be reduced, limiting the recognition of novel ideas and hence an incentive to produce them. Research managers believed that they are often preoccupied by the need to overcome policy and administrative constraints to creativity.

....we need to be a lot more creative and forward thinking and futuristic in our thinking..."

Leadership

The key to research leadership is the ability to identify an important area or idea or problem and enable it to be followed up. Researchers distinguished between leadership which they believe is sorely lacking and management. They believe that the formal institutional structures, cultures and processes incline people towards being managers rather than leaders.

> *I think the problem in our structure is that the team leader is seen as a quasi manager, rather than a blossoming scientific leader.*

They report considerable variation in the flexibility allowed and the adequacy of professional leadership.

> *When the politicians get in and the administrators start to ape the politicians and think that all you have got to do is worry about tomorrow and the next three years at max. Well that is the antithesis of what is required for research management.*

Effective leadership is tolerant of creative people and prepared to address identified problems. Mentoring is viewed as a positive development if it does not stifle novel perspectives. It is imaginative and brings together people with different ideas and backgrounds.

> *I think a few of us here have been fortunate to have been in those creative working situations and most of them you can relate to the leadership you were given and the environment that leadership allowed you to develop. The leadership support might be subtle sometimes in terms of bringing in people with different backgrounds and ideas. .... The opportunity for staff to travel to interact with other people and so forth. I mean creativity is just ideas, ideas based on knowledge.*

Good professional leaders think about the profession and its future – they are not divorced from the work bench.

> *The interesting thing is that there has been this management and executive perception that there isn't a need for the individual (institute leader) to have a strong scientific background.*

On the other hand researchers report that good industry leaders of research quickly get sidetracked by agripolitics and short term bushfires.

> *There are some good people coming through from industry but they tend to get diverted by agro politics; and also industry people are very much focused on the latest bush fire. They tend not to have that long term view. And they get a long term view by talking with scientists and people like us.*

The research system seems to limit opportunities to travel and interact and there is a lack of young people coming through. Researchers perceive that it is often the system rather than the manager that doesn't understand research or have a vision. Responses to a question from the facilitator as to why discussion group attendees had participated included:

> *We are clutching at straws here. You are our final hope for some changes to occur from the top.*

> *It is something a little different and it intrigued me, creative research, what we were going to talk about and perhaps yes, that if we came up with something that was beneficial to us that it might come back through (the system).*

But I think there is going to be a difference between when the report comes out, and hits the desk of (someone in the executive) and there is recognition of the problem. The emphasis (should be) to do something about it and we all know that rarely takes place. Recognise the problem but try to brush it under the carpet.

I'm just as cynical as everybody else and I've been with the organisation for fifteen years. External things will change, but internally rarely anything changes.

.... if you were a bureaucrat taking notes, I would have said, sorry but I've got too much to do. I was interested because you'll be using it for your own research. If I thought it was a report that you didn't think was important, it's just the job you were given to do, I'd not come.

Researchers placed more emphasis than did their managers on the importance of leadership within the proximate research environment and within the organisation. In some situations, both researchers and research managers were highly critical of their organisational leadership and of the apparent lack of flexibility given to their research leaders and managers.

Funding and Direction

This topic was discussed with perhaps more intensity than any other. It is linked with many trends in other sections of this report. Researchers identified several limiting tendencies of the R&D Corporation model.

First, there are several problems in the planning process. As noted previously, it can be limited by the capacity of people on industry committees and R&DC boards, committees and staff, to understand the relevant science and the research process.

....so it's really up to the industry body itself in a lot of cases ... the calibre of person that is on the industry body ... I don't think that they have that long-sightedness in a lot of cases.

Collaborative planning processes are inhibited by the nature of the competitive processes adopted by corporations which exclude those not in the inner circle and which mitigate against open discourse. Cronyism and influence are viewed as problems implied by the system structures.

....I am saying that competition drives creativity, it is the failure to have the opportunity to have competition that is restraining creativity, that's the way I look at it.

....overseas now, research programs are tendered, that means that all the individuals have the opportunity to make a bid for it. Here is going the other way. With the proposals from (a RDC) coming to us and saying hey, look, there is a problem, you're trying to suggest that you can do this, so we put in a proposal. So that's what we do, we put in a proposal. Our proposals are one year, two year short-term projects with immediate outcomes.... And also it (competition) opens it up for immediate peer review because of the diversity of proposals coming in, there is no way that the chairman of one organisation will be sufficiently knowledgeable to be able to assess all the applications and you will have to call upon a team of peers to review all of the proposals. Usually when you start doing that, cronyism is very hard to establish. Now when you see cronyism... I'll say is that people can nominate their referees and they can also nominate people they don't want to referee. But let's face it, there are so many experts in so many areas.

Greater use of peer review might assist existing RDC decision makers to form judgements about the potential of new approaches and long term approaches which fall outside their own experience or expertise.

Second, there is a systemic tendency for funding agencies to focus on incrementally directed research (short-term, low risk applied projects) with predictable outcomes. The system can be unsympathetic to anything that is totally new. There is a penalty in loss of future funding which discourages intelligent failure.

> *Yes, they (industry) are setting the agenda in so far as they are looking for developments, rather than research, really. They want a product process, some intellectual property, something that is an outcome of their research and they're not really prepared to put a lot of resources now into investing in some more fundamental sorts of areas which will give them a basis for further development in the future. That's one of the dangers I see that we're making withdrawals on things that we've developed over a number of years and from external funding bodies, anyway, we're not getting any investment into any ongoing fundamental research that's going to provide the foundations for more developments later on.*

Incremental approaches tend to favour short-term reductionism into outputs and outcomes at the expense of taking the broad view, the long term view, or integrating across disciplines.

> *Obviously there is a balance there somewhere. I mean you wouldn't want to disband incremental research, because it can build on years of solid research. But there just needs to be that opportunity to give people a go with a brand new idea.*

There is a view however that the R&D portfolio balance should come from within the R&D institutions rather than only from the R&D funding agency.

Sometimes both the ends and the means of the research are prescribed and researchers are asked to compete on price alone. Then, researchers do not have the opportunity to participate in problem identification and their only real opportunity for creativity is in being economical or efficient rather than genuinely exploring possible solutions.

Creative ideas are not generated or are lost because of presumptions that they will not be funded. When R&D funding agencies almost exclusively limit their funding to issues they have specified and for prescribed R&D processes they lose potential creativity in relation to issue identification, specification and resolution.

> *The current system is too constraining. Get a project, do the milestones, write them up and move on to the next one. It's just too constraining.*
>
> *The funding bodies are more and more into commissioned research.....and I don't think there is anything better designed to kill creativity than that! ....With the federal funding bodies, they are all there for a period of say three years or whatever. So that is where the commission of research comes in. So the continuity there also has problems.*
>
> *... they (the corporation) said, this is the work we want done and they listed everything that they wanted done exactly and they said, O.K, give us a price and we'll see who gets it. That left no creativity on our behalf to put up projects.*

There is a need to recognise the requirement for creativity across the spectrum from the development to the use of information.

If we take the whole spectrum of from basic work through to implementation, the more creativity that we're going to have over that span the better, and obviously it's going to be more effective to achieve things through that spectrum. But as scientists, we tend to look at creativity at the basic level. We are looking at new products, the new way of doing things or interpreting things but, once we get through to the implementation phase, creativity is more the human psychology and the motivation of people and how they take up ideas. So as scientists when we think of creativity we tend to fall into the trap of thinking (only) of the new product, the new model, the new mathematical formula.

The research funding system requires that researchers start new projects before they have written up the previous project. Researchers are on a treadmill with little time to think creatively about the next direction. The twelve month delay between a proposal being submitted and commencing also inhibits creativity.

In our system where funding applications have got to be put in twelve months out before you start work or that sort of thing, creative type people quickly lose interest, they have got to wait twelve months before they can start work.

Researchers report that unofficial exploratory work variously called 'skunking' or 'CDK' (chief doesn't know), does occur either outside or within a group of funded projects, but that it is getting harder to find the time and resources for this to happen. There is a fear that the necessary imaginative work is not being done now to form the basis for future development oriented work.

Management and Administration

Creativity would be enhanced if R&D funders would specify outcomes required, and why but did not specify the processes to be used. Creativity is stifled by short time frames, prescription of methods and increasing administrative requirements.

I think it is the prescriptive nature of process that would cause a problem rather than saying that this is the outcome we want.

Some funding organisations have become managing organisations and their innovativeness has declined. The funding environment has led to costs being driven down to unrealistic levels, meaning that projects are under-resourced. Tasks of research scientists have broadened to include administrative and technical aspects of the work, and the trends to increased accountability and consultation, despite more rapid communication capacity, have also eaten into the time available for creative research. The time required for administrative tasks is important as is the frustration resulting from these tasks which appear to be irrelevant and not aligned to the skills and aspirations of scientists.

It's not just this strategic plan stuff, it really is the reporting. Really the manner of reporting of this organisation, I am stunned by it.

I think we've got a danger of learning to live with it (bureaucracy). And all the comments so far are a reaction to that. All this administration stuff, all the restrictions that are imposed on us, anything really that irks you can restrict the creative process.

The pressure to maintain employees funded on short term contracts has also increased the administrative load. Instead of less time available per project, a focus on implementation should logically lead to more time being invested in each project. However, a failure to allow for the time and space required for creativity, demands imposed by institutional initiatives and funding limitations overtake the ability to personally manage time and work flows.

The biggest constraint to creativity for me is lack of time to think about what I am doing.

Ad hoc industry and government pressures to change priorities and add additional workloads limit creativity.

So you need to have so many projects going just to bring the money in, so you actually have to do the work on most projects. We actually don't have a lot of technical staff left any more, so we are actually washing the glassware and everything else as well, and on top of that you've got projects you're writing up, like dream ones for grants, you've got the ones you're starting, the ones you're actually doing, the ones you're trying to find the time to write the papers for, plus trying to get a few students going somewhere. It is just crazy!

... To be creative, you have to have mental space - you have to have time to be able to sit and ponder on things from time to time and that doesn't exist in my life at the moment. I think what has happened to a lot of senior scientists in our organisation is that they are so busy with the day-to-day management of the research projects in their portfolios and meeting the milestones that they don't have the mental space to think creatively any more and that is what I think is a major problem in creativity in research management.

Researchers commonly believe their managers lack creativity and/or the environment within which they could express it. Research managers recognise that management needs to be tailored to the researchers' individual personality, experience, skills and ability to work best with or without boundaries. Managers are as conscious of the time constraints on creativity as researchers but they feel powerless to constrain accountability, funding and administrative burdens.

....as managers we really don't have the time often to sit down and take the time to be creative. I know that most of my time is really just putting out one bushfire after another. And they're coming in at a rate of about twice what I'm able to put them out.

Communication, Teams and Training

In general, teams are viewed as encouraging creativity. Interaction with other disciplines and face-to-face, team and conference contacts are viewed as essential to fresh approaches and creative solutions. These contacts are limited by competition between teams and by the tendency to manage projects rather than people and teams.

Creativity comes about more easily I think if you start talking to other people in other disciplines.

A lot more is achieved by talking to people.

The development and maintenance of strong disciplinary teams has been so dissipated over the last ten years of management restructuring that there is a real problem there.

I found that going to a project basis is a definite stifler to creativity. In the past we would get together, there weren't such defined projects and little clusters, there might be a project of one or two people and there has been a great decline in intellectual intercourse, in other words, we'd get together ad hoc. There was ... it goes back to time constraint... there was more time to get together ad hoc and just throw things around with others. This seems to be missing because so and so is working on this

project and he or she is flat chat and so and so is there and they're not getting together to cross fertilise.

Both funders and research organisations are seen as discouraging or not supporting conference attendance, which researchers view as essential for ongoing networks and new approaches, as well as for promoting recognition and acceptance of their findings by their peers. Particularly for researchers in remote locations, opportunities for face to face contacts are limited.

...I guess, because I am old fashioned, I will defend a little bit management but not in some of these areas and that's one (attending conferences) where there is a blatant over statement of policy and a perception you have got to fight tooth and nail to get approval to attend conferences and there's no question what everyone has said is accurate. So you can tackle that one when you go.

Sadly the (organisation's) stand on conferences is deplorable. It is one of the most annoying things that I have come across.

Researchers identified the synergy and stimulation which comes from people with varying skills working on the same problem. Communication among disciplines is viewed as very limited by both time and opportunity, and there is a potential for tension between different perspectives which can be managed to produce positive results.

I think communication between scientists throughout the world is always beneficial to creativity, because you learn how other people are applying their ideas or their creativity in situations and you think.

I'm most creative with groups of people working on the same problem in a lot of different ways....

Creative output is viewed as peaking in the time between an individual becoming fully skilled and later moving out of an active research role. Researchers view mentoring as a positive move in new staff development, but one which is not actively promoted. Increasing opportunities for contact with post graduate students' projects is also supported. Other areas of training are not viewed as positively, and there is concern that basic discipline skills are becoming diluted. Creativity has to be underpinned by good basic skills. Science training based on rote learning and repetitive application of a simplistic scientific method is not a sound basis for creative or lateral thinking.

I mean some of the best kicks I have had in the last few years is being able to work with young people.....one of the better things that I think the (organisation) has done in recent years is to start this mentoring system but it is not something that is actively being promoted.

I reckon you can (be trained to be creative) and I think that's where scientists lose out... You do creative art or you do science

I don't think our education system is very good at producing people that are creative..... It's just the way I was taught, was never to think the way I think now. It was actually to spit back what I was taught.

Recognition

Both researchers and research managers judge professional recognition as being important to creativity. Yet they view the RDCs and research organisations as providing little feedback and virtually no positive recognition. In particular, the lack of meaningful feedback on milestone and final reports was noted.

It is extremely important professionally and personally that you are valued for what you are doing.

You might expect to get some feedback from the corporation that says, well, you met those milestones and not only did you meet them but you have actually made a difference to this industry. But surprisingly you get very little feedback at all ...

Performance planning and evaluation procedures can affect creativity by imposing a fear of failure and hence a risk adverse environment. In some industries annual events attended by industry and researchers provide very good feedback which is greatly appreciated by researchers.

All the scientists and industry people get together every year .... So there is strong accountability. That is fairly honest and open debate. You get very good feedback. I think that is a great approach.

Perhaps most valued is peer recognition, especially when work is cited or applied in further research or in industry applications.

SUMMARY

In considering these views of researchers and research managers, the challenge is to see how environments can be created which positively affect the scope for creativity, and who might be able to introduce the necessary adjustments to achieve enhanced creativity, building on the judgement that greater creativity leads to different and better outcomes from research.

Research is targeted principally for those in industry and elsewhere who utilise the results, and they may contribute to desired change. Researchers and research managers themselves have the potential to achieve some improvement in the conditions facing researchers. Senior organisational managers in research organisations, as well as research funding organisations and their managers, have the capacity to positively address some of the issues raised, as well as the potential to pull the rug from under existing creativity. Lastly people responsible for setting accountability provisions for public sector agencies need to work with research managers to ensure that those provisions provide effective accountability without unduly constraining creativity.

Our fundamental question is how these players can be encouraged to make the necessary effort to enhance creativity, and whether these efforts will be effective individually, or only in combination.

Edited Transcript: 'The Views of Agricultural Researchers and their Managers'[3]

Coffey: Could you elaborate on the research management and leadership aspects of the data?
Woods: There was a consistent view from researchers and research managers that many people leading research teams were not leaders but managers.

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[3] *Presenter - Beth Woods on data collected by Tony Gleeson : Chairperson - Alan Trounson*

Kerin: Part of the rationale for establishing the RDCs was to improve research by increasing contestability and to ensure R&D was not just the play thing of Boards with less expertise in research. The progression of the RDC model varied between industries..... perhaps it is now time to look at it again. We need to look at these issues and possibly this work on creativity will give us some new insights. There are problems emerging, especially in wool and meat. The amount of time and effort that goes into research direction is critically important.

Dickman: So many of these points related to research are common with issues facing rural community development more broadly - access to expertise, security of tenure, length of funding. Most spend 50% of their time chasing money and this jeopardises what they can do in their communities.

Trounson: Should we be more flexible in the funding duration?

Dickman: World best practice community development programs are usually funded for between 7 and 10 years.

Woods: Even though there is recognition that some issues are long term, funding usually gets provided for three years.

Trounson: It is really two years before researchers have to gear up again to get funding.

Dickman: It is difficult to retain people.

Perkins: Are we becoming too specialised and less integrated? A lot of the problem with the lack of creativity is I feel too much specialisation and a lack of diversity.

Hamblin: A lot of the focus is on the marginal funding but there were very few comments on change within the research organisations.

Woods: The institutional changes were seen to reduce the time available for research. But basically the whole effort is being driven by the marginal funders.

Hamblin: This reflects an inability of senior managers to allocate their resources. I have a feeling that people are just seeking to go back to the good old days.

Woods: I can't really comment on those issues. I would like to raise however the question of how much creativity is necessary; what is the value of creativity?

Trounson: The forms of assessment for scientists seems to present some dichotomies.

Woods: Recognition can also come from the results being adopted.

Gleeson: Just a couple of quick comments. We estimate that 70% of research influence comes from the RDCs. And one of the general conclusions we came to in a study of the application of competition policy to agricultural research was that the real problem was the virtual absence of any competition between the purchasers of research. There may well be too much competition at the doing end. The RDCs act as monopolies in buying research in their particular charter fields, as do state departments and CSIRO in different ways.

Borell: There is a fair bit of comment about discovery in this information. There is a link between science and exploration and it has to do with discovery. In exploration one might be looking at the landscape but with research one is exploring the mindscape and hence is at the cutting edge. So we need an environment where people can go where no one else has gone before - a sense of exploration.

Trounson: One of the big points that comes out is you don't know whether you will be funded, or have a job.

Borell: It is like politics.

Lever, John: So far we have heard of the limitations of time frames and funding but they can also represent incentives. In the 'good old days' we never had these boundaries and time limits.

Trounson: Can we expand on that?

Lever, John: There is a demand for a higher degree of focus, for results within a given time span. When people take on research projects they have to look at the ability of their team to perform. When there were no time frames there was a complete divergence away from focus and now that isn't the case. Whether it has gone overboard I don't know.

Trounson: Are the CRCs, with their 7 year time frames and involvement with end users, a better way to go?

Lever, John: Depends on the research. Some can be done in a year and others it takes 20 years or more.

Trounson: Flexibility.

Duffield: The research was done across three organisations - can we see any differences between organisations?

Gleeson: It is probably too difficult, politically. There are some differences but I come back to the fact that the similarities are much greater than the differences. The differences are ones of degree and emphasis and the differences are both within and between organisations.

Coffey: We spend a lot of time on how people will do their work and we don't do enough on what to do. If we look back to what Tony Gleeson said earlier, a lot of the stifling of creativity has to do with once we set the target, not letting researchers work out how to do it.

Trounson: More interactive review?

Coffey: Maybe, but there isn't much courageous decision making coming from management. We look at high risk projects and marginal ones but not so much at the others that take up most of the resources. Perhaps we need to clear some of the issues out of the pipeline and give some space for new issues.

4 THE NEED FOR CREATIVITY IN AGRICULTURAL RESEARCH AND DEVELOPMENT

When we began this work we gave little attention to the question of whether there is a need for creativity in agricultural research and development, largely because we thought the answer was obvious. On reflection, however, the answer may not be as obvious as first thought, for a variety of reasons.

Why do we need to be more creative when time and time again studies have demonstrated high rates of return to agricultural R&D (Industry Commission 1995)? Australian farmers are thought to be the most efficient in the world, due in no small part to agricultural R&D. Furthermore, many agricultural advisers and research managers believe that substantial productivity gains could result merely from the application of existing knowledge, and there is little need for creativity which they associate exclusively with the generation of more knowledge. This viewpoint is strengthened by the observation that, given the global nature of many technological developments, Australia could import technology and adapt it for our environment. Last, some agricultural researchers wonder why there is any need for creativity; their perception is that funding for agricultural R&D is almost exclusively directed at short term research with a high probability of success and highly predictable outcomes.

This chapter addresses the question of why creativity is important in society generally, and particularly in agriculture and in agricultural research and development.

SOCIETAL IMPORTANCE OF CREATIVITY

The importance of creativity in society is examined from three interdependent and arguably equally important perspectives: the first, that of an evolving national culture, only briefly (for want of competency); the second, that of the individual, again only briefly, for related issues have been discussed in earlier chapters; and the third, that of achieving national prosperity somewhat more fully.

National culture

Cultures are socially constructed shared systems of meanings consisting of the values, norms and beliefs an individual holds in common with members of the group. They are learned designs for living which are manifest in such things as language, rituals and objects.

As genes are the units of biological evolution, memes or created units of information are the units of cultural evolution. To state the obvious, we create our culture. Language enables cultural units to be transmitted across generations and, with further creativity, our cultures evolve. More contentious perhaps is the view that creativity is not restricted to memes and that genes in someway exhibit insighfulness in their search for adaptive forms (see Wesson 1991). In any event the form of our culture, including our capacity to evolve it, will be an important determinant of our future, a point reflected in the following quote from Csikszentmihalyi and Sawyer (1995):

> *A culture that in principle cannot differentiate between more profound and more superficial aspects of an issue because it lacks the concept of insight is likely to have more trouble coping with its material and ideational environment.*

Approximately thirty years ago Professor Sol Encel made a similar but more scientifically oriented observation in giving the 1968 JM Macrossan lecture at the University of Queensland:

> *The scientific way of life, and the scientific way of looking at things, are at the heart of our culture, and the valuation which a community puts upon them is an index of its own health. What policy can do in this area is to watch for signs of scientific creativity and nourish them as precious possessions.*

The individual

Considerable joy is associated with being creative when one's mind is stretched to its limits in a voluntary effort to accomplish something new and worthwhile. These circumstances and other challenges that totally focus the mind or body lead to optimal experiences, or as described by Csikszentmihalyi, a state of flow, in which people are so involved in an activity that nothing else seems to matter.

While the joy of creativity is usually associated with the actual point of discovery, wherein insight leads to the 'Aha!' experience, it is not restricted to this event. For instance periods of elaboration and verification of an insight require persistent focused attention during which one has at least a sense of control over one's consciousness.

The innate drive for creativity is established as a person searches for the joy associated with being in a state of flow. This search results in growth in the complexity of the individual and a putting away of the fear of there being no meaning to life.

National prosperity

The goal of a nation could be expressed as being to produce and sustain a high quality of life for all its citizens. This begs the question as to what the term 'quality of life' encompasses but certainly there is an economic component, the subsidiary goal of improving economic productivity, defined as the value of output per unit input of labour or capital. A key question then is what in the global economy determines productivity?

Prior to globalisation (which fundamentally is the global flow of capital, information and technology) differences in the availability and cost of factors of production, such as natural resources, labour and capital were generally sufficient to explain differences in competitiveness. But the tide has turned and countries, regions and people who remain dependent upon low value and low skill exploitation of natural resources will not be internationally competitive in the global economy.

Anderson (1998) in a article titled 'Are Resource-Abundant Economies Disadvantaged?' reviews data that show negative relationships between the growth rate of a nation's gross domestic product and indexes of comparative advantage in natural resource-based products and of food self-sufficiency. Hypotheses explored by Anderson to explain this phenomenon include the observation that relative to resource-scarce countries, resource-rich countries face:

- continual decline in terms of trade
- fewer growth inducing factors than countries more dependent on manufacturing
- less catch-up potential through the use of technologies
- larger protectionist barriers, and
- more distortionary policies

Anderson concludes that policy distortions, for which read protection, especially of industries with potential growth in the production of tradeable goods, may be the main explanation for the relatively slow growth rate in resource-rich countries.

Another, not necessarily antagonistic, perspective is gained if one begins from an innovation-centric position, where innovation is understood to be the process by which firms or other economic units assemble, from a wide variety of internal and external sources, the know-how necessary to enhance their competitive position (see for instance, Sheehan, Pappas, Tikhomirova and Sinclair 1995). Given that recent models of innovation emphasise systems integration and networking, as distinct from the earlier linear (technology push), market pull, coupling and integrated process models, the role of the strategist, the thinker, has become paramount.

Ohmae (1982) defined the mind of the strategist to be one in which:

> *insight and the consequent drive for achievement, often amounting to a sense of mission, fuel a thought process which is basically creative and intuitive rather than rational. Strategists do not reject analysis. Indeed, they can hardly do without it. But they use it only to stimulate the creative process, to test the ideas that emerge, to work out their strategic implications, or to ensure successful execution of high potential "wild" ideas that might otherwise never be implemented. Great strategies, like great works of art or great scientific discoveries, call for technical mastery in the working out but originate in insights that are beyond the reach of conscious analysis*

It is not surprising that the same author was later (1990) to conclude that:

> *The prosperity of countries depends on their ability to create value through their people and not by husbanding resources and technology*

This emphasis on people, and the related factors of institutional cultures and policies is a common thread throughout Porter's 'Competitive Advantage' (1985) and 'The Competitive Advantage of Nations' (1990) in which he observes that innovative firms are those without barriers to perceiving and acting on discontinuities. These discontinuities arise from creative people finding insightful solutions to insight problems.

Further support for the importance of skills, knowledge and technology in driving growth and national prosperity is to be found in 'new growth theories', as reviewed by Dowrick (1992) and in the framework proposed by Latham (1998) for dealing with societal needs in a globalised economy.

Dowrick suggests that the new growth theories provide intellectual respectability for the contention that education and training, research and development and investment in new machines and equipment are potentially important elements in promoting long run growth, a contention which Dowrick observes is 'fairly obvious to the lay person, yet greeted in the recent economics literature as a new insight'. A cynic could observe that the 'discovery' of new growth theories is a classic example of the constraining effect of closed domains and fields on creativity.

New growth theories and other considerations enable Latham (1998) to make a convincing case on political, functional and equity grounds, for a redefinition of the rationale and strategies for government policy in a globalised economy, a re-orientation towards enhancing social capability. For current and potential research personnel, this surely should encompass the means to improve their productivity, in particular through enhancing their creativity.

Perhaps the discovery of new growth theories will add weight to the 1989 plea by Professor David Yencken for the recognition of creativity as the key factor in industry - creativity in product or service development, creativity in technological development, creativity in marketing, and creativity in management and leadership.

In our catch-up scramble to acquire information technology, to access information and to develop skills, we should be careful not to overlook that it is all for nought unless we use those capabilities to be creative, to gain insight. These insights are the foundations of our development as individuals, as a society and as a nation.

AGRICULTURE

At the beginning of this chapter, we mused that the need for creativity in agriculture and agricultural R&D may not be particularly transparent. However we hope the following observations, even though they do not encompass important environmental and social issues (see ABS 1996; SCARM 1998), might accelerate the realisation that the need is acute.

Value of output

Since the early 1970s, there has virtually been no change in the real gross value of Australian agricultural output, notwithstanding a two fold increase in the real value of world trade in agricultural based products. It appears that, at an aggregate national level, agriculture is an increasingly unattractive investment for Australia with aggregate real net farm income falling two fold over the twenty years to 1994/95.

Figure 4.1   Performance of Australian Agricultural Farm Sector, 1971-72 to 1994/95[1]
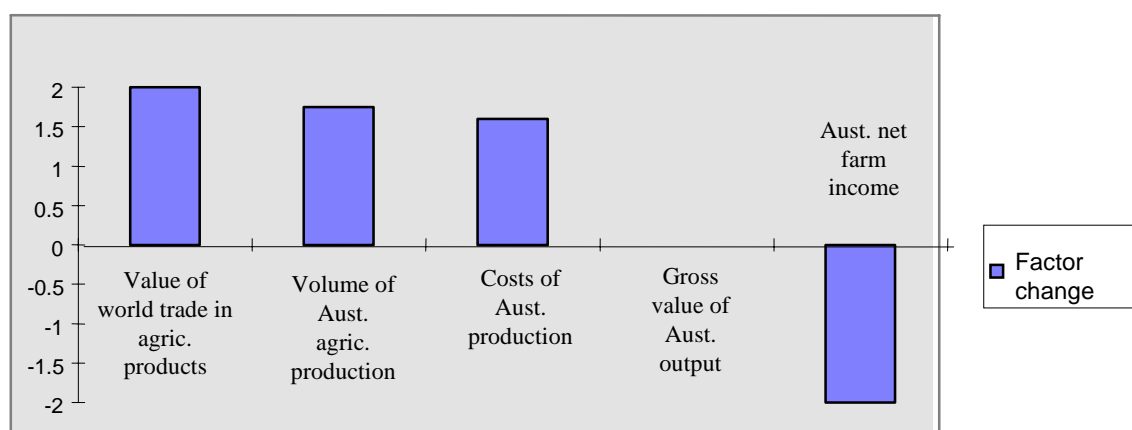
1. 1994/95 dollars
Source: Adapted from Synapse (1997)

Export-import performance

It is generally concluded that approximately 75% by value of Australian agricultural products are exported and that those exports represent about 20% of all Australian exports (*see* ABS 1996; DPIE 1997) . However, comparable production, export and import statistics across industry sectors are not readily available and the proportion by value of agricultural products exported is inflated by comparing farm gate production values with early stage processing export values. Some analyses estimate the proportion of agricultural products exported as low as 33% (*see* DITAC 1993).

A clearer picture emerges when one examines the export-import statistics for the food and fibre industries. These industries combined account for approximately 30% of Australian merchandise exports. Over the ten years to 1996/97, the ratio of imports to exports of non-manufactured food and fibre products[4] was about 1:4.5, that is imports equated to about 23% of exports and for manufactured

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[4] Standard International Trade Classifications 0,1,2 except 27 and 28.

food and fibre products[5] ,the ratio was approximately reversed with exports equating to about 18% of imports (ABS 1998c). The overall outcome for the food and fibre based industries is that, in general terms, Australia imported by value about half as much as we exported, with net exports in 1996/97 being valued at about $12 billion. Interestingly, if one were to accept the widely published current estimates for the value of agricultural production and exports of about $28 billion and $23 billion respectively, one is confronted with the statistical aberration of imports of non-manufactured food and fibre products equating to approximately 45% of the total value of domestic consumption of about $11 billion.

Sectoral inter-dependencies are a feature of maturing economies, as is illustrated in Figure 4.2. In fact, when both direct and indirect inputs from the service sector are taken into account, the service sector contributes about 40% of the value added to Australian exports as compared to about 14% from the agricultural sector. This 14% statistic reflects that agricultural exports comprise approximately 20% of all Australian exports, that there are contributions from the agricultural sector in exports from other sectors and that direct and indirect inputs from the service and manufacturing sectors comprise about half the value of agricultural exports (*see also* Deeley 1991).

Figure 4.2   Sectoral Contributions to Exports
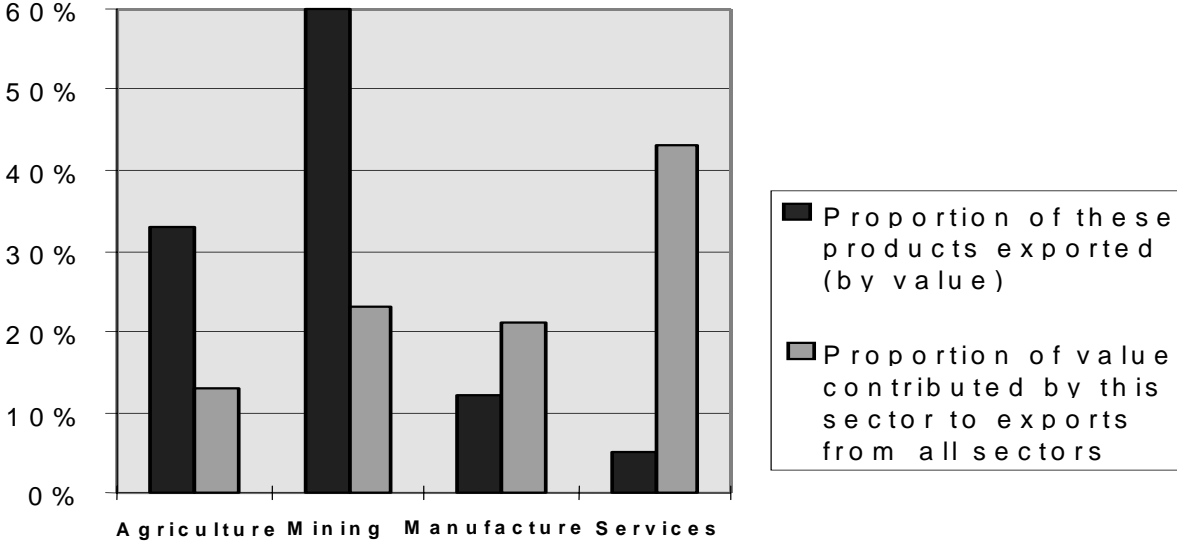
Industry structure

There is a high though variable, concentration of production in both the farm and non-farm components of agribusiness systems.

The food processing sector employs approximately 166 000 people in over 40 000 establishments. Just 50, or about one tenth of 1% of those establishments account for over 60% of sales (Prattley 1995). In the farm sector, there are approximately 116 000 commercial[6] farms, of which 73% are broadacre[7]

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[5] Standard International Trade Classifications 61, 62, 63, 64, 65, 84 and 85.

[6] Commercial farms are those with an estimated value of agricultural operations (EVAO) of more than $22 500 (ABARE 1996)

farms. Thirty percent of these 24 000 broadacre farms produce 70% of the gross value of broadacre production.

Concentration of output is greater in industries where there is significant vertical integration. In the poultry industry, two companies supply approximately 75% of all day-old broiler chickens and process approximately 70% of broiler chickens marketed in Australia. While the balance of production is shared among several medium sized companies and a myriad of smaller producers, marketing of poultry products is conducted mainly through the two largest companies. Within the pig industry many of the larger holdings are vertically integrated and the top 2% of farms own 40% of the industry's total sow population (Douglas 1995).

The vast majority of farms are family owned. For instance, in 1994-95, only 0.4% broadacre and dairy farms were corporately owned. These corporately owned farms account for 6.5% of the gross value of production, and because of their relatively high incidence in the pastoral zone, they occupied some 26% of the land occupied by commercial farms.

Diversification

Changes to the mix of enterprises presumably reflect anticipated differences in profitability between enterprises and/or their mixes. Over the past twenty years, the proportion of the gross value of agricultural output arising from the major commodities[8] fell from 75.5% to 59.0%, with the rate of decrease over the past five years (1.6% pa) being double the average over the past twenty years (0.8% pa).

Farm productivity

Productivity and net income vary considerably between farms. This variation is related to farm size, as reflected by cash receipts. However, the potential for improved economic performance in the farm sector is considerable, as indicated by a four-fold variation in economic productivity within groups of farms categorised three ways on the basis of farm receipts (Figure 4.3).

This pattern continues with ABARE observing in the 1998 Farm Survey Report that the top 25% of farms (ranked by their average rate of return in 1996/97 and 1997/98) earned business profits at least 50% higher than the average for farms in the same size and industry group, and, in many cases, more than double. Interestingly in the cropping industries the rate of return for the top performing 25% of the middle sized operators was marginally greater, at 16.4%, than that for the comparable sub-group of the top largest operators (15.8%). Nevertheless approximately two thirds of broadacre farms, in ABARE terms, make negative business profits, more generally called losses.

Figure 4.3   Variation in Productivity of Broadacre Farms (1990/91)

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[7] Broadacre farms include wheat, cereal grains, coarse grains, oilseeds, grain legumes, mixed livestock-crops, sheep, cattle and sheet cattle farms (ABARE 1996)

[8] Major commodities have been classified as Wheat, Sugar, Meat, Dairy, Wool, Pigs, and Poultry

Receipts: Capital Ratio (%)

0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

Farm A   Farm B   Farm C
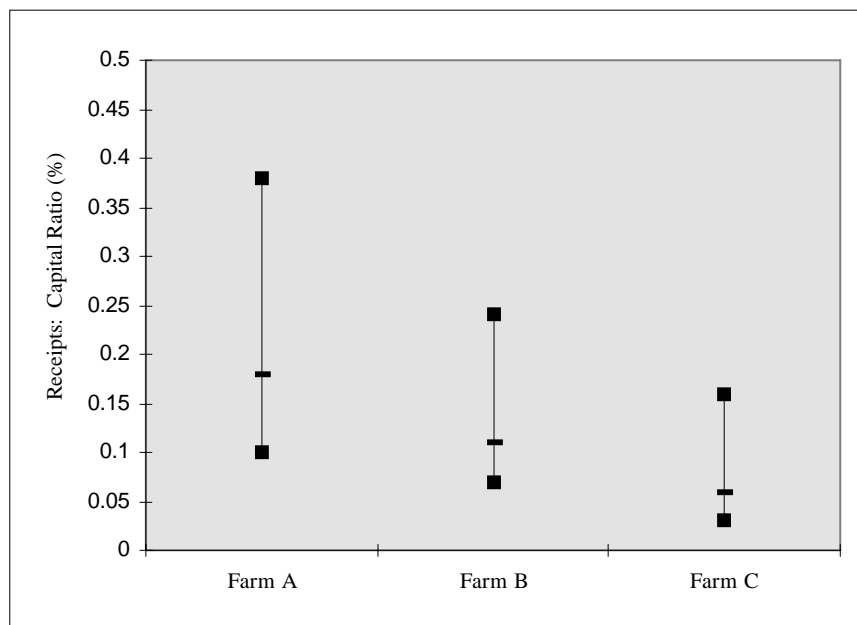
Broadacre farms categorised as A (largest 30% of farms accounting for 68% of output), B (next 35% of farms, accounting for 24% of output) and C (remaining 35% of farms, accounting for 8% of output). Bar charts represent data for the middle 75% of each group, that is for the sample bounded by the lower and upper 12.5 % percentiles.[5] Synapse (1992).

Off farm income

Average nominal off-farm income on broadacre farms increased from about $7000 in 1983/84 to about $19000 in 1995/96 (Garnaut and Lewis 1997). Approximately 42% of this off-farm income was from wages and salaries and 6% from welfare payments, the remainder coming from off-farm business and investments (Peterson and Moon 1994). In 1996/97, the ratio of off-farm income to farm cash income for the smallest 33% of mixed livestock-crop producers was 1.6, for the smallest 49% of sheep producers 3.5, for the smallest 67% of beef producers 13.2, and for the smallest 70% of mixed sheep-beef producers it was 4.2.

Employment

Agriculture now accounts for about 5% of the Australian workforce and a quarter of all rural employment, down from about 50% in 1976. Over the same period employment in rural areas increased by about 50%.

Assistance

In 1994/95, government assistance to agriculture totalled $1.9 billion (Industries Commission 1996). It has been suggested (DPIE 1997) that this level of support should be compared with the total income for agriculture of $23.5 billion. Another perspective is provided by noting that agriculture represents 3% of gross domestic product, receives 16% of budgetary assistance from State and Commonwealth Governments, receives a level of assistance approximating net farm income and has effective levels of assistance equal to or higher than those in all other sectors.

The agricultural picture

In summary the overall picture is not encouraging.

Gains in physical productivity have not been sufficient to increase the real gross value of production. Aggregate farm income has deteriorated substantially, notwithstanding a substantial increase in the value of world agricultural trade. In the food and fibre based industries, Australia imports half as much as she exports. On-farm economic productivity is largely driven by economies of scale and more efficient production techniques, neither of which is likely to sustain competitiveness in the longer term. The majority of graziers earn the bulk of their income off-farm and, through the 1980s, tax payer support to the farm sector approximated net farm income.

The purpose in painting this picture is neither to become overly depressed, nor to attribute fault. It is a reality check, enabling a realisation of the need to reconstruct the 'problem', to gain insights and to transform those insights into creative products and processes.

Is agricultural research and development well placed to contribute towards achieving these goals?

AGRICULTURAL RESEARCH, DEVELOPMENT AND EXTENSION

The Australian agricultural research, development and extension[9] activity costs approximately $1 billion annually or about 15% of total Australian R&D expenditure. Australia accounts for approximately 2-3% of annual expenditure on agricultural RD&E worldwide, estimated to be $30 billion (adapted from Roseboom & Rutten 1996).

Institutions

The principal agricultural RD&E organisations include the State departments of agriculture, CSIRO, universities, Commonwealth bureaux and Cooperative Research Centres (CRCs). However, the range of public sector institutions involved in agriculturally related RD&E also includes, for instance, departments of environment and natural resources and State departments of business and commerce.

Public sector RD&E agencies are principally financed from public sector consolidated revenue. However, they, and private sector organisations, also obtain funding from Research and Development Corporations (RDCs).

Within their respective charters, the RDCs are dominating purchasers of RD&E services on behalf of the industries they represent. Similarly, to the extent that State Departments of Agriculture/Primary Industries are able to maintain RD&E programs not influenced by the RDCs, they are dominating purchasers and performers of RD&E services within their State boundaries. CSIRO is in a similar position to that of State Departments, except that its activities are delineated generally by the nature of the research rather than by geographic boundaries.

Expenditure

In 1996/97 Australia spent $8.7 billion on R&D, of which 61% was directed at economic growth. Agricultural R&D, costing $826 million, accounted for approximately one-sixth of R&D directed at economic growth. Environmental R&D in Australia accounted for a further 7.5% or $657 million of total R&D expenditure. (ABS 1998a).

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[9] Research is experimental, theoretical and investigatory work undertaken to acquire new knowledge. Development is systematic work drawing on existing knowledge (OECD 1994). Extension is defined as the use of communication and learning processes to facilitate change (QDPI 1990)

Expenditure[10] on R&D in Australia increased steadily over the past decade, with spending in 1989/90 terms, increasing by 57% between 1988/89 and 1996/97 (ABS 1998a). The business sector[11] has been responsible for most of this increase in R&D expenditure. While the Commonwealth and State Governments remain the main source of funds for agricultural R&D, expenditure on agricultural R&D as a proportion of total R&D funded by the government sector fell from approximately 39% in 1988/89 to 30% in 1990/91 and has remained at about this level.

Source of funds

For agricultural R&D undertaken by the government sector in 1996/97, 73% of the funding was sourced from within the organisation performing the R&D. Joint government/business sources, including funds provided via levies, contributed a further 15% and funds provided by the Commonwealth Government which were not spent on internally performed R&D activities accounted for 5.8% of funding. Private business enterprises (excluding agricultural enterprises) and overseas sources provided, respectively, 3.3% and 0.3% of the funding for agricultural R&D spent by government organisations in 1996/97 (ABS 1998b).

Only a small proportion of R&D funds provided by State Governments are allocated to R&D performers other than within the agency to which the allocation is made. For instance, in Queensland, only 3% of State Government R&D funds are allocated to the private sector, with the Department primarily responsible for agricultural systems allocating less than 1% of its R&D funds to the private sector (Synapse 1994).

Private sector RD&E performers operate in one or more of the following ways. First, they operate within commercial firms which are both funders and performers of R&D. These activities are estimated to represent approximately 4% of total agricultural R&D expenditure, or about $30 million per year. Second, agricultural consultants provide services to private sector clients at an estimated cost of approximately $50 million per year (based on Prinsley et al. 1994).[12] Third, private sector RD&E providers seek competitively allocated R&D funds from the RDCs, most of which have policies to encourage private sector involvement in R&D. The level of funding of private sector R&D firms does not exceed, on average, 10% of total RDC project funding, equating to approximately 3% of total agricultural RD&E funding, or $25 million per year (Synapse 1998).

Source of influence

A summary of agricultural R&D expenditure by funding and performing agencies is presented in Table 4.4.

Approximately 80% of agricultural RD&E funds are provided by the public sector and, of those funds, just under 90% is allocated by way of direct appropriation to agencies which are both RD&E purchasers and performers. This appropriation funding, which represents about 70% of total agricultural RD&E funding, is virtually all spent internally by the agency to which the appropriation is allocated. Additionally, public sector agencies, and the private sector, compete for funding from RDCs.

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[10] 'Expenditure' describes the costs associated with the performance of R&D as opposed to the original source of funds for the R&D.

[11] It is important to note that the Australian Bureau of Statistics (ABS) data for expenditure on R&D by the Business Enterprise sector do not include expenditure by enterprises primarily involved in agriculture, forestry and fishing. These enterprises are excluded from the Business Enterprise sector in the ABS R&D survey 'partly because of collection difficulties and partly because such enterprises are believed to have very low R&D activity' (ABS 1996b)

[12] Additional technical services are provided adjunct to the marketing activities of suppliers of agribusiness inputs.

Industry provides approximately 20% of agricultural R&D funds and less than 10% of agricultural R&D is performed by RD&E providers in the private sector. Nevertheless, industry, particularly via the RDCs, has a major effect on R&D directions and strategies. However, this influence is not conceived separately from that arising from other sources, including that from researchers. With this qualification, Synapse (1998) estimated that the RDCs are responsible for about 70% of the total influence exerted on R&D directions and strategies.

A survey was conducted to determine if this estimate applied to those people involved in the focus group discussions (refer chapter 3). The survey was conducted some six months after the focus group discussions.

Focus group participants were asked to estimate the influence of the RDCs over the direction (what is done) and the management (how, when and by whom) of research and development in their organisation and whether this influence generally is likely to decrease, remain stable or increase over the next five years. Seventy-one percent of the 65 participants responded to the survey questions. Three responses were not attributed and hence not included in the analysis.

The survey results indicate that sixty-two percent and forty-four percent respectively of the influence over the direction and management of research is attributed by focus group participants to the RDCs. There were no substantial differences in the average responses of people from different organisations. However managers estimated the influence of the RDCs over management to be much lower than the comparable estimate by researchers, fifty and thirty-two percent respectively. Approximately half of the respondents judged that the general influence of the RDCs would increase over the next five years, thirty percent indicating the influence would remain stable and twenty percent indicating the influence would decrease.

Table 4.4: Patterns of Agricultural RD&E Expenditure and Influence

Funding and performing agencies	Australian RD&E funds by providing agency[a] (funders & purchasers) (%)	Australian RD&E funds by receiving agency[a] (performers) (%)	Degree of strategic influence on Australian RD&E[b] (%)
Commonwealth Government			
via CSIRO	20	26	10
via RDCs	12	--	20
via Bureaux,			
Universities and CRCs	8	20	5
State Governments	41	47	10
Industry			
via RDCs	15	2	50
directly	4	5	5
TOTALS	100	100	100

(a) Approximate values based on several sources (Gleeson 1992, Industry Commission 1995, ABS 1998a & b)

(b) Synapse estimates based on views of persons experienced in the management of agricultural R&D.

People

RD&E's greatest asset (and cost) is people, with the direct and indirect costs associated with each scientist over his or her lifetime estimated to be between $3-5 million. The Australian Bureau of Statistics estimates that, in 1996/97 approximately 8300 person years were committed to rural R&D in Australia, out of a total committed to R&D of approximately 90 000 person years.

Outputs

As discussed in chapter 1, creativity and innovation arise not only from research and development, and may occur throughout organisations. Traditionally, the outputs of research and development are new and improved processes, devices and systems. Benefit cost analyses of research and development focus almost exclusively on the rate and extent of adoption of these products. However, the systematic processes which comprise research and development, particularly if executed in a participatory fashion, can lead to improved motivation and skills of the participants, which may not be directly related to the traditionally defined products arising from the research and development. These considerations should influence how agricultural research and development is funded and managed and the choice of institutional frameworks within which it is executed.

The R&D picture

In summary, Australian agricultural RD&E is characterised as being:

- substantial, with expenditure approximating $1 billion per year

- located within a total Australian R&D market of about $8.7 billion per year and an international agricultural market in excess of $30 billion per year

- conducted almost exclusively within public sector institutional and cultural settings and lacking in diversity

- dominated in direction and strategy terms by RDCs operating as dominating purchasers of RD&E services within their legislatively established charters and on behalf of the industries they represent

- generally not open to private sector RD&E providers, and

- fragile given its heavy dependency on public sector policies and institutional capabilities.

SUMMARY

There is a broadly based need for creativity to contribute to the development of the national culture, to the individual and to general economic prosperity. The need in agriculture, and hence in agricultural research and development, seems particularly acute.

The agricultural sector, and the broader political-policy environment within which it operates, is poorly attuned to globalisation and the changed nature of national and international competitiveness. The current debate about the future of the pork industry in Australia provides a contemporary illustration of this reality. The industry has been shielded from international market forces and now appears poorly positioned to participate in international trade.

The Native Title debate is another illustration of our inability to deal creatively with opportunities to expand the context within which agriculture operates. Native Title is a ball lying just outside the goal posts of cultural diversity, untapped creativity and environmental and product differentiation. But instead of developing a cohesive bi-cultural force to benefit from this opportunity, we have created opposing teams which sit in the dressing sheds paralysed by ignorance and fear. How then can we hope to manage the 'green' issues including food safety, nutrition and health, resource conservation, bio-diversity, animal rights and welfare and the economic and social stability of rural communities? When will it dawn on Australians that narrowly conceived policies based almost exclusively on agricultural issues are unlikely to make a decisive contribution to rural and regional development?

The present configuration of agricultural research and development has its genesis in the establishment of publicly funded agricultural research agencies in the United Kingdom and in Australia in the early 1850s (Alston, Pardey and Smith 1998). These experimental stations were staffed by scientists, a practice largely unaltered today, as is the over whelming dominance of the paradigm of increasing production through technological innovation. Private sector R&D remains underdeveloped and largely excluded from public funding. There is scant institutional or program diversity and competition between purchasers of RD&E services is virtually non-existent.

But perhaps most telling are our findings during this project of a widespread perception amongst researchers that they are neither led nor managed creatively.

Edited Transcript: 'The Need for Creativity in Agricultural R&D' [13]

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[13] *Presenter - Tony Gleeson: Chairperson - Alan Trounson*

Trounson: The picture you paint is fairly dark but, if you push the boundaries out beyond Australia, then it is brighter and maybe you need to do this to release the creativity.

Gleeson: Yes, but we don't even have a truly national R&D system. For instance, we don't have interchange of people between State departments.

Trounson: What is the future for these agencies?

Gleeson: I've advocated stronger connections between agricultural research and education and we must capture that fundamental synergy. To be blunt about it, the existence of State Departments & CSIRO have mitigated against the association between research and education, as does the lack of accountability of our tertiary institutions. Until we begin to address these issues, then I would not anticipate much change.

Lever, John: There needs to be stronger links with customers.

Drinan: If things are as bleak as you say, then why are we funding agricultural research?

Gleeson: I'm not suggesting we don't do it. Why we are has to do with history, politics and with the fundamentals of economies - one thing that is clear is that a lot of the growth in the economy has to do with the resource based industries. This inter-sectoral connectedness is not picked up sufficiently in the data I presented.

Eady: We don't build into the value of agricultural products the actual production and environmental costs.

Trounson: But how could you sell it if you do that?

Dickman: Have the agricultural industries not grown in absolute terms or is it just in relation to the size of the economy?

Gleeson: There has been no growth in absolute terms but we do need to recognise the competition for resources between industries, for instance for capital and labour. The essential point is, however, that there has been no growth in the real gross value of production, even though there are comments in the rural press that would have you believe otherwise.

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5   INVITED PAPERS ON CREATIVITY

This chapter comprises five papers contributed to a workshop on creative research environments in August 1998. As time permitted, the workshop participants discussed these papers after their presentation. Edited transcripts of the discussions are presented at the conclusions of three of the papers.

1   THE CREATIVE SELF - *Elke Niedermüller-Hughes*

In order to get a better understanding of the Creative Self, let us begin by looking at its tools for creation, which are the brain and the subconscious.

The Brain

The brain is a divided, walnut-shaped maze of 12-15 billion cells called neurons. That is, about three times the entire population of the earth waiting to be utilised. The power of the brain is largely a function of the number of neurons and richness of their connections. The potential number of inter-connections in the brain runs into trillions. Mostly they are made by using the brain. The brain is the only organ that expands through use.

The junction at which two nerve cells meet is called a synapse. A connection is made when one of a number of chemicals is released to bridge the gap between two neurons. These chemicals are called neuro-transmitters. The transmission of brain activity then is not electrical, but a physical/chemical reaction to an original electrical impulse.

The speed of the electrical activity of the brain is measured in wave forms and corresponds to different states of consciousness:

- the Beta wave is found in our normal waking conscious states (13-25 cycles/second)
- the Alpha wave characterises relaxation and contemplation, the state of mind during which we daydream or let our imagination run. It is a state of relaxed alertness that facilitates inspiration, allows for fast assimilation of facts and heightens memory. Alpha opens the door to the subconscious where our self-image can be reached (8-12 cycles/second)
- Theta waves are dominant during ages 2-5. They are observed in states of high creativity, deep contemplation and reverie (4-7 cycles/second)
- Delta waves reflect deep states of dreamless sleep. (0.5 - 3 cycles/second).

The relaxed states of either alpha or theta brain waves are most conducive to creativity. They allow us to explore the subjective worlds of our being by letting the imagination roam freely to find answers to our questions and solutions to our problems.

The Subconscious

The conscious state of Beta waves is like the tip of the iceberg, whereas the subconscious is the vast area which is immersed in deep waters.

It seems that Freudian psychology likens the subconscious to a large garbage bin. It contains all the traumas or unresolved issues of our personal existence. But this might be only one part of the picture. Carl Gustav Jung regarded the subconscious as "no mere depository of the past, but full of future psychic situations and ideas."

How do we access then this garbage bin/treasure box under the water in order to transform problems into opportunities or to bring the riches from the depth to the surface?

Einstein said, "Our thinking creates problems that the same type of thinking will not solve". In a letter to the mathematician Jacques Hadamard he elaborated, "The words or the language, as they are written or spoken, do not seem to play any role in my mechanisms of thought. The physical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be voluntarily reproduced or combined."

Einstein's statement is consistent with findings that affirm that the language of the subconscious and the conscious differ. The subconscious does not respond to concepts or words. The subconscious speaks in images and feelings.

What is the advantage of a language in images? It is simple: a picture is worth a thousand words. Picture thinking is estimated to be, overall, 400-2000 times faster than verbal thinking.

Nevertheless, positive thinking without feeling is like driving a Porsche without fuel. It won't go anywhere. "Thought creates form, but it is feeling that gives vitality to thought", said Paul Twitchell.

The subconscious deals with non-verbal material and does not differentiate between "actual facts" or "imagined happenings", it responds to both. "The human body cannot tell the difference between something real and that which is vividly imagined", said Maxwell Maltz.

The "as if principle" or "working from the end" is a means of getting
co-operation between the conscious and the subconscious. Many athletes make use of the "as if principle" by visualising the perfect outcome of their performance.

Working "from the end" is not a substitute for discipline but combined with a sound training, it is a means for making our dreams come true.

The language of dreams is also in images or metaphors and symbols. In dreams, our censoring mechanism is lowered and therefore our mind is more receptive to new ideas.

So it doesn't come as a surprise that many artists and inventors make use of their dreams to find answers to their questions. For example, the scientist Kekule dreamt about a snake biting its tail and this dream helped him to figure out the hexagonal shape of the benzene ring.

Bryan Mattimore recommends in his book *99% Inspiration* that "a good way to build your intuitive problem-solving skills is to start giving your subconscious nightly 'assignments' before going to bed. When you wake up in the morning, write down whatever happens to be on your mind. Often, these 'as-you-are-waking' thoughts will hold the answer - either literally or metaphorically - to the problem you posed the night before."

When I gave my subconscious the assignment to inform me about the nature of the creative self, I woke up in the morning with the memory of watching a mating dance of some large fan tailed birds. By closer examination of this dream I realised that a mating dance is a ritual towards the release of sexual energy and then it didn't take long for me to understand that sexual energy is actually creative energy.

Dreams are not only useful for resolving day to day problems but they also provide us with deeper insights. "That which the dream shows is the shadow of such wisdom as exists in man, even if during his waking state he may know nothing about it... We do not know it because we are fooling away our time with outward and perishing things, and are asleep in regard to that which is real within ourselves" (Paracelsus).

The Creative Self

We began by looking at the brain as the physical aspect of ourselves. Then, we examined the next level of our being, which is comprised of feelings and thoughts (our psyche). Finally, we will now consider the spiritual aspect of ourselves - or the creative self.

Artists, scientists and mystics alike refer to the creative self as the spiritual nature of man: William Blake said "now this creative power I think is the Holy Ghost." Albert Einstein spoke of "The most beautiful emotion we can experience is the mystical. It is the power of all true art and science." Finally, Paul Twitchell said "The secret of creativity is that ability to release the spiritual energy within one's self."

How do we go about this?

One way is through taking note of our dreams. "Dreams are a starting point for many who wish to begin the spiritual journey to God and do it in the easiest possible way. Dreams taught me to face myself, let me see the future, and took me to the heavens of God" (Harold Klemp).

Another way is to create moments of solitude to contemplate in. "Guidance then ventures in to the clearing we have created for it" (J. Cameron).

"All exists within," state *The Upanishads*. The ability to come up with inspired ideas and to make astute decisions comes from listening within. This cultivating of the inner self is a way of life rather than a technique. Creativity is not something we do but something we are.

"We are not human beings having a spiritual experience. We are spiritual beings having a human experience" (Teilhard de Chardin). To be creative is to claim our birth right as spiritual beings.

When Leonardo da Vinci was asked what his greatest accomplishment was, he replied: "Leonardo da Vinci".

We too are creators of ourselves, we determine our own destiny by our thoughts, ideas, actions, and creativity. "Human freedom involves our capacity to pause between stimulus and response and, in that pause, to choose the one response toward which we wish to throw our weight. The capacity to create ourselves, based upon this freedom, is inseparable from consciousness or self awareness" (Rollo May).

2   THE CREATIVE GAME - *Zara & Troy Swindells-Grose*

When we were asked to take part in a workshop on creativity on Tangalooma Island, we pondered how a couple of comedy-types, like ourselves could possibly offer anything valuable on such a deliciously broad topic as "The Creative Process"?

However, the thrill of a challenge is something we relentlessly pursue in our working lives ... so of course, we accepted the offer, packed our bathing suits and headed for paradise! Yee-ha, the creative process here we come!!!

Mind you, it was at this point that we were prompted to ask ourselves if we even had a creative process. Extraordinary! We had been working in the creative arts for the last fifteen years and never once stopped to question the process we had been subconsciously applying to every venture in our lives. So we are thankful for the gifts of awareness and clarification.

One of the mottos we live our lives by is quite basic, and yet consistently provides us with jaw dropping accuracy - put simply, it is this:

>   everything is exactly the way it is supposed to be

See, we figure that *stuff* is always going to happen, regardless of our approval or disapproval. So, why waste time lamenting what's lost ... when so much can be done right here right now... with whatever limited resources or time we may have?

We've started with a personal motto, because we believe the creative process is an intensely personal experience. All of our perceptions are incredibly coloured and influenced by our internal and external environment. So, how could we hope to improve our working situation, without first understanding our own inner conditioning?

Now this may come as a surprise but we are NOT living in a Perfect World (no shattered illusions there!). Regardless of what good intentions we all start out with, it's difficult to maintain a positive approach when at times it feels like everyone and everything is working against you.

That's why we've developed a process that ensures none of our creative time is dissipated or wasted on negative energy. This process, when circumstances are less than ideal or even restrictive, not only generates creativity, it encourages it. Rather than waiting for conditions to be close to perfect (or even bearable), our approach enables us to use any difficult situation to our advantage.

How.... we hear you ask? Well, we don't "work", we "Play"! Welcome to "The Creative Game"!

Viola Spolin, renowned theatre director and writer, said, "Essential elements for creative thinking are spontaneity and intuition."

Games encourage us to be spontaneous, because games are fun. Let's face it, everyone loves a good game. A game with challenging obstacles, defined boundaries and understood guidelines inspires us in both a relaxed and highly creative way. Interestingly, games with very restrictive time frames are often the most exciting games to play.

By applying a game philosophy to our work, we're learning to work smarter, not harder!

Understanding that work is play means that suddenly we accept the rules easily and with enthusiasm. When playing a game, restrictions are actually seen as a necessity, to ensure a degree of challenge, and provide fair play for all those involved.

When did we all get so serious? We just can't afford to put the "fun factor" on hold until we finish our "work". When playing a game, our energy levels are almost doubled. We rise to the challenge... we accept the rules with enthusiasm and ease, because we understand they provide us with a positive challenge and a clear objective.

Whether chess is your game, soccer, or even naked Twister, there's something about playing games that ignites the human spirit. It's more than just competition, or a battle to reveal the strongest or best participant - it's the sharing of one primary focus, a common unity! Obviously, we're not suggesting you turn up to work on Monday wearing jerseys and runners ... (although if that makes it more fun, go right ahead). The game happens in your head - it's an attitude. It's a shift in perception. Looking at the same task from another angle. To turn work into play, all that is needed is a revised thought system.

Any game worth playing is highly social and has a problem that requires a solution (just like work) - an objective in which each individual must become involved, if the team is to reach their designated goal. Once all players are aware of, and have agreed upon, the rules - the game begins! When work becomes fun, the players become agile and alert. The personal capacity to involve oneself in the equation of the game, and the effort expended to handle the multiple stimuli, whilst still abiding by the rules, determine the extent of the players' growth and, ultimately, success. When a game is in play, every part of the person is involved as a small organic whole, working within the larger organic whole.

So why did we turn our lives into one big game? We realised that what was lacking from our professional lives, was a sense of play. The word "work" over many years, had become so loaded with negative connotations, we realised it was no longer serving us well. We decided to give work up, and go out and play. We just got sick of waiting for conditions to improve around us, and decided to BE the change, before it could take place!

Playing, rather than working is about getting on with the job! Once the game is under way, you can't stop to complain how far away the goalposts are! There's no lamenting dropped balls ... so to speak! Your teammates, the other players, the officials, the sponsors, the crowd ... they're all relying on you! By treating our work as a game, we are instantly at a psychological advantage, as there is no longer the mental separation between work and play. It becomes more apparent that "work" is needed, to sharpen our playing skills, and "play" is needed, to enhance our work.

The beauty of the game is that you need do nothing more than shift your consciousness a little ... and instantly you become a player! All you have to do, right now is: train hard, obey the rules, respect your teammates, and understand that success will always be a combination of hard work, persistence and chance.

3   CREATIVITY IN SCIENTIFIC RESEARCH IN THE PUBLIC AND PRIVATE SECTORS - *Merilyn Sleigh*

What is Creativity?

Creativity in science is that extra spark that bridges the gap between a workmanlike set of technical results and a genuine advance in knowledge or understanding. As Albert Einstein said, "A theory can be proved by experiment; but no path leads from experiment to the birth of a theory".

Can Creativity be fostered in a commercial setting?

As a nation, Australia has been very successful in generating and publishing new scientific data. Internationally, innovative research commonly emanates from university laboratories and research institutes, less commonly from within industry. However, the emergence of Silicon Valley and the plethora of small biotechnology companies that have sprung up in the USA in the last twenty years indicate that innovative activity can take place in a commercial context. This paper examines to what extent conditions considered to foster creativity in research can occur in a setting where research is directed by commercial imperatives, or structured within tight time lines and narrowly defined pathways.

Conditions considered to be important in fostering creativity in research have been widely discussed. Developing ideal conditions for creative research is dependent on interacting characteristics of the research environment, the management context and the qualities and capabilities of the individual researcher.

Creative Research Environments

Environmental factors that can help to foster creativity in an individual or a research team include:

Time
- to develop depth and breadth of knowledge in a field
- to explore the specific problem being addressed with adequate allowance for inevitable failure and delays
- for "unconscious thinking" about the problem, to allow an out-of-context idea to develop, which may offer a new direction

Resources
- expertise, money and information need to be in adequate supply.

This does not imply that creative research can proceed only if money is unlimited. Rather, enough flexibility to explore unexpected findings and for thorough thought and high quality experimentation is required. Immediate access to scientific literature and frequent informal interaction with scientific peers is also highly desirable.

- Appropriate Reward.
- Recognition by peers may be at least as important as financial rewards
- Availability of mechanisms to inform and persuade others.

Creative research can only impact on a field if other scientists know of and believe in the work. Recognition by both management and the peer group is an important aspect of the reward structure, so presentation to the Board, and publication and presentation of results at conferences should be encouraged.

Creative Management Environments

Management can foster creative behaviour in research by:

- showing tolerance towards apparent disorganisation and towards the style of creative individuals who may not fit the mould of presentable company employees. A reasonable amount of failure and delay must be expected
- development of an approach to project planning which very clearly defines objectives but can tolerate some flexibility in the pathway to how these are reached. An appropriate balance between control and risk must be reached
- looking for project champions. Creative research is much more likely to result from intrinsic motivation (the researcher has a strong intellectual commitment to the project) than extrinsic motivation (the researcher is responding to someone else's agenda but does not have a strong personal commitment to the question being examined)

The Creative Individual

The creative individual:

- may be bold in approach or unconventional in his or her personal style, but can tolerate frustration and failure
- has an open mind, does not close off options too early, but recognises the importance of serendipity and the unexpected
- is able to integrate inputs from a range of sources, as well as building on a depth of knowledge in the field in question. Inputs may come from a broad range of knowledge of the individual, but will also come from a range of individuals with different backgrounds addressing different aspects of the same problem.

The Network of Enterprise

Creative research, or indeed any productive research, is ideally carried out within a network of enterprise, a set of related and interlinked activities proceeding simultaneously within a research group. The benefits of this environment are that it:

- provides intellectual, physical and resource critical mass, including multi-disciplinary inputs
- provides for exchange of people and ideas between different activities. If a roadblock is encountered in one area, focus can shift to another for a while
- allows for novel findings in a structured project (i.e. one constrained by timelines) to be diverted for exploration in a less structured setting
- allows for co-existence of structured (i.e. commercially-oriented) and non-structured (basic) research projects for inter-feeding of ideas
- allows for rapid uptake of commercial ideas emerging from basic research.

The Co-operative Research Centres provide a model for the Network of Enterprise concept and, when well organised and creatively managed, the CRC's have demonstrated the success of this approach.

Comparison of Academic and Commercial Research Settings

As might be predicted, it is much more difficult for the ideal conditions for creative research to be established when research is tightly controlled within formal management structures, and yet many companies have created strong research enterprises in which creativity has flourished. US Biotechnology pioneer, Genentech, contributed a number of major breakthroughs in the field of recombinant products in its first few years. From its beginning, it emphasised a neo-academic atmosphere, focusing on excellence in research, and publication of results in major journals. With

sufficient resources at its disposal, it established strong connections with nearby universities, and encouraged appointment of short term postdoctoral scientists and training of PhD students. These were attracted by the exciting atmosphere and excellent science of the company, and in return were able to develop a core of strong research to support the commercial interests of the company. Since the founders of Genentech were themselves scientists (and some of them quite eccentric), tolerance was high, provided that productivity and excellence were achieved.

Resources and rewards are areas where companies could be expected to outperform academic workplaces. Companies have the potential to deploy additional resources (people, money, external expertise) rapidly into a project when needed, providing strong support to their scientists. They often have considerable flexibility in reward systems. However, money is not the only motivator and scientists also need the acceptance and recognition of others, preferably their scientific peers, as well as of company management.

Time is always at a premium in the commercial world. Long term employees may be asked to change research areas relatively frequently (reducing the value of the knowledge base from which they must build creative research), while there is always pressure to complete projects within time and budgeting restraints. This leaves little opportunity to follow up unexpected results, or even for full evaluation of the results obtained.

Planning and reporting are essential components of any research activity - identifying the right question to explore, and stating it clearly, then planning at least the outline of how it will be addressed. These are very valuable exercises for a focused research effort. If creativity is desirable in developing a project, however, then reporting against this plan needs to be made a positive exercise to help in re-presenting the problem and re-focusing for the next stage. Reporting should not be a punitive exercise where any delay or deviation from the pathway is greeted critically. Scientific research cannot be planned and executed with the certainty of building roads or bridges, activities in engineering from which the current approaches to project management have originated.

In an academic setting, the periodic preparation of grant applications fulfils the planning requirements, while assessment of grant outcomes is part of the process of applying for the next grant. Generally, this assessment centres more on general evidence of productivity and progression in thinking than on narrow adherence to an original project plan.

What can companies and funding agencies do to encourage creative approaches?

Companies are not homogeneous and some are more successful than others in encouraging creative outcomes from work they fund. Some strategies that may be used in a commercial setting include:

- engagement of experts to address the problem. These people may be located outside the company and brought in on a secondment, as consultants, or funded *in situ* to address the question. Whichever, the appropriate body of background knowledge can be applied immediately to the problem, which can also be addressed within a network of related activities. A team approach with multi-disciplinary input may be appropriate
- insistence on excellence. Bad science can take a company along the wrong path and waste a lot more money than the 15-20% extra resources that might be needed to do that extra experiment or recheck uncertain results. Encouraging scientists to publish their results in good journals is an important strategy - not only does it help with the reward structure, but it also provides management with a quality check on the work being done. Famous scientists, Krebs and Lavoisier, have agreed that scientific writing is an integral part of the creative process, since it helps in ordering ideas and identifying gaps in knowledge
- engage in planning. Developing a shared view of the problem to be addressed, making sure scientists have good opportunities to describe their findings to management and recognising that

the research pathway may not be a linear one if creative steps are needed, are all important components of the creative research environment
- allow scientists sufficient time to deal with the problem and sufficient resources to cover gaps in their own expertise
- do not proceed with the work unless the responsible scientists are clearly committed to the project, and believe in its goals
- look for new ways to assess progress so that this becomes a part of the creative process
- allow individual scientists a certain amount of time to pursue ideas driven by their own curiosity ("skunk works") as long as these are not to the detriment of progress on the main task.

Conclusions

Maintaining creative research environments is an increasing challenge in Australia. Universities and research institutes are under increasing resource pressure, which not only detracts from the quality and quantity of output, but also endangers the critical "mental space" needed for creativity. Commercial environments have some advantages in flexibility of resources and reward systems, but time and resource pressures as well as lack of continuity for research staff in a research field may significantly discourage creative activity. Tightly structured projects carried out in an academic setting may be in the most difficult position, since resources, time and flexibility are all under pressure. However, there are some strategies that managers commissioning research can consider employing, as discussed above.

Very creative companies continue to emerge, indicating that creativity can flourish in a commercial setting. Australia will need to find ways to implement the models provided by these companies if it is to benefit from its own technological development in the future.

Edited Transcript[14]

Gleeson: Does the need for creativity differ according to the sort of research being undertaken?
Sleigh: Where there are clearly defined pathways there may be less need for flexibility of approach but this will not always be the situation.
Trounson: In some places there are strong cultures of discussion involving people from outside the research group. Does this still happen?
Sleigh: There is no single formula but most have a version of that.
Trounson: Do you think it promotes creativity?
Sleigh: Possibly, it varies between people. For me, it (the creativity enabled by conferences, seminars, discussions) may not be related to what is being said, it may be some idea on something else.

Source Literature

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[14] *Presenter -Merilyn Sleigh: Chariperson - Tony Gleeson*

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4 EDUCATION: FOSTERING OR CONSTRAINING CREATIVITY?
- Graeme Russell

This paper is based on my experiences in being both an observer and a participant in the education system, with a little help from the research literature. My observational experiences also draw on the analyses and insights of someone who has spent over 28 years as a primary teacher and two years as a lecturer in a teacher education program.

Creativity and the educational context

In the educational context, creativity has been closely aligned with divergent (as opposed to convergent) thinking. A commonly accepted definition is of the form:

> Creativity means a person's capacity to produce new or original ideas, insights, restructurings, inventions, or artistic objects, which are accepted by experts as being of scientific, aesthetic, social, or technological value. (Vernon, 1989, p.94).

As has been pointed out by Ryhammar and Brolin (1991, p. 270) there is considerable doubt about the links between performance on standard divergent thinking tests and creative production. Nevertheless, there has been an ongoing emphasis on the encouragement of divergent thinking strategies in relation to problem solving, especially in the early years of education.

A quiet revolution in the early years?

Torrance and Goff (1989) have argued that, since the early 1960s there has been a quiet revolution occurring in the US education system. The shift has been towards a greater emphasis on both creative problem solving and creative expression. This shift is evident in the Australian educational system as well. In the area of primary education there is now more emphasis on:

- an overall focus on diversity, individuality and on responding to individual differences
- structuring learning situations that require children to express their ideas about maths and science in both oral and written forms
- emphasising that there is more than one way to do a task or activity
- encouraging approaches to problem solving that have characteristics like: open-endedness, creativity, without prescription or a standard formula - there is no set way
- exploration and inquiry (especially in maths, science and human society and its environment), hands-on experiences or discovery learning
- applying learning from the inquiry process to design and product development
- group work and collaboration - recognising that creativity often develops from this process
- providing improved opportunities for people with exceptional talent and creativity to develop, e.g. in special classes or within mainstream using groups and questioning techniques
- recognising differences in learning styles and using these across curriculum areas
- reflective learning
- students taking more responsibility for their own learning.

The content of the curricula also reflects a broadened approach to creativity. Evidence of an emphasis on creative problem solving and creative expression can be found within the particular learning areas. In the Key Learning Area of Science and Technology, for example, three fundamental learning processes have been identified. Samples of statements made in the syllabus document are presented below to provide a flavour of the approach in relation to creativity:

Investigating

- "All people engage in the activity of investigating. It is an activity that capitalises on and develops curiosity. It is the core process whereby students develop understandings about natural and made environments. In the process of investigating, students should develop the following skills:

    Exploring and discovering phenomena and events*: exploring and discovering are closely related and interactive and foster curiosity.*
    Proposing explanations
    Predicting outcomes: *but to predict accurately, careful observations should be made about the relationships between observed events."*

It is also pointed out in the syllabus document that: "It is important to ensure that students are provided with opportunities at each stage of the investigative process to reflect upon their actions, their learning and how such learning relates to other situations."

Designing and making

- "Designing is an activity in which all people engage. It is a core process through which students try to identify needs and propose practical means by which these needs can be addressed." This process involves the following activities:

    Identifying needs and wants and defining a design task.
    Generating and selecting ideas to best meet the design task objectives. "This may involve lateral and imaginative thinking"....
    Using resources to assemble or construct products, systems or environments.

Using technology

- "A significant proportion of human activity involves the use of technologies. As a result of science and technology education students will learn to use a wide variety of tools, hardware, materials, equipment and software appropriately and safely." Among other things, it is intended that technology will be used: "as a resource to enable students to develop co-operative skills, risk taking and a sense of control over technology."

Possible constraining factors

The successful implementation of a different and more creative approach to education, of course, depends on a range of contextual factors. Experiences in the six years since the formal introduction of this different approach indicate that the following factors have operated as significant constraining forces:

- the hierarchical nature of the school system
    - a lack of leadership in valuing creativity
    - a lack of consistency of philosophy throughout the school system
- an emphasis on formal assessment
- a renewed emphasis on teaching basic skills and evaluating educational outcomes in terms of performance in public exams
- a continued reliance on traditional teaching methods (chalk and talk)
- physical and resource factors: size of room and number of students, lack of flexibility in furniture/room organisation, lack of flexibility in resource allocation, absence of resource material

- classroom atmosphere/culture: it is difficult to foster creativity without having a classroom based on trust, warmth and security. This is needed especially to ensure children will take risks and express themselves
- absence of appropriate role models from teachers
- lack of knowledge and commitment from teachers. Issues here include:
  - lack of knowledge and skills (absence of in-service training). Teachers need to believe in what they are doing and be able to use questioning skills.   They need to know what types of questions to ask to foster creative thinking (vs telling and being the source of information)
  - some teachers are unwilling to use alternative teaching strategies, e.g. group work and discovery
  - fear of not having control and not being able to manage the classroom behaviour of children. This is a more challenging way to teach and requires greater planning and energy.

The tertiary sector: being creative about creativity?

As Ryhammar & Brolin (1991, p. 269) point out: "It seems reasonable to say that the university has traditionally been regarded as a natural home for those who think differently, for those who are creative and have the capacity to see reality in new and original ways." Yet, we are unsure how close this is to reality for, as they argued, there is very little research on factors within the university that either facilitate or constrain creativity either at the undergraduate or postgraduate levels.

I want to re-visit the changes in approaches to primary education identified above and use this as a way of analysing the tertiary sector. I have not conducted a thorough analysis of this sector and hence my comments are based heavily on my experiences. It also needs to be recognised that there are excellent examples of alternative and creative approaches to tertiary education, for instance the work of Professor Richard Bawden at the University of Western Sydney and the approaches being adopted in the Medical Faculty at the University of Newcastle:

- An overall emphasis on diversity and a focus on individuality and individual differences.
  There is little recognition of this approach in the tertiary sector. Yet, in one of the few studies conducted, Chambers (1973), found the following characteristics of university teachers to have the greatest impact on student creativity: treatment of students as individuals, encouragement of independence, being positive role models, more time spent with students outside class, expectations of excellence and achievement, enthusiasm, acceptance of students as equals, directly rewarding students' creative behaviour
- encouraging students to express their ideas
  We commonly expect students to "go to the library" and find support for their ideas. We place overwhelming emphasis on the accumulated body of knowledge and research and tend to dismiss discovery learning. Students are often discouraged from pursuing an idea if it is not part of someone's theory or if there is not a standard measure for it
- demonstrating that there is more than one way to do a task or activity.
  Our approach emphasises consistent standard processes. We rely heavily on traditional approaches to teaching: lectures, tutorials, practicals, essays, research/laboratory reports

- encouraging approaches to problem solving that have characteristics like: open-endedness, creativity, without prescription or a standard formula - there is no set way
  The majority of assessment processes emphasise a standard outcome or solution to a problem. There are few opportunities for students to develop creative problem solving skills
- exploration and inquiry (especially in science), hands-on experiences.
  Learning is usually highly structured and there is limited opportunity for exploration and inquiry. More often, exploration and qualitative analysis is seen as being preliminary to the main event - a tightly controlled experimental study based on theory. Yet, a good deal of our current knowledge in many fields is based on exploration/observation/ description, for example, Piaget's work in understanding cognitive development in children

- applying learning from the inquiry process to design and product development.
  There are limited opportunities to engage in the process of applying learning. Indeed, in a recent review of one university department, a postgraduate program was criticised because it was too applied!
- group work and collaboration - recognising that creativity often develops from this process. The overwhelming emphasis is on individual work. There are limited opportunities for genuine collaboration in the context of creative problem solving. Indeed some universities place restrictions on how much of a student's assessment can be based on group work. In contrast, in a course this year, I have divided tutorial classes into teams. Each team has responsibility for conducting two tutorials. They have been given only two guiding principles: (i) Enable the class to understand better the basic lecture/textbook material; (ii) Facilitate group discussion/questioning.
  The analysis conducted by Gran (1981; cited in Ryhammar and Brolin, 1991, p. 274) is also instructive here. Gran conducted an empirical investigation of obstacles to innovation in the university. Factors identified included: lack of resources, jealous guarding of preserves, competition, insecurity, intolerance, lack of involvement and poor internal relations.
- providing improved opportunities for people with exceptional talent and creativity to develop. There are limited opportunities for those with exceptional talent to progress in a different way. The only option they have at the undergraduate level is to complete more courses in a reduced timeframe
- recognising differences in learning styles and using these across curriculum areas. This is rarely recognised
- reflective learning. This is rarely incorporated into the university teaching process.
- students taking more responsibility for their own learning.
  Most learning is directed towards formal assessment and there are high demands for students to focus on this goal only.

Despite the general lack of research into creativity in universities, Bargar and Duncan (1990, p.60) argue that they were able to identify five general supervisory principles (supported by the literature) that will facilitate creativity in PhD research:

- help the student increase his/her understanding of the complex processes involved in creative research endeavours
- establish and maintain an empathic relationship with the student to facilitate relevant student-adviser communications about the creative research endeavour
- help the student identify and conceptualise a research problem consonant with his/her talents and goals for personal and professional development
- optimise the levels of student autonomy and responsibility in all phases of the creative research endeavour
- develop mutually acceptable qualitative expectations for progress, enabling the student to focus his/her creative potentials on the research task.

Finally, universities are increasingly emphasising more broadly based student outcomes.

At Macquarie University these have been determined to be:

- mastery of the fundamental principles of their chosen disciplines
- a commitment to life-long learning with the capacity for independent learning and inquiry
- an appreciation of the search for truth in complex fields of study and experience
- generic skills with flexible applications in the workplace over a life's career, including communication skills, teamwork and the capacity to work with others
- the capacity to bring interdisciplinary approaches to solving problems
- a sense of social responsibility and a sensitivity to other peoples and cultures

- critical and analytical skills
- an understanding of the role of science, technology and the humanities in society.

It seems that the development of this approach to university education provides an opportunity to engage in a debate around the value of creativity and to develop processes and outcomes to increase the possibility that our graduates are able to make a creative contribution to research and to society.

Edited Transcript[15]

Fawns, Kate: There are lots of techniques you can use to enhance creativity - we talked about colour and music. These are used in some classrooms. And Andrew Borell mentioned that he feels he needs to be creative across several areas for him to be creative in science.

Drinan: You never know where the corporate creativity force will come from in an organisation. So it is all about creating the conditions that enable the creativity to be expressed. How, Tony Gleeson, does this fit with your reading, your thoughts?

Gleeson: The world is awash with management advisers who advocate the generic adoption of particular strategies. But it is a complex situation with lots of different factors operating. There are factors irrespective of the environment, for instance, perseverance.

Drinan: I think the point is that you never know which of the creative persons is going to be creative.

Gleeson: There is probably not much mileage in trying to select creative people for research because you probably need a mix of people anyway. And there is the issue raised by Beth Woods of how much creativity do we require - though I think we need to be careful to avoid the presumption that because we might work in applied areas we don't need to be creative.

Borell: The talk about children makes me think of the need for unstructured time for children to explore and exhibit creativity and I wonder how this fits into research.

Russell: I agree, the unstructured nature of time is important.

Eady: How should we design our performance evaluation programs? That is what I'd like to get out of this workshop.

Russell: That is a challenge and we might not have the time here to deal with that issue for every situation.

Gleeson: This study, at this stage at least, is not about what strategies a particular organisation should adopt but rather it is about the processes of creativity and what principles we can deduce from that understanding.

Trounson: Are there some strands that are common between different levels of education from children onwards - is it all to do with curiosity?

Russell: I don't have a problem with that. There are lots of approaches that could be used across the different levels of education. But the problem we have at the moment in the tertiary sector, is that the structures, the systems, the expectations limit change.

Trounson: In many situations it appears that very structured systems in Asian classrooms produce high levels of performance across a range of assessments and they have virtually no free time.

Russell: The emphasis on basic skills tests will push us in that direction and I'm not sure that will promote creativity.

Drinan: As another university person I'd agree with your analysis that universities generally are not fostering creativity. But there are some good examples at Newcastle and at the University of Western Sydney Hawkesbury. So it is possible, but the resistance is very great.

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[15] *Presenter - Graeme Russell: Chairperson - Tony Gleeson*

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5   HOW INDUSTRY CAN FOSTER CREATIVITY IN AGRICULTURAL RESEARCH AND DEVELOPMENT - *Wendy Craik*

Before examining how industry might foster creativity in agricultural research and development, it is useful to examine the public impressions of farming and of farmers for these impressions in part influence the environment within which research and development operates.   The following information is drawn from an independent survey of Australians conducted by Sweeney & Associates for the National Farmers Federation in 1997.

Of those surveyed, 99% believe that agriculture contributes to the economy, 46% believe it is the most important industry and many think agriculture constitutes 30-60% of national gross domestic product. People think of farmers as honest, down to earth and hardworking and they have an "old McDonald" image of farmers as being people who milk cows, check crops, etc. Their information on farming and farmers comes primarily from their early school days, with fewer people than in the past with relatives in farming and fewer visiting farms. However, agriculture and rural Australia are still important to the Australian psyche as evidenced by the popularity of Country Road designer clothes, Akubra hats and RM Williams boots.

In summary, impressions of agriculture are of sweat and blood, of honest yeomen and antiquated technologies and that it is important to the economy. The reality is that more than 30% of the agricultural workforce are women, productivity is high and technology uptake is rapid. The top 25% of farmers achieve a 10-15% return on capital, although 60% do not make a profit. The negative image of farming and of farmers discourages the entry of young, bright people and discourages investment.

The characteristics of agricultural industries which are performing relatively well, as presented in Table 5.1, may tell us something about how to promote creativity.

Although one can't be categoric about it there does seem to be a synergistic relationship between industry success, R&D and creativity.

There are various actions that industry can take which will either directly or indirectly affect creativity.

Education and Training: Training, skills and education are very important for taking up new ideas/flexibility and these need to be promoted by farm organisations.

Leadership: Australian Rural Leadership Program and other leadership programs including grass roots leadership training.

Diversity: More women and more young people in farm organisations.

Image of Agriculture: Promote good news stories.

Recognise R&D Achievements: Promote R&D, $ value and other values

Table 5.1 - Characteristics of Selected Agricultural Industries

Cotton	Wine	Dairy
• age • gender • lack of government involvement in marketing • strong research and development • sensitivity to community ideas • conference - all parties participate • over-arching organisation	• little government involvement in marketing • branding, quality • research and development • 25 year plan - all sectors	• restructuring: 30 000 have left the industry • reducing government involvement in marketing • transition from bulk milk to cheeses, etc • instant feedback on products • co-operative research and development

Institutional Arrangements: Industry needs to reflect on the institutional arrangements for R&D as there does seem to be a basis for some concern. Industry organisations have a responsibility to constructively engage in promoting reform as and when it is required. My experience is that new organisations tend to be creative but it requires a will to keep it that way. The NFF ran a conference with all players about three years ago and possibly needs to consider some form of follow-up action. This is an opportunity to review and look forward as an industry to where we want to go.

Diversity in R&D: Encourage people outside agricultural R&D into it; interdisciplinary, multi-disciplinary; consider the need to restructure jobs of some people in our research organisations; people should do what they are good at: counting beans or R&D.

Partnerships: Involve clients on day one; ensure the involvement is genuine - not token; some of most creative/enjoyable lasting work is done that way.

In conclusion, industry (and other players) could foster creativity in agricultural research and development by:

- promoting good things in agriculture
- encouraging and valuing education and ideas
- encouraging diversity broadly within the sector
- finding ways to get players into new environments, eg overseas
- encouraging leadership programs
- industry and R&D jointly developing proposals and working on them
- encouraging interaction between all facets of industry
- jointly preparing a plan for industry sectors
- industry recognising and rewarding creative achievement, and
- industry tolerating a greater percentage of blue sky research.

Edited Transcript[16]

Gleeson: The discussion with scientists indicated some concern about the competencies of industry people on research advisory committees and boards. I felt at the time that many may not have known much about those people and I wonder if it would be useful to publicise their capabilities so as to improve trust and respect? And perhaps there is also a need for training of appointees?

Craik: I think that is a fair comment. There are trade-offs of the time and costs. The other comment I'd make is that these advisory committees need to be properly resourced and listened to. And more interaction between the advisers and advisees is desirable; otherwise it becomes counter-productive with the advisers getting fed up with not being properly regarded and the advisees not getting what they need.

Lever, John: One needs to build change into the business plan. If you look at agricultural R&D responding to a fairly conservative client base, how do you see this happening?

Craik: That is an interesting question and I'm unsure of the answer. There needs to be attention to those who are successful. And we need to consider the balance of research on single commodities versus more broadly based approaches.

Kerin: In general, policy will move towards the top 20-30% or it will go regional. In terms of research and development, we really do need a lot of younger smart people rather than the experienced agro-politicians And there is the difficulty in dealing with public good research.

Trounson: The difficulties can be demoralising. For researchers it isn't appealing to put one's bag of creativity into an industry with bleak prospects. Do you have a view on this?

Craik: It can be a negative feed back loop.

Drinan: Could I ask you to elaborate on your comment about moving away from single commodity research?

Craik: Perhaps we ought to look at this.

Drinan: You mean two or more corporations working together?

Craik: Yes, maybe.

Drinan: We already do that to a fair extent. R&D has driven down the costs of production for those who do remain in the industry.

Woods: You mentioned that perhaps industry should tolerate 5% of blue sky work. And there are gender issues as well broader tolerance considerations.

Craik: I think there is the broader issue of needing to increase diversity and tolerancegenerally in agriculture.

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[16] *Presenter - Wendy Craik : Chairperson - Tony Gleeson*

6 WORKSHOP DISCUSSIONS ON CREATIVITY

The purpose of this chapter is to present observations from a workshop on creativity in agricultural research. Workshop participants included agricultural scientists, artists, educationalists, innovators, industry and community representatives, comedians and research administrators, as listed in Appendix I.

INTRODUCTORY DISCUSSION

A plenary workshop discussion was held after presentation of papers on How Creativity Happens (Gleeson) and The Views of Agricultural Researchers & Their Managers (Woods), as presented in chapters 1 and 3. The discussion chairperson was Alan Trounson. The following is an edited transcript of the discussion.

Trounson: This is an open session, although I suggest we avoid spending time on the quantum of resources available for research.
Lever, John: Could you tell me where creativity ends and innovation starts?
Trounson: Gleeson's paper does provide a distinction and we could probably debate that for a while.
Gleeson: I have changed on this, for I started with Csikszentmihalyi's view that a product is only creative when it has had an impact on the discipline area, or the art field or whatever. And this can lead on to a view that it has to have say an economic impact. But terms are only of any use if they can be used to differentiate and so I tend to side with those who define creativity as the process of producing novel and useful ideas and these can be recognised but not used then or in the future. Whereas innovation is the pulling together of those ideas and others and, with further creativity, their implementation. There are many creative steps needed to produce something from the initial creative idea. Creativity needs to be not just focussed on the technological product but also on managerial and organisational change. Innovation has to do with the gaining of societal wide benefits from creativity.
McDonald: I'd like to challenge the perception that may have arisen from Gleeson's presentation that the creativity arises only from the scientists, whereas in reality it also arises from research managers, clients and people not closely associated with the research discipline.
Trounson: Could I ask John Passioura to comment?
Passioura: Yes ,some groups do lose their way. The enormous importance of the environment has been mentioned on several occasions. There has also been comment about the good old days which were highly productive. Now clients have more impact and this perhaps helped initially but it may cause a fall off in creativity. We need to work to get the best out of systems that involve both clients and scientists.
Trounson: How do you see this situation, Wendy Craik?
Craik: I don't have a long history in agricultural R&D but Tony Gleeson was talking about creativity requiring tolerance of ambiguity and I don't think the rural sector is very comfortable with ambiguity generally. One of the things that needs to be built into the system is an acceptance of failure. Perhaps the degrees of accountability we require selects against risk adverseness. The RDCs are regarded highly but, reflecting on John Kerin's earlier comments, perhaps we ought to reflect on the current system. Industries regarded as being successful - say cotton, with 1300 people at conferences, a high proportion of females, lower average age and people from all different functional areas; diversity and interaction. Is this related to creativity?
Trounson: With cotton and wine they have the financial capability to grow.
Craik: We really don't know how important these factors are to creativity.
Dickman: Is creativity cyclic? What are the causes and effect?
Sleigh: Those industries seem to share problems, whereas in other industries there is more of a stand-off with the RDCs in the middle between the researchers and the industries.

Drinan: Reverting to Beth Wood's presentation, I find it a bit hard to believe that the views of scientists and their managers are common for all RDCs, because the RDCs really do differ a lot. Additionally, if we look for enhancing creativity we should look not only at the RDCs, or just at the research institutions. We need to recognise that it is these relationships and maybe others that are important. And you mentioned the idea of trust and I think if we can get trust between the RDCs and researchers then we can get longer term projects.

Trounson: That seems to be important, and intellectual property is a key element, especially in the international scene. We need to come together in larger projects and institutes.

Pini: I wonder if the scientists are thinking of themselves as the experts and that others ought to leave them alone?

Trounson: The team spirit was seen to be important.

Pini: Yes, with other scientists, but more broadly?

Woods: There is a lot of potential in the partnership idea. One of the drivers for creativity is the worthwhileness notion defined in usefulness for clients, industry. There were a lot of comments that the creativity needs are not restricted to the science activity.

Perkins: Maybe we should be measuring creativity not only in ways that can be measured by dollars.

Trounson: Could you elaborate?

Hamblin: Yes, for example, it is difficult to measure the benefits of education. The attempts to broaden the national accounts reflect a changing view, and I agree with Wendy Craik about the need to allow for intelligent failure.

Coffey: There is work in the environmental areas related to costs of not publishing failures.

Dickman: Why not measure the success of research against the expectations of those putting up the money?

Trounson: Would you comment, John Drinan?

Drinan: I'm unsure. Ian Perkins mentioned social and natural capital. For the RDCs we need to satisfy industry and government and they need to know the usefulness of their investments. But we do need to keep a focus on the social and environmental policy.

Dickman: With a lot of community development, they know what they want but need help as to how to achieve it.

Gleeson: This is important. There is a failure to appreciate the fact that the industry pays only about 15-20% of the cost. So you have the dear old taxpayer paying about 80-85% of the cost of research development and extension. And these people aren't there throughout the process. The second problem is that you have a very fragmented system so the different co-funders have different interests and timescales. Third, a lot of the specification of the benefits are measured in relation to the individuals in the industry at that time, rather than in relation to the industry at a future point in time.

Trounson: Can we just try to pinpoint some of the key issues? The interlinking between people is one of the issues. Second, creativity is needed throughout the chain of innovation.

Perkins: If you value the process, then it becomes easier, for the process is very important, not just the traditionally measured outputs of the research.

Woods: One of the considerations is how long the RDCs have been going.

Hamblin: Audit requirements tend to be in relation to inputs, whereas industry looks for outputs. And second, the level of understanding of research varies enormously between and within industries.

Kerin: Is the research better in different organisations?

Lever, John: Image is important. We need to market research, the scientific profession.

Trounson: But movements tend to be small and the media aren't interested.

Lever, John: But marketing people would take a different approach.

Craik: The tall poppy syndrome exists. Also people with new ideas aren't valued as compared to sports people, financiers etc. Our scientists aren't known.

Dickman: And that will affect entry of young people into science.

Lever, John: If the taxpayers pay 80% of the costs, they should be told what they are getting for their dollars.

Dickman: Is it that the wool industry didn't capitalise on the good time?

Trounson: Difficult to determine where to put research dollars in the wool industry.

Niedermüller - Hughes: There seems to be a lack of communication between the researchers, the RDCs, the industries and the taxpayers.

Trounson: That pulls it together nicely.

Niedermüller - Hughes: You Anglo-Saxons are hung up on the dollar.

Borell: I think scientists should also be involved in the marketing because they are passionate and knowledgeable about what they do.

Passioura: The Grains RDC has a good marketing arm but it is time consuming.

Niedermüller-Hughes: It is not just a matter of marketing but better communication and mutual understanding between the various groups - there needs to be a change of consciousness.

Sleigh: We need to go back to the trust issue; and how one goes about the communication is terribly important in relation to trust.

Hamblin: We cannot rely only on market driven research. Also it is difficult to do co-operative research in a highly competitive funding situation.

McDonald: The most creative team in our group is isolated from RDCs, industry and other researchers because of the need to protect intellectual property. And there may need to be more of this sort of arrangement.

Trounson: Should we be looking at reward systems?   Should there be the potential to pay elite salaries?

Woods: Most of the scientists were not focused on personal rewards, in monetary return.

Gleeson: Researchers were most concerned about the lack of recognition from RDCs and their own research organisations. And in commenting on John Drinan's earlier point about whether all RDCs are perceived to be the same, we haven't data to answer if all RDCs are considered to be the same. The RDCs were not uniformly represented by the researchers interviewed but, by and large, there was a broad smattering of people with contact across the corporations. Turning to Ian Perkins' point about criteria for evaluation of R&D, the economic performance of the sector is poor. If we are going to move away from the economic angle, then we need to conceive a whole new world. In spite of a 2.5 fold increase in world agricultural trade, we haven't made an additional real gross dollar over the past twenty-five years.

Dickman: What are the others doing better?

Gleeson: I'm not sure. There are more players and there are different policy settings. But there are also cultural features.

Eady: Are we lacking creativity in the science areas or in communities more generally, in the farming sector? Why target creativity in science?

Gleeson: I'll touch on this tomorrow but creative products need to be useful and, if we are to have partnerships, we can't quarantine one group from the need to be more creative.

Trounson: I think it will get worse. We need international partnerships.

Coffey: We have had a focus on net present value of research. But some US data would show this might not be the best way to go and we should look more at the alignment between research and corporate goals.

Eady: We have focused on research creativity. We need to focus it more broadly for our scientists are very creative. We should focus on marketing and the commercialising of our research.

Trounson: Internationally, there will be enormous amounts of money put into these things.

Dickman: Rural communities focus on education, human capital.

Trounson: That is important.

Hamblin: The economy is maturing and we need to look closely at the ownership of intellectual property. This is where the creativity is needed.

Drinan: Creativity in science and creativity in industry development - the challenge is to harness all this together. DRDC is spending about one third of the budget on regional development.

Trounson: Internationally?

Drinan: No, locally and not much internationally.

Fawns, Kate: I don't think there has to be a problem for creativity to happen and this opens up the discussion more broadly. In the arts area, there are training sessions for funding applicants, there is extensive use of peer review. Maybe the lack of peer review in agricultural science is a problem. Such peers appreciate the creativity and are flexible in regard to how it (the project) progresses.

Woods: We haven't looked at creativity in research in the commercial sector and maybe we are too dependent on research in the public sector.
Trounson: I've heard people talk about building private sector capacity but it hasn't happened.
Kerin: The private sector won't develop without access to research funding.
Coffey: We need to become unfettered by the need to be working in Australia on Australian problems.
Trounson: I reckon that it is important to broaden that framework. But we must conclude at this point.

PERSPECTIVES ON CREATIVITY

In the final workshop session participants began a process to identify principles to guide how we might foster creativity. The session was chaired by John Drinan and facilitated by Shaun Coffey.

Overview (Tony Gleeson)

It is difficult and possibly not very productive to isolate the various elements of creativity. It is a complex phenomenon and, while there are substantial environmental impacts on creativity it remains very much a product of the individual and of the social context within which that individual operates. Hence, rather than examining the separate elements of creativity, I suggest we explore it in its entirety from the perspectives of the end users of the research, of research funders, of research organisations, of research managers and finally from the perspective of the individual or team of researchers. We also need to examine creativity across the various investigatory, marketing, production, financing, processing and other functions that comprise our agricultural systems. Hence, we might think of creativity as dew drops on the web of innovation, not just at the centre, but throughout and inter-connected.

In examining creativity from each of these perspectives, we should avoid externalising the need for it. To illustrate this syndrome, research managers who participated in our focus group discussions generally highlighted the creativity needs of researchers rather than those of themselves.

There is a wide range of issues that we need to distil to develop a framework for creativity. We need to consider the individuality of creativity, yet recognise that the preparation, evaluation and elaboration phases at least are heavily dependent upon the social context within which they occur. Everyone, not just the researchers, needs to become immersed in the issue and its context. Hence, the utility of the concept of time bound consultation is open to question and possibly we should be exploring innovative ways to increase the scope and depth of immersion.

How do we strengthen social interaction - over and above implementing more defensible and open policies on attendance at conferences, sabbaticals and the interchange of personnel? How do we ensure in our project management paradigms that we recognise the importance of the investigatory team and that project-specific decisions are likely to have broader ramifications for the vitality and cohesiveness of the social framework? How do we capture the creativity ignited by gender, age, discipline and cultural diversity and how in fact do we better nationalise and internationalise our research efforts?

Discussion

John Passioura endorsed the need for individuals to be fully immersed in the discipline(s) and problem or issue contexts yet he raised the important concern that overconnectedness may constrain the time and space available for creativity.

Alan Trounson emphasised the key role of the research manager, team leader. They set the scene yet they get tired and need the opportunity to recharge themselves.

Beth Woods and Andrew Borell highlighted the importance of working in a group of people who have multiple and varied interests which they are prepared to share.

Bea Duffield raised the need for trust to enable people to explore their mindscapes in a social context, a view endorsed by Andrew Borell who recognised that, continuing his exploration analogy, people "on the edge" often are very vulnerable. Kate Fawns added the desirability of positive feedback to help transform the interest into a passion, perhaps touching on the link between sexual and creative energies mentioned earlier by Elke Niedermüller-Hughes. Alan Trounson reminded us that the climate of trust is affected by the way competition, intellectual property and recognition are managed, a point that was raised in a number of the focus group discussions.

The importance of the "skunk works" phenomenon was discussed in some detail, with the general view being that is an important area for research creativity. Vicki Dickman drew parallels with the community development activity, where the project has to be reasonably well advanced before funds can be applied for, with the attendant danger that the project will be deemed to not require additional resources. For public sector research organisations, the importance of competitively sought funds as compared to appropriation funds is important as is the way in which the appropriation funds are allocated.

John Taylor suggested that greater use might be made of scoping studies to determine the nature of issues, their importance and whether they are researchable. This is an emerging approach as accountability requirements increase. Possibly, some elements of our current systems reflect a high level of creativity in the past absence of adequate accountability so in some way we need to place this creativity into an accountability context. It is a question of balance and that is the real challenge. John Drinan observed that the RDCs are still evolving from an initial position of needing to improve focus and accountability to a position now where trust has developed to a the point which enables alliances to be developed between the funders and providers.

To assist progress of the workshop, Shaun Coffey provided a distinction between principles, viz., guidelines and fundamental truths, and strategies, viz., for planning and conducting activities. Workshop participants considered the extent to which it is desirable and possible for generic strategies to be developed.

There was considerable empathy with Sandra Eady's call for the principles governing creativity to be translated into pragmatic and implementable strategies. However, there are dangers in adopting a generic prescriptive approach to fostering creativity and the general view was that it would be preferable for the workshop to identify guidelines for subsequent consideration and implementation within particular circumstances and organisations. Beth Woods raised the question as to whether action to foster creativity by any one organisation can be effective, given the multiplicity of organisations and individuals involved in most agricultural research programs.

John Drinan suggested that we might draw on our conceptual understandings of creativity by reflecting on our experiences of creative environments as illustrated by the following edited transcript of his description of his own experiences at the University of Western Sydney, Hawkesbury.

Soon after I got there a new head of school was appointed, Richard Bawden. When Richard arrived it was like a breath of fresh air - no, more than that, a gale of fresh air ... and he would say, 'If you have ideas, use them, I'll not hold you back' .... There was a lot of unease within the faculty and Richard capitalised on that unease to the point that, as soon as things began to stabilise, he would throw another rock into the pond and cause another set of ripples ... he would constantly inject new ideas

into the system... without notice, he would barge in and excitedly talk about his ideas ... hence giving permission for people to experiment, to think.

Workshop participants worked in four groups to develop principles to guide creativity from the perspectives of the end users of research, the funders of research, the managers of research, and of the researchers themselves. There follows a synopsis of the observations of each group and a short edited discussion on those observations.

Perspective of End Users of Research

Synopsis

We need to measure, encourage and recognise research in terms of the progression of the process as well as in outcome terms: so take the word "failure" out of the picture. From a community point of view, communication in all directions is a very valuable principle to encourage creativity: to help ensure that the right research is done, to help in the adoption of results and to assist the processes of creativity in all groups. The community itself needs to be open to diversity and to new ideas. We need to focus on uniquely Australian products and systems and we should look less to European systems, in order to identify what will be sustainable in Australia, e.g. research on acacia versus wheat for flour production. And, finally, end user groups need to market and encourage the adoption of research findings.

Discussion

Lever, John: We need to resolve who are the stakeholders. Our group concluded they are the rural industries rather than communities at large. And we need to go back to scratch and divorce ourselves from the traditional pressures which are such a force in Australian agriculture.
Coffey: We need to suspend judgement and encourage diversity in ways which are unique to Australia.
Perkins: Perhaps we ought to think of these past 200 years as immersion and move on from there?
Lever, John: We should encourage commercial service companies to invest in R&D in developing new industries.

Perspective of Research Funders

Synopsis

Funders need to provide quality feedback not only to researchers but also to industry, to provide a sense that all contributions are valued. We need to include the whole spectrum of business and other people in the research processes. Funders have a responsibility to indicate both what they are and aren't doing, and why. Funders should encourage perspectives from outside the box and not rely entirely upon those we know to be performers in our respective fields. Funding organisations do need targets but need to be careful not to overly specify those targets. And we need to reduce the administrative loads.

Discussion

Coffey: Do research funders assume that researchers have a level of responsibility?
Russell: I'd have thought most researching scientists would have a reasonably high level of responsibility.
Dickman: If there is creativity in the vision and culture of an organisation, then scientists will work towards those goals without having them imposed.

Coffey: One of the difficulties is in ceasing operation in certain fields and in stating what is not going to be funded.

Dickman: How do you decide when you have done enough in certain areas?

Coffey: It usually comes to a collective decision.

Woods: In practical terms, it is usually decided that we will do less, not nothing.

Gleeson: Coming back to the point raised by Graeme Russell about the responsibility of scientists, it clearly is a question of balancing freedom and control and perhaps we ought to think more of the researcher of the future.

Woods: I think we need to be careful in our assessments about the level of responsibility exhibited by scientists. We do need checks.

Gleeson: Yes, a question of balance but in surveys I've done, and it might not even be recognised in the funding agencies, milestone reports can be required at an average of six week intervals and that is madness in most situations. I'm not suggesting it ought to be six years, but that it really is a question of balance.

Perspective of Research Managers.

Synopsis

To stimulate creativity, research managers need to provide the freedom to explore new ideas and to make errors in a climate of trust. There is a need to value and accept differences and to be open minded about opinions and ideas other than their own. Creativity is a 24 hour occupation and people need to be able to 'have a life', to have a variety of interests and pursue each of those interests creatively. Valuing people and accepting non-rational behaviour is another desirable attribute of the research manager.

Discussion

Drinan: How do we create research managers?

Russell: That needs to come as part of the system, so these values need to be adopted through the whole system.

Woods: We need internal structures that reward creativity and the development of role models.

Coffey: The principles seem to do with permission to be creative, assisting the process of creativity and building a climate of trust to enable the status quo to be challenged by all team members, including the manager.

Gleeson: Additionally, the managers need as a group to operate creatively, in part to remove constraints to their own and others' creativity.

Dickman: Perhaps the time and space to be creative is too often viewed as a luxury rather than as a necessity.

Trounson: To me the quality of leadership and inspiration is important.

Dickman: Inspiration and creativeness often comes from working together as a team, not just from the leader.

Perspective of Researchers

Synopsis

Researchers need a sense of intellectual security and openness. The also seek leadership from nominated leaders or the group as a whole. The work environment should enable and encourage open communication both within the organisation and externally. Communication should extend across disciplines, and creativity is required in comprising research teams and in how individuals relate to those outside the team. Administrative duties are seen to detract from the time available for research but much administration is really part of research planning. Scientists need to take control of their time. Administrative procedures, including milestone requirements, are set jointly by researchers and funders, and scientists should exercise responsibility in how they play their role in determining administrative and accountability processes. Creativity in science may arise from curiosity without there being a defined problem requiring a solution. Champions and mentors can be very beneficial to creativity.

Discussion

Coffey: There is a strong theme of people needing to take responsibility for their own creativity.
Trounson: The joy of discovery is very important.
Coffey: There is a need for curiosity before discovery.
Perkins: Can we explore how ritual and celebration could expand our creativity, perhaps by looking at how creativity is rewarded in other cultures. Are there dangers in adopting a generic prescriptive approach to fostering creativity?
Propsting: Personal responsibility is a huge area and we would need to get deeply into that to establish principles.
Borell: This issue of integrity is important.
Eady: And it will become more important with new techniques.
Drinan: We talk a lot about how important diversity is but I don't see much evidence of it. If we really are looking for more creative results, we should mix up our disciplines much more radically. There is a terrific untapped potential.
Dickman: In that situation people will begin to feed off each other.

7   A FRAMEWORK TO FOSTER CREATIVITY IN RESEARCH AND DEVELOPMENT

The purpose of this chapter is to propose a framework within which to foster creativity in research and development. The focus is on the operational features of the existing agricultural research and development environment in the public sector. However, it would be desirable also to redesign some of the organisational features of that environment.

The creativity framework comprises a structure, concepts and principles. Illustrative strategies are suggested but to propose strategies for universal application would be to deny the complexity of the creative processes and the need for diversity. Additionally it would be counterproductive to propose strategies without the involvement of the people responsible for and affected by those strategies, as well as with those having different perspectives.

Creativity is defined in the literature in many ways, each of varying utility, depending upon the purpose at hand. Almost universally however, definitions of creativity include the elements of novelty and usefulness. For the purpose of this discussion, creativity is taken as being a person's capacity to produce new or original ideas, insights, restructurings inventions or artistic objects which are accepted by appropriate people as being of scientific, aesthetic, social or technological value (after Vernon 1989). Research and development is creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

STRUCTURE

There are two dimensions to the creativity framework. First, activities to foster creativity in research and development should address the needs of both the researcher and members of the field. These activities need to be based on an understanding of the state of the domain and the relationship of scientists and the field participants to that domain.

Scientific creativity arises from interactions between scientists and those constituting the field of gate keepers of ideas, products or processes. Field participants for agricultural research and development include:

- the Boards and all levels of management of Rural Research and Development Corporations and of other research funding agencies and members of advisory panels to those corporations and agencies
- organisational leaders and research and program leaders and managers in research and development organisations, professional peers and executives of professional organisations
- elected and management representatives of industry and other community organisations, and
- collaborators at the program and/or project level.

As discussed in chapter 1, the importance of the interaction between researchers, the domain and the field was highlighted in a detailed study of the lives of prominent creative people which led Gardner (1993) to conclude that:

Creativity lies not in the head or hands of the artist or in the domain of practices or in the set of judges; rather, the phenomenon of creativity can only - or, at any rate, more fully - be understood as a function of interactions among these three nodes.

Both researchers and members of the field need to be operating creatively.

Figure 7.1:   Creativity Framework: Creative People
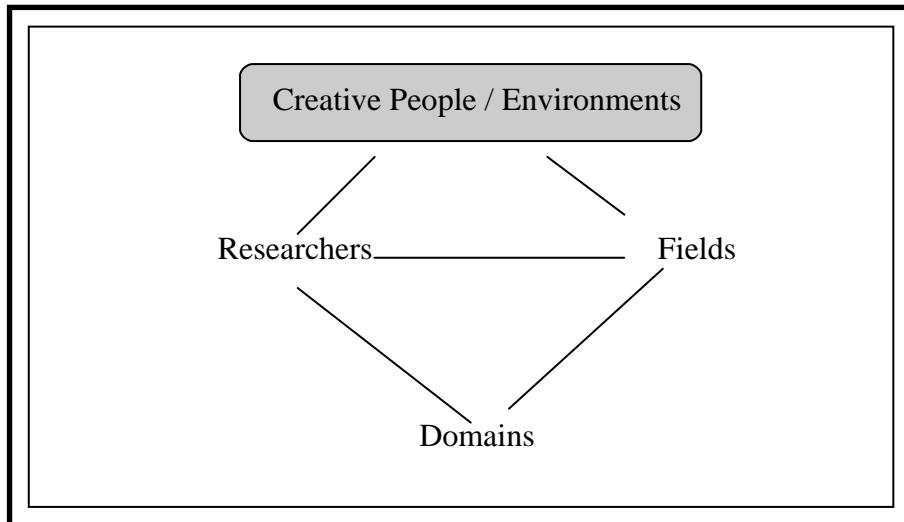
The second dimension of the creativity framework is that creativity should operate through all the processes which comprise innovation whereby new and valuable ideas are generated and put into practice. Innovation occurs throughout organisations and may involve technological, managerial and/or organisational change generated through, for instance, research and development, organisational learning, intuition and serendipity.

Innovation is the conception, development and application of new knowledge, or new or improved materials, devices, products, processes, or services. But how does it happen?

To assist in describing innovation, Gleeson has developed an organic metaphor of innovation, as pictorially presented in Figure 7.2.

Figure 7.2:   Creativity Framework: Organic Innovation
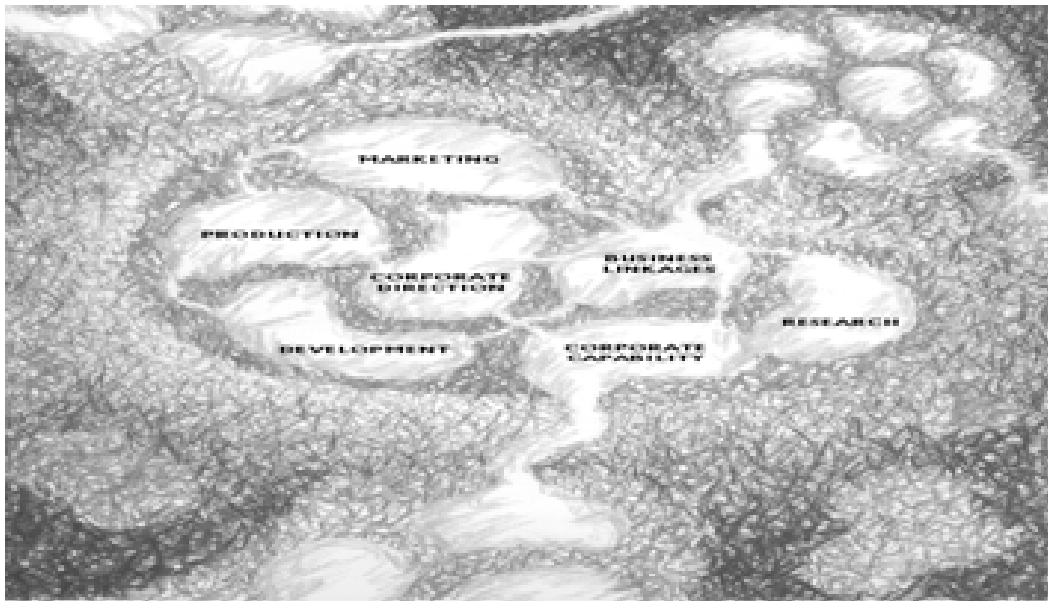
In the organic metaphor, each of the functional elements of the innovating
organisation are pictured as being enclosed by a permeable membrane. As is the situation in a cell,
there is a constant whirl of activity within the organisation; it is not a static state.

The cellular elements interact and spin around the values, vision, culture and focus of the organisation
in much the same way as various cellular bodies relate to the cell nucleus. All elements are guided thus
by the values and vision adopted by the organisation. They operate within a culture which is akin to
the functioning of the clear cell sap of living organisms.

Innovation occurs throughout the organisation and is not restricted to the research and development
function. Hence organisational structures and cultures need to promote and reward the processes of
innovation throughout the whole organisation.

Firms and agencies operate beside other firms and agencies, as illustrated in the figure, and inter-
corporate synergy can be captured by interlocking any or all of the various functional elements,
including the processes of innovation.

However, like the cells of organisms, each organisation retains its own individuality and focus.

Knowledge flows and human relationships are the mediums for intra and inter-organisational
activities. These linkage mechanisms can be effective only if each of the key elements of the firm
possesses the desire and capability to innovate.

CONCEPTS

The conceptual elements of the creativity framework introduced in chapter 2 provide a unifying
platform upon which to build principles to apply across the structure of the framework.

There are three key concepts.

First, there is the principle of intrinsic motivation described by Teresa Amabile:

> *People will be most creative when they feel motivated primarily by the interest, enjoyment, satisfaction and challenge of the work itself - not by external pressures.*

The second and link concept is Deci and Ryan's cognitive evaluation theory:

> *The impact of an event is determined not by the objective characteristics of the event but by its psychological meaning for the individual.*

And the third is the concept of flow as described by Mihaly Csikszentmihalyi:

> *Flow is an optimal state of inner experience achieved when consciousness is harmoniously ordered.*

These concepts point to the importance of the motivational state of a creative person and they provide a framework within which to consider how creativity might be enhanced.

Principles and strategies to foster creativity need to be built, at least in part, on an understanding of what drives people to be creative. There is ample evidence to support the conclusion that people will be most creative when they are intrinsically motivated, that is, they feel motivated primarily by the interest, enjoyment, satisfaction and challenge of the work itself - not by external pressures.

It is important however to recognise that different people, or the same person in different circumstances may respond differently to the same stimuli, a phenomenon embedded in Deci and Ryan's cognitive evaluation theory, where the impact of an event is held to be determined not by the objective characteristics of the event but by its psychological meaning for the individual. Hence, for instance, the inter-personal climate between the conveyor and the recipient of a communication may be as an important determinant of effect as the message being communicated.

These concepts help explain the preferred motivational state for creativity and how it is brought about. The innate urge for creativity arises however from the people's urge to control their consciousness by being totally immersed in a cognitive or physical challenge. In these situations the activity becomes autolytic, in that it is an end in itself, and people experience, to use Csikszentmihalyi's terminology, the state of flow.

PRINCIPLES

Complexity is one of the most common and prominent features of creativity. To deal with this complexity, creativity processes are usually described analogically rather than directly, for instance Perkins' exploration of various cognitive topographies.

Complexity is not restricted to creative processes. It is evident in the pluralistic nature of the policy, institutional, funding and management arrangements for agricultural research. This plurality and complexity may lead to the misconception that there is a diversity of approaches to funding and managing of agricultural research. Last, agricultural enterprises are both variable themselves and in their capacity to relate to and adopt the findings of institutionalised research and development.

Compared to all this complexity, the principles in the design of environments conducive to creativity in research are stunningly simple. One only has to ensure that the people involved are appropriately motivated and capable.

To achieve this we need to encompass the two structural components of the creativity framework, that is, in the context of research and development, they need to be applied both to researchers and to field participants, and they need to be applied across all facets of innovation.

Strategies to foster creativity will need to be designed to meet the particular requirements of each situation. However, in all probability, it will be appropriate to base these strategies on the creativity principles generic to agricultural research and development.

The five principles arising from this work are that creativity in Australian agricultural research and development would be enhanced by:

- setting creativity goals
- balancing freedom and control
- improving recognition of performance
- improving social interaction, and
- providing of more effective leadership.

Goals

Creativity is affected by the presence and nature of goals, an unsurprising conclusion given the concepts of intrinsic motivation, cognitive evaluation and flow as discussed previously. The following guidelines should apply to goal setting:

- the state of flow and hence of creativity is more readily attained when goals are challenging yet achievable
- creativity is more easily developed and sustained when the creative person is able to identify with the goals and internalise the challenge and when the goals reinforce intrinsic rather than extrinsic motivational factors
- it is preferable to establish both creativity and productivity goals and for the problem solver to have a high level of discretion over work processes. Assignment of either a productivity goal or a creativity goal detrimentally affects the achievement of the other goal
- the impact of the same or similar goals will differ between people and will be influenced by the manner by which they are established, monitored and reviewed.

There is of course no ideal single formula for goal setting in all agricultural research and development. The guidelines proposed here arise from interpretations of the literature and from the observations of the researchers and their managers interviewed as part of this study. There appear to be few, if any, incongruities in principle between the observations reported in this study and the literature on environmental factors affecting creativity. For instance researchers commonly observe that their creativity is affected adversely when research funders prescribe how work should be conducted, an effect predictable from the literature.

The impact of process prescription on creativity arguably differs, on the one hand, in research, and, on the other, in development; and even within either. Certainly, an understanding of the processes of insight suggests a need for greater process freedom for these problems where the solutions are least evident. However, there are dangers in equating the need for insightfulness with the extent to which the work is at the basic rather than the applied end of the research and development spectrum; the basic-applied distinction primarily refers to purpose, rather than to the nature of the creative work required for success.

Researchers comment unfavourably also on the setting of outcomes which they judge unrealistic, given the resources and time available.

Researchers and their managers observe that the milestones specified in research contracts are often too frequent, too prescriptive and seemingly too inflexible. Certainly milestones are usually established by the researcher alone or in consultation with the funder, but a sense of insecurity of funding, a wish to curry favour with the funder, and some adverse reactions from funders to applications to modify milestones, lead to too many milestones, poor specification of milestones and an over-reluctance to seek to modify milestones as projects progress.

Strategies which might flow from this principle could include:

- incorporating both creativity and productivity goals into organisational cultures and processes, including monitoring and evaluation procedures for researchers, managers and members of advisory panels
- ensuring field participants have an understanding of the need for and nature of creativity so that their actions inadvertently do not constrain creativity unduly, and
- adopting a flexible approach to the evolution of research processes to ensure that they are neither prematurely conceived nor judged.

Bounded Freedom

The principle of bounded freedom arises from the need to balance community, organisational and group requirements with those of the individual.

In keeping with the creativity framework concepts outlined earlier, bounded freedom is defined here as the psychic balance which the researcher or field participant feels about what he or she seeks to achieve and what the organisation or group would have him or her achieve. It is that balance between doing one thing rather than another, not necessarily the actual balance in terms of committed time; nor is it the balance between achievement and the freedom not to achieve.

Bounded freedom is an umbrella concept which is most effectively implemented through a range of strategies associated with, for instance, leadership, goal setting and recognition. Obviously, the need to constrict an individual's mental exploration is less when the requirements of the organisation, the group and the individual are closely aligned. However, this alignment is likely to come at a substantial cost in terms of diversity, in identifying opportunities and in allowing the evolution of the community, organisation or group.

The institutional and managerial arrangements for agricultural research and development present some particular challenges in achieving bounded freedom. As observed by many researchers and their managers, public sector domination of the funding and execution of agricultural research leads to a very risk-adverse research environment - an ironic situation, given that the risky nature of research is one of the rationales for public sector involvement in it. Proliferation of managers for a given project, a focus on projects rather than people, and the fiscal and economic pressures favouring shorter term goals also lead to a perceived diminution in the freedom of the individual relative to the organisational imperatives.

Strategies which might flow from this principle include:

- actions to enable researchers to identify with the presented problem, including decentralised participatory program development forums, publication of analyses and opinions leading to selection of preferred topics for research, and recognition that the process of research planning is as potentially rewarding in terms of knowledge development as the research program so conceived

- ensuring individual researchers and research groups have research portfolios balanced for risk, organisational and personal goals and productivity and creativity goals, and
- (subject to adequate capability and performance) providing increasing levels of autonomy in relation to work schedules and practices, within budget expenditures and staffing guidelines.

Recognition

Recognition and reward systems are important components of research environments and their development and implementation need to reflect the concepts of intrinsic motivation, and cognitive evaluation and flow. That is, they need to reflect the fact that creative people are primarily driven by the satisfaction and joy of controlled consciousness and creative achievement, that creativity is driven by intrinsic motivational factors and that some stimuli may be interpreted differently by different people or by the same person in a different context.

Researchers and their managers participating in this project were generally very critical of the lack of recognition they received from research funders and, in some cases, from their own organisations. Interestingly, discussions about recognition and reward almost invariably focused on the value of recognition from leaders, managers, clients, peers and colleagues rather than on either the formal systems for determining promotion and remuneration or the outcomes of those systems. (It should not be inferred however that promotion and remuneration systems are unimportant but rather that those involved believed that considerable benefits would result from improved broadly based systems which recognise and reward creative performance.)

It should be stressed that the need for recognition generally and for creativity specifically is as acute for field participants, including research managers, funders and industry advisers, as it is for researchers.

An important distinction needs to be made on the basis of the intent of reward systems. The use of rewards to motivate behaviour and more particularly the competitive use of contingent recognition is likely to have deleterious effects on intrinsic motivation and creativity. However, the use of rewards to convey a sense of appreciation and the provision of positive feed back, if experienced as informational rather than as controlling mechanisms, are likely to enhance intrinsic motivation and creativity.

Strategies to improve recognition particularly of creativity might include:
- research funders, organisations and clients responding meaningfully to researchers on research progress and final reports and, in due course, on the adoption or otherwise of the outputs of research
- assisting researchers and field participants to communicate with their peers and other interested and relevant individuals
- ensuring that formal recognition and remuneration processes encompass a consideration of both creativity and productivity.

Social Interaction

The state of the domain and the expectations of the field form part of the framework within which the subconsciousness operates, particularly during periods of incubation and insight. Researchers need access to and interaction with, the appropriate domains and fields.

Researchers' need for broadly based social interaction in their fields is accentuated in agricultural research because it is highly institutionalised, geographically dispersed, divorced in location and culture from end users and arguably, overly dominated by a narrow range of disciplines.

Creativity is fostered by social interaction designed to assist problem solvers and field participants:
- to learn and enhance their skills
- to internalise the issues and problems to be investigated
- to overcome fixation on inappropriate aspects of the issue/problem and hence to reconstruct it
- to enhance the joy and recognition of being creative
- to communicate on an intra and inter-domain basis, and
- for researchers to access the field and for field participants to familiarise themselves with research.

Social interaction should be fostered in varied ways, to accommodate a range of personalities and the varying requirements of phases of the research cycle.

Additional benefits of social interaction include:
- linkages to expand the personnel, infrastructure and budgets necessary to effectively and efficiently conduct research
- improved capture of the benefits of research through increased rates of utilisation of its findings.

Strategies to improve social interaction might include:
- developing policies and processes which recognise the importance of face to face participation in seminars, workshops and conferences, both locally and internationally, with this participation broadly based so as to include in particular the less experienced researchers
- promoting organisational cultures which value intra and inter-organisational discussions and seminars, preferably with the active involvement of both researchers and field participants
- increased devolving of authority, with due accountability, for expenditure of project funds for the purpose of travel, communication and conference attendance
- stronger linkages between research and development and education and training.

Leadership

Researchers and research managers participating in this study identified leadership as an important constraint to creativity in research. Researchers perceived a need for research leadership within the proximate research environment, and both researchers and research managers perceived a need for more effective organisational leadership.

Researchers, correctly, distinguished between leadership and management. Their observation that the research and development corporations have increasingly become managerial rather than leadership-orientated is an interesting observation, given the very great influence these corporations exert over the direction of agricultural research.

To lead is to develop and communicate a vision and a direction; to have the imagination, insight and ability to release the creative talents of others, to resolve what should be done and why. In contrast, management is concerned with how it is done, when work is done and by whom.

Zalenznik (1992) makes the interesting observation that leaders have much more in common with artists, scientists and other creative thinkers than they do with managers. Leaders tolerate chaos and a lack of structure and are thus prepared to keep final answers in suspension, avoiding premature closure on important issues. They nevertheless continually struggle to attain some sense of order. In contrast, managers seek rationality and order.

Developing effective strategies to improve organisational and research leadership requires an understanding of the factors which might be constraining such leadership. The information collected in this study provides little guidance on these issues and further in-depth analysis would be required to enable even illustrative strategies to be suggested. Research would need to examine leadership issues within research and development organisations, within industry and within the community more generally. Questions which could be examined in these analyses include:

- do leaders in research and development agencies perceive themselves to have been crowded out of and/or rendered less potent in research leadership by the research and development corporations?
- do research and development corporation processes, particularly regarding the selection and tenure of Board members and the managerial responsibilities of corporation staff, limit the effectiveness of leadership by the corporations?
- does industry consider research and development leadership an important role for industry?
- what is the likely impact on research leadership of the amalgamation of research and development corporation functions with other industry activities such as marketing and promotion?
- does externally induced institutional uncertainty preclude the development of effective leadership?
- do current perceptions of leadership simply reflect the changed demographics of the researchers?

Reference

Zalenznik, A. (1992) 'Managers and Leaders: Are They Different?' *Harvard Business Review,* March-April 1992, pp 126-135

Appendix I

## CREATIVE RESEARCH ENVIRONMENTS
WORKSHOP PARTICIPANTS

- Mr Matt Ahern, Policy Officer, United Graziers Association, Brisbane Qld
- Dr Andrew Borell, Research Scientist, Department of Primary Industries, Warwick Qld
- Mr Shaun Coffey, Co-ordinator, Meat, Dairy & Aquaculture, CSIRO, Rockhampton Qld
- Dr Wendy Craik, Executive Director, National Farmers Federation, Canberra ACT
- Ms Lara Daley, Science Communicator & Research Assistant, Synapse Consulting, Brisbane Qld
- Ms Vicki Dickman, Project Development Officer, Grow Zone Development Network, Roma Qld
- Dr John Drinan, Chair, Dairy Research & Development Corporation & Deputy Director, Centre for Advancement of Learning & Teaching, University of Newcastle, NSW
- Dr Bea Duffield, General Manager Research & Extension, Department of Primary Industries, Brisbane Qld
- Dr Sandra Eady, Office of the Chief Executive, CSIRO, Canberra ACT
- Ms Kate Fawns, Creative Artist, Writer & Teacher, Toowoomba Qld
- Mr Mac Fawns, Primary Industries & Taxation Adviser, Toowoomba Qld
- Mr Tony Gleeson, Director, Synapse Consulting, Brisbane Qld
- Mr Ben Goss, PhD student (Polymer Science), University of Queensland, Brisbane Qld
- Dr Ann Hamblin, Horticultural Research & Development Corporation, & Bureau of Resource Sciences, Canberra, ACT
- Dr Elke Niedermüller-Hughes, Lecturer & Educational Consultant, University of Queensland, Brisbane Qld
- Mr John Kerin, Chair, Co-operative Research Centres (several) & Company Director, Canberra ACT
- Ms Lillian Lever, Koorana Crocodile Farm, Coowonga Qld
- Mr John Lever, Koorana Crocodile Farm, Coowonga Qld
- Mr Barry McDonald, Institute Director (Sheep & Wool), Department of Primary Industries, Brisbane Qld
- Dr John Passioura, Grains Research & Development Corporation & CSIRO Plant Industry, Canberra ACT
- Mr Ian Perkins, Director, Livestock & Property Management, Stanthorpe Qld
- Mr Asher Propsting-Perkins, Of Boundless Creativity (aged six months), Stanthorpe Qld
- Ms Barbara Pini, PhD Student (Gender Issues), University of Queensland, Brisbane Qld
- Ms Sue Propsting, Stanthorpe, Qld
- Dr Graeme Russell, Associate Professor of Psychology, Macquarie University, Sydney NSW
- Ms Gail Rutherford, GCR Designs, Fortitude Valley Qld
- Professor Merilyn Sleigh, Dean, Faculty of Life Sciences, University of New South Wales, Sydney NSW
- Mr Troy Swindells-Grose, Actor-Comedian, Brisbane Qld
- Ms Zara Swindells-Grose, Actor-Comedian, Brisbane Qld
- Dr John Taylor, Director, Land & Water Resources Research & Development Corporation & CSIRO, Brisbane Qld
- Professor Alan Trounson, Deputy Director, Institute of Reproduction & Development, Monash Medical Centre, Melbourne Vic.
- Mr Michael Whitwell, Senior Consultant, Workforce Planning & Development, Department of Primary Industries, Brisbane Qld
- Professor Beth Woods, Chair, Rural Industries Research & Development Corporation & Professor of Agribusiness, University of Queensland, Gatton

Appendix II

PROFILE OF FOCUS GROUP PARTICIPANTS

Q1.   For approximately how many years in total have you been principally in research/research management?

Figure 1   *Research Managers: n=15*   *Researchers: n=48*
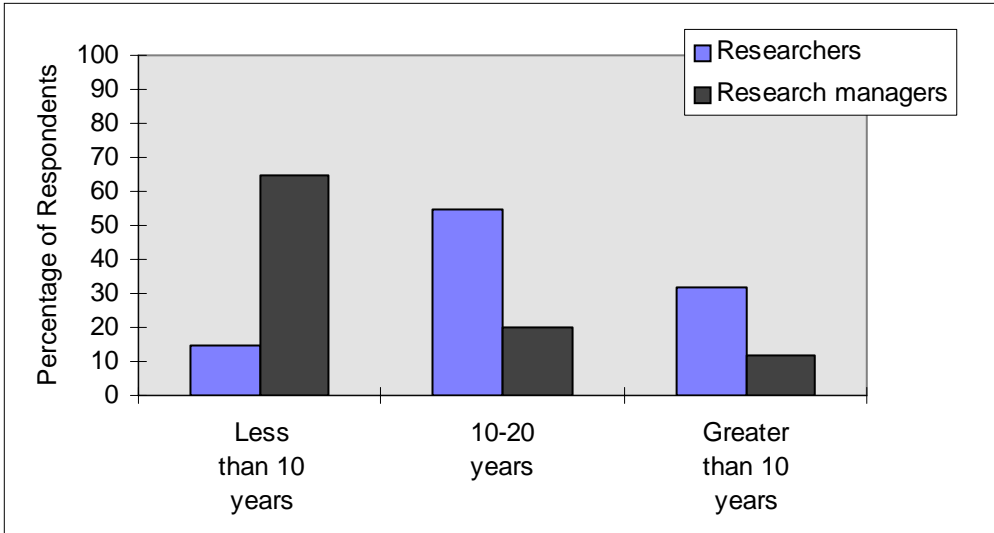
Q2.   Are you occupying a permanent or a time bound position?

Figure 2   *Research Managers: n=17*   *Researchers: n=48*
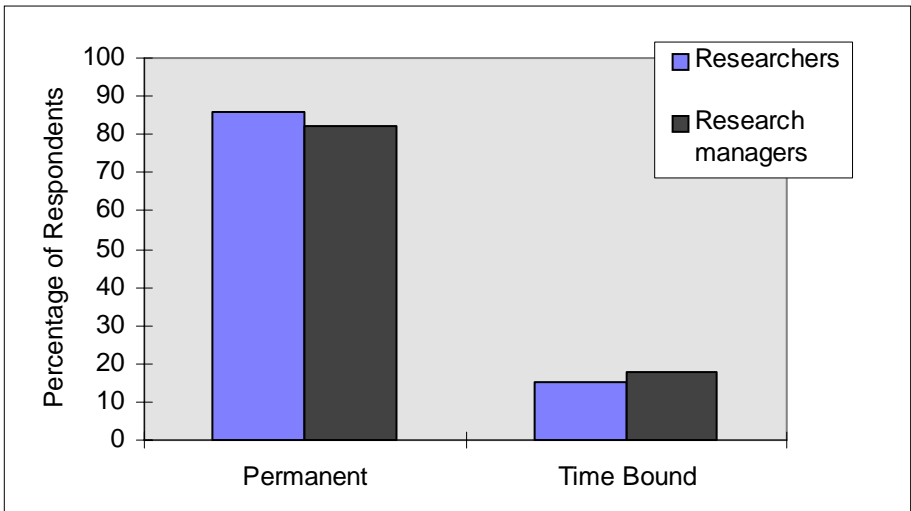
Q3.   What is your highest degree?

Figure 3 *Research Managers: n=17* *Researchers: n=48*
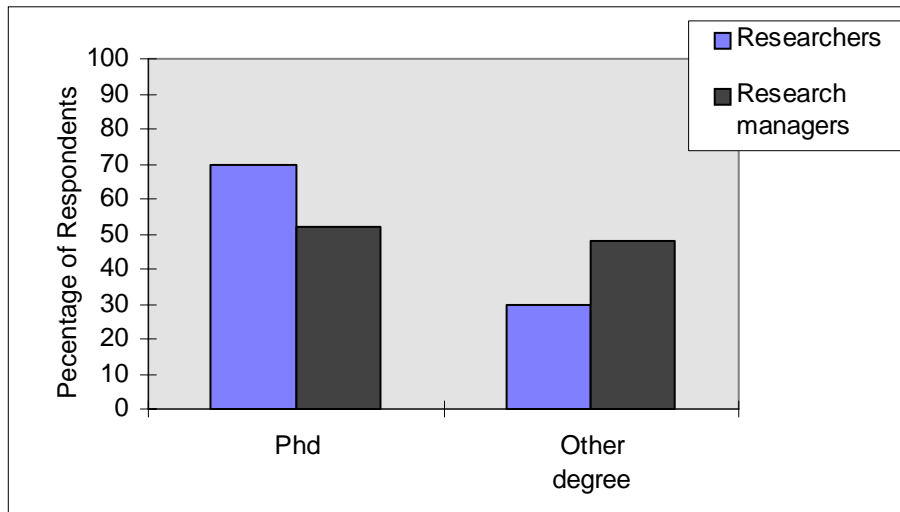
Q4. Approximately what proportion of your working time (over the past three years) has been spent on:
- laboratory research and development
- field based research and development
- managing research and development
- extension
- other activities?

Figure 4A: The proportion of respondents who spend at least 10% of their time on the indicated number of activity categories.

Research Managers: n=16 *Researchers: n=48*
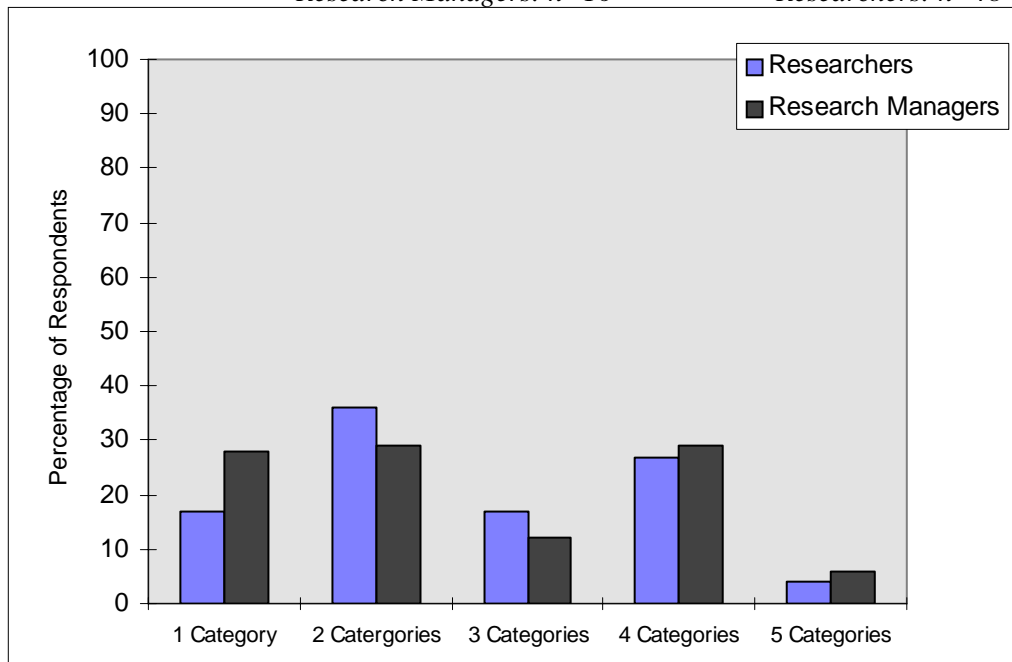
Figure 4B: The proportion of respondents who spend at least 10% of their time on the specified activity.
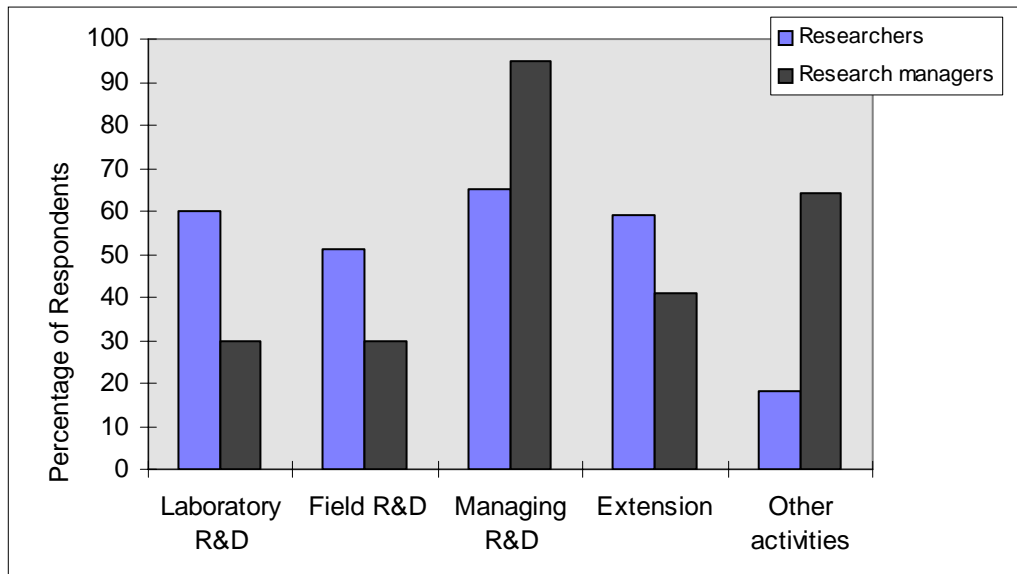
Q5. Over the past three years what proportion of your research operational costs (all costs excluding salary and capital costs) is provided for by way of external funding sources?

Figure 5   *Research Managers: n=16*   *Researchers: n=48*
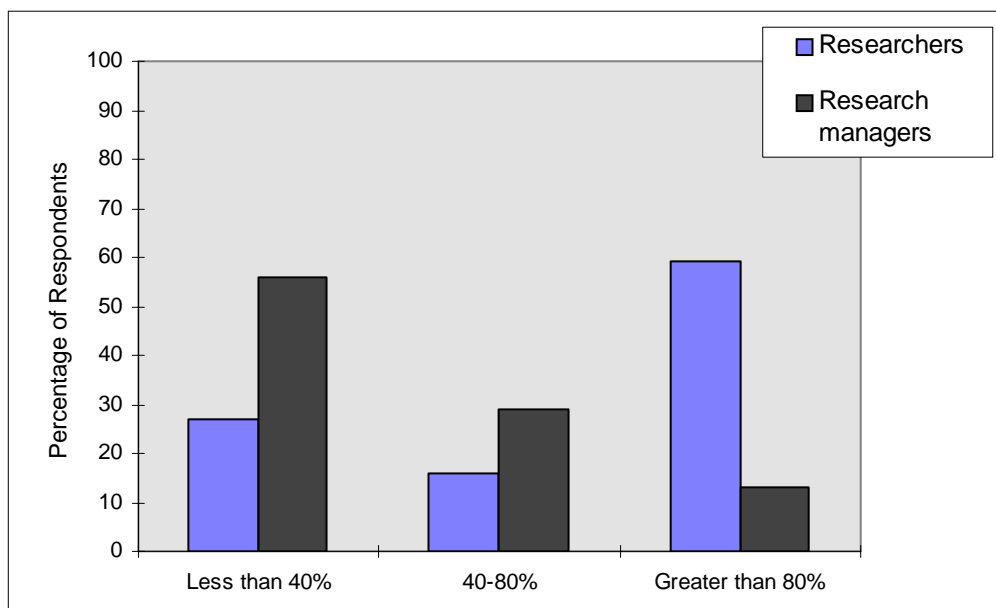
Q6. Approximately what proportion of your external funding over the past three years is provided by a Research and Development Corporation?

Figure 6 *Research Managers: n=14* *Researchers: n=46*
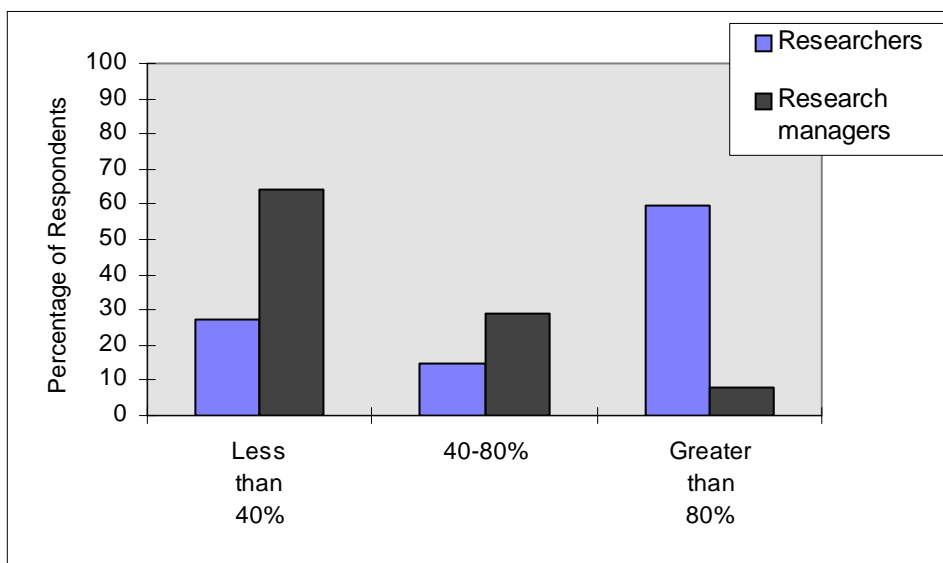
Q7. To what fields of activity does your research primarily relate?
- livestock systems
- agricultural farming systems
- horticulture systems
- resource management
- other

Figure 7A The proportion of respondents who chose the specified number of fields of activity.

Research Managers: n=16 *Researchers: n=48*
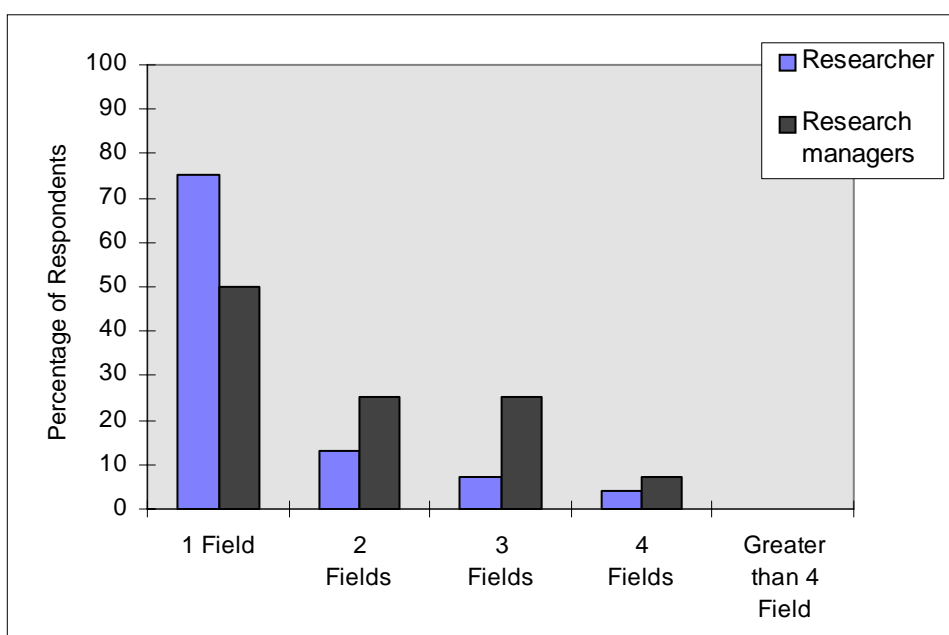
Figure 7B   The proportion of respondents who chose the specified field of activity.
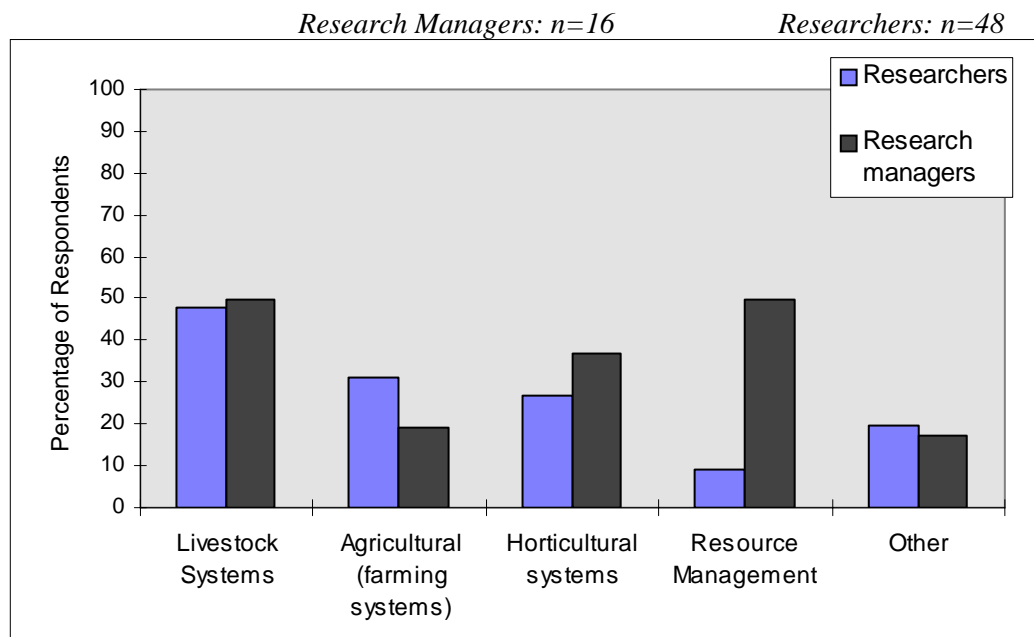
Q8. Who do you expect to be the primary end users of your research findings?
- commercial industry operators
- industry organisations
- community groups
- government agencies
- other researchers
- other

Figure 8A The proportion of respondents who nominated the specified number of end users
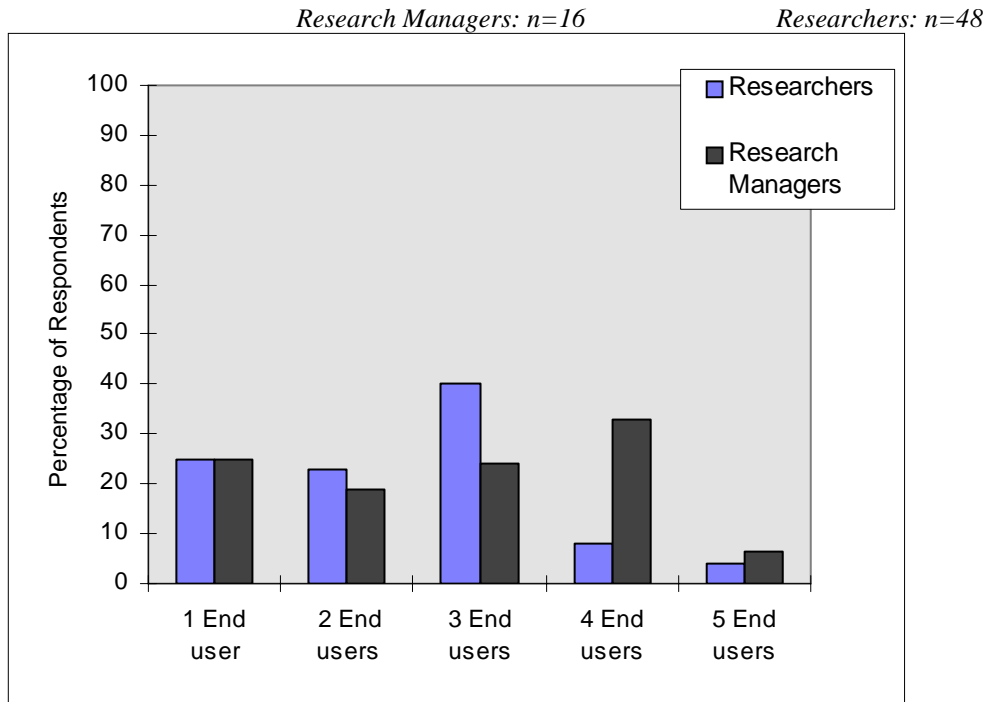
Figure 8B   The proportion of participants who nominated the specified end user

Research Managers: n=16   *Researchers: n=48*
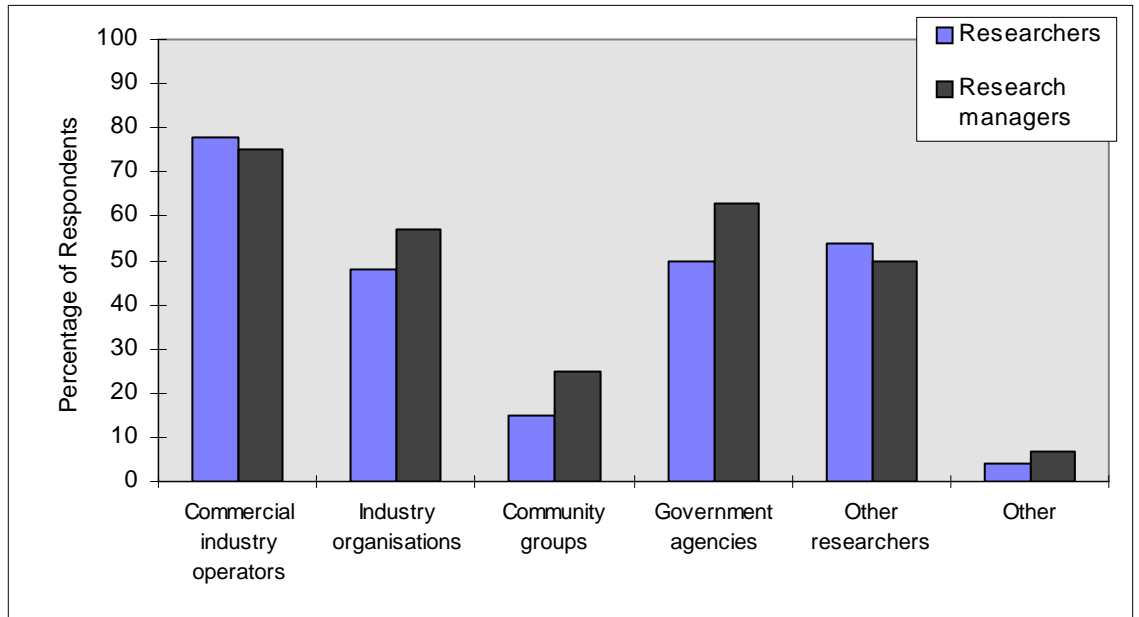
Q9.   How active is your involvement with end users of results of your current research activities?
- very active
- active
- moderate
- slight
- negligible

Figure 9   *Research Managers: n=16*   *Researchers: n=48*
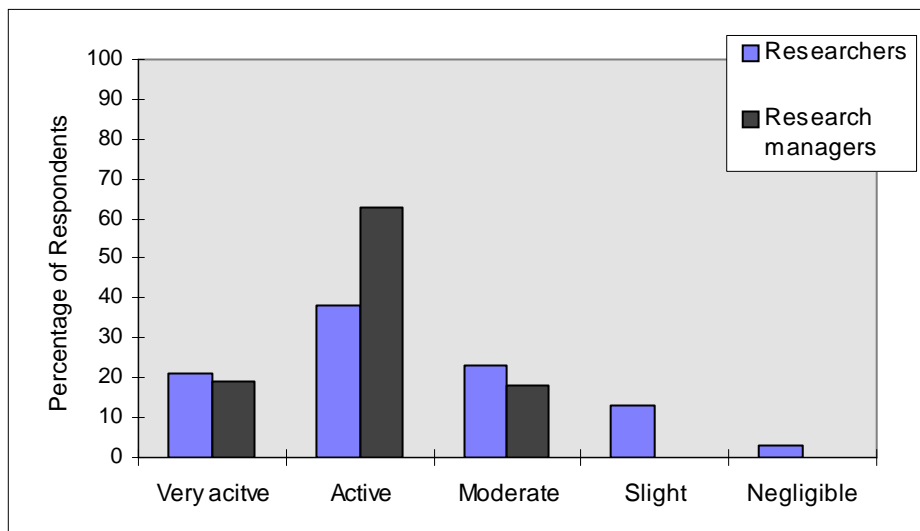
Q10. How conducive to creativity is your research environment?
- very conducive
- conducive
- moderately conducive
- slightly conducive
- not conducive

Figure 10   *Research Managers: n=16*   *Researchers: n=48*
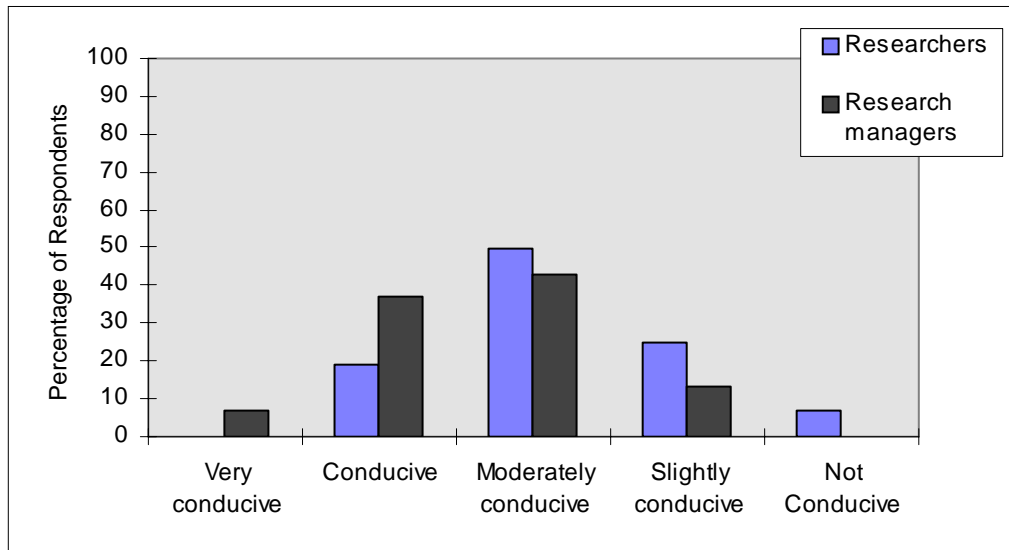
Appendix III

VERIFICATION OF RECORDS OF FOCUS GROUP DISCUSSIONS

Participants of the focus group discussions were invited to respond to a synopsis of a transcript of their discussion. The synopses consisted of statements which were comprised by the facilitator to reflect the general views of the discussion group and selected extracts taken directly from the transcript. If the participants felt that statements contained in the synopses did not encapsulate the essence of the discussion, they were asked to amend, delete or add to the record. It was to be assumed that, if no response was received, the participant believed the synopsis to be an accurate account of the discussion.

Research Managers:

The eight responses received from research managers were generally favourable and there were no requests for deletions from the transcripts. Comments relating to editorial changes were used in the editing of the transcripts and incorporated in the summary of the discussions. The clarifications offered by research managers are listed below. The number following the statement refers to a statement with the corresponding number in the Summary of the Discussions with Research Managers (Appendix IV).

> *Financial limitations constrain some dimensions of creativity - not necessarily on the creativity directed at solving the problem at hand. (4 5 1)*
>
> *Financial limitations constrain creativity to a degree. (4 5 1)*
>
> *Financial limitations constrain creativity but should also be a prompt for how to do things better. (4 5 1)*
>
> *Constraints to the reallocation of resources is an important determinant of the creativity of the research manager. This statement conflicts with the notion that 'creativity emerges from adversity. (4 4 1)*
>
> *Is the statement 'remuneration depends on the number of subordinates' correct? (4 6 4 3)*
>
> *Creativity also includes making cross linkages between things that already exist and novel situations - not just coming up with something that doesn't exist. (4 1 1 2)*
>
> *There is a need to clarify the statement, "The principal focus on creativity by managers is in relation to the creative needs of their staff rather than on the need for they themselves to be creative." (9 2 1)*
>
> *There are 2 Ph.D students on site that aren't on staff, another 10 CR (consolidated revenue) or industry funded staff are enrolled in Ph.D's*

or Masters and about 65 professional and technical officer staff. (9 4 3 1)

Total students is just over 100 currently. (9 4 3 1)

There are different levels of creativity not just at the 'bottom line'. (9 1 1 3)

One research manager observed that the use of the word "control" by the facilitator in the context of project management, was inappropriate as control "is the antithesis of creativity". (4 2 4)

Some general observations were offered by the research managers and are listed below. These observations were not included in the summary of discussions with research managers. The observations however have been taken into account in the formulation of the views of researchers and their managers (Chapter 3).

The institutional culture needs to be perceived as positive and encouraging - fun to be a part of rather than fearing personal failure or ability to keep up. (4 8 1)

Creativity is not something we think about very much. No one had a firm plan of how to be creative or how to engender creativity. (9 1 1)

Creativity is a difficult topic to discuss in depth, and an area we need to have some training in. (9 1 1 1)

There are severe limitations on creativity because of time constraints, the narrow focus of most funding sources and the need to follow the 'politics' of the day. Whether these limitations are real or perceived does not matter much - they are limitations. However, if they can be overcome, then we'd like to know how. (9 3 1)

Have we been too slow to change to different expectations? Funding bodies wanting short term outcomes? There are huge pressures on industry to remain viable and increased pressures and costs of sustainability. Who is looking at big picture issues? (9 3 1)

Diversity of thinking is discouraged at the executive level. (9 3 1 3)

The balance of power within the government gives the country vote a big sway. This can be a restriction and can have some advantages. But it does have a big impact on what we can and can't do with our limited resources. (9 3 1 3)

Managers should try to create the opportunities for the staff to be creative. (9 2 1)

Researchers:

The seven responses received from researchers contained favourable comments on the essence of the summaries. The summaries were described as being "an accurate and well-balanced account" and were found to be "representative of the discussions". The editorial comments offered were included in the editing of the Summary of the Discussions with Researchers (Appendix V). There were no requests for deletions from the transcripts.

A minor point was raised by two researchers in relation to a question posed by the facilitator as to why the people participated in the discussion given the previously indicated time constraints. The researchers felt that the response which transcribed in part as "it was to get away from the hum drum' was misrepresentative of the overall discussion on this topic. They felt it was more important that the facilitator had provided sufficient notice of the discussion to enable it to be included in their schedule.

Other observations offered by researchers are:

> *In response to the comment that "creativity is happening in projects on the side"; this is not possible in a lot of cases with increased auditing of R&D funds. (Not included in Summary of Discussions)*

> *The statement that, "the (corporation) staff giving advice aren't competent" may have been said; however there is disagreement as to the accuracy of the statement. (Not included in Summary of Discussions).*

Appendix IV

SUMMARY OF FOCUS GROUP DISCUSSIONS WITH RESEARCH MANAGERS

1. *Nature of Creativity*

There are degrees of creativity. It can produce fundamentally novel concepts and products or it can usefully apply in one domain what is happening in another. (4 1 1) *[17]

"The sort of creativity that probably we are looking for in the research and innovation type world is really being aware of what is happening around and being quick enough to say yes that could apply here and opening up whole new vistas of things particularly beyond the square." (4 1 1 1)

"Creativity is actually coming up with something that didn't exist before - an idea or a thing or whatever, that to me is creativity." (4 1 1 2)

Creativity is a complex process and it should be embedded in the culture of organisations and individuals. (9 1 1)

"I think it is a sophisticated dynamic thing and you must be careful not to define some common recipe to something that is really quite internally sophisticated and complex. You are dealing with pre existing structures." (9 1 1 1)

"But the question that arises in my mind, is should creativity be part of our culture? Something that we are embedded with rather than having to actually take time out to have a creative thought." (9 1 1 2)

"I think that, going back to our roles as managers and directors, always the challenge is to create the environment for the individual to have the opportunity for him or her to develop that creativity. I'm always concerned that we have these ad-nauseam sort of planning things which go across states and across organisations and so on, I don't think there is a lot of creativity in that. Where the creativity occurs is at the bottom line." (9 1 1 3)

Creativity is the generation of new ideas, answers for existing problems or new problems to be solved. (10 1 1)

" --- creativity certainly means in the area we are working the generation of new ideas and ways to put those ideas into practical research environments and to get answers to questions that have been posed or problems that have arisen. It's just the generation of new ideas and directions I think." (10 1 1 1)

" --- (creativity) is looking for new answers for either existing problems or new problems to be solved." (10 1 1 2)

---

[17] * Reference Codes

> *"Someone has to have an inquiring mind that says 'why' or 'how does it happen?', 'what is happening and what is causing it to happen?'. That to me is the beginning of creativity as far as we are talking in terms of scientific research."* (10 1 1 3)

2. Drivers of Creativity

Creativity emerges from environments characterised by adversity. (4 2 1)

> *"Is it a truism to say that adversity is an environment in which creativity emerge?."* (4 2 2 1)

The satisfaction from research management comes from enthusing and developing individuals, providing solutions to clients, creating good working environments and seeing how the science fits into a broader picture. (4 2 2)

> *(I get satisfaction from being in research management from):*
> - *"being in a position to be able to enthuse, influence and see a response and growth in the individual, that's a kick for me."*
> - *"mine is quite different, mine is being able to provide solutions to people who need an answer to a problem."*
> - *"I don't see myself as providing a solution, but creating an environment where they are starting to spark and then I am part of that interaction I guess."*
> - *"there is no power that just resides in the (management) label; there is no authority or power that resides in the label. Your achievements are directly related to what you can negotiate, and really one of the big buzzes for me is being the cheer leader and being the person who winds everyone up and keeps them basically pointed in the right direction."* (4 2 2 1)

> *"My feeling is that research management is very much a one-on-one environment and that environment is determined by the researcher himself."* (4 2 2 2)

> *"I think individuals have to be handled differently from a research management point of view."* (4 2 2 3)

> *"So that whole philosophy right from the point of recruitment should be one that prides its creativity above all else and say well, our situation will change it is inevitable that it will change within the time that you will be working for us, and your ability to remain employed with us is very much tied to the relevance of your skills and the experience that you can offer. There is nothing tragic in that."* (4 2 2 4)

To be creative, managers have to be able to work in a team. Management is often driven by the need to provide solutions to policy and administrative boundaries to creativity, for example, in relation to conference attendance and travel. (4 2 3)

The R&D managers, as providers of R&D services, wish to control how projects are done, how teams are formed, working conditions etc. They also wish to have an input into the planning processes of R& D purchasers. (4 2 4)

The principal focus on creativity by managers is in relation to the creative needs of their staff rather than on the need for they themselves to be creative. (9 2 1)

> *"Being able to help people is certainly a major plus being a manager."*
> *"That's helping people within your group?"* **(facilitator question)**
> *"Both them and clients."* (9 2 1 1)

"One of the things we do get satisfaction from other than achieving either through process or outcome is nurturing staff along and seeing them developing and coming to fruition." (9 2 1 2)

The initial interest of the scientist in an issue may not be related to any potential commercial outcome and others may need to examine the R&D outputs to identify potential commercial outcomes. (10 2 1)

Ingredients of a creative research environment include the appropriate level of resources, a critical mass of capable research people on site, sufficient time for communication and mental and experimental exploration, the absence of distracting activities, an open sharing environment and a sufficiently narrow focus but with the opportunity to communicate widely. (10 3 1)

3.   Omnibus

The organisation needs to be a lot more creative and forward thinking. Creativity is constrained because:
- **the organisation is very risk adverse, reflecting the governmental, political and industry political climate**
- **too few resources and too little time are allocated to lateral thinking**
- **there is insufficient diversity of thinking**
- **the industry is overly focused on producing quick solutions to current problems. (9 3 1)**

"...we need to be a lot more creative and forward thinking and futuristic in our thinking......" (9 3 1 1)

"...the industry tends to be looking for quick fixes and things that are very much in the short term; ideas that are a bit left field or ways of solving problems that are a bit left field stand a real risk of being drafted out because they might have a higher risk of success in the long run. I am concerned too that the industry funding bodies tend to (have) basically made up their mind. They have their own culture that they follow and they may not necessarily be creative in terms of their selection procedures and the mould that they're looking to put things into." (9 3 1 2)

"If you went to the general public and you listed all the organisations in Australia, and ask where they would rate on this creativity score. I'm sure you would find that government would be pretty low in terms of the general community, they are not necessarily perceived to be creative bodies. And there is probably is a lot of room for improvement in this area."

"Is that perception or reality?" **(facilitator question)**
"I think it is partially reality, because we have to be so risk averse."

"Why? Seems to me you don't need to." **(facilitator question)**
"The politics are becoming so constraining these days I think"

"What politics?" **(facilitator question)**
"Government politics, party politics."

"Not industry politics?" **(facilitator question)**
"They impact on it. Well, anything you do these days has to be weighed up against the political implications at that government political level and that is often a real constraining problem that we have to face." (9 3 1 3)

"What are probably a couple of constraints we face in the (organisation) is that (first) we don't devote many resources to looking for innovation and going back to that brainstorming.

We don't seem to have time to do a lot of that. We're busy getting on with the job so to speak. And I think also a constraint is that often if we do want to brainstorm something we're often getting like minds together instead of getting a diversity of minds together." (9 3 1 4)

"We are a very risk averse organisation. I reckon that would probably go against us trying to do too many things outside the box because, for example, of the political wave especially in an election year." (9 3 1 5)

"I guess that we get our creativity by interacting a lot with other agencies, I think. And as I mentioned before having diversity within the group." (9 3 1 6)

4.   Leadership

Constraints to the reallocation of resources is an important determinant of the creativity of the research manager. For example, employment practices, limits to collaboration within and between agencies and inappropriate remuneration criteria for managers all can result in misallocation and mismatch of resources. (4 4 1)

"Creating a supportive environment is about allowing your staff to get into situations where they are confronted with other disciplines or other problem areas or things like that." (4 4 1 1)

"We should be getting rid of the things that don't work. Inevitably that is a barrier, often we can't because it is enshrined in legislation or the office of public service does not agree with it or there is some historical reason why it can't happen." (4 4 1 2)

"The creative research manager definitely requires the flexibility to be able to pull together what is needed for x amount of years and with x amount of dollars and move on." (4 4 1 3)

The principal foci of senior management are to deal with issues external to and within the organisation, to ensure their people are as well resourced as possible and to provide a broad indication of the areas within which their staff should operate. (9 4 1)

"So whilst we're trying to encourage creativeness there has got to be a certain direction which follows the core activities of the department. Sometimes those two things at a research level don't come together because a researcher may see a particular project which he believes should be done but it may not necessarily be directed towards the core activities of the organisation. (9 4 1 1)

"......collectively as head office we're probably not seen in a very positive light, because we're all grouped together - it's always head office against us, that sort of thing. But individually I think that we would be perceived reasonably well within a staff. That is hard to judge but personally I haven't received too many negatives. I'm always accepted by many people and get along and I think they appreciate what I attempt to do, to do on their behalf. Collectively I think as head office, there is a them and us attitude." (9 4 1 2)

"As managers, we are managing people and resources and broad technical direction. I don't think they're should be an expectation on us to be the fonts of ideas of what ought to be done. I tell our people that I'm going to give fences within which you are to work and I'm expecting to set up processes and provide resources to allow you to come forward with ideas but don't expect me to come up with ideas. I'm out of that game, except to say that here are the broad areas with which government is now telling us to move - from there to here, so the fences have now shifted across that way. The resourcefulness and the creativity is more in terms of gaining the resources, the people, the sources of funding that people have eluded too. Basically keep them broadly on track." (9 4 1 3)

"How can you be leading when you are spending all your time managing constraints to creativity?" **(facilitator question)**

"I agree. I think there is a fair amount of tension. And the more staff the person is responsible for, the less leadership they can do. And some people in this organisation have far too many staff to manage to really be a creative research leader. There is no doubt about that." (9 4 1 4)

"What are examples of what you think has been really creative from your general position? It's not just creative accounting that we're talking about. It's something better than that." **(facilitator question)**
"Some programs have some terrific examples of accessing non traditional funding. There has been a lot of what I would call broadly creativity in the way in which we've gone about that."

"I guess that we get our creativity by interacting a lot with other agencies, I think. And as I mentioned before having diversity within the group."

"What we're talking about is being creative in gathering necessary resources to do jobs and not putting our time and effort into being creative in developing new knowledge, at the research level." (9 4 1 5)

There is a widespread perception of a lack of leadership within the organisation. Individuals need to take responsibility for their own development and career. (9 4 2)

"I think that there is a general perception that all program leaders are good people, they work hard, but they are dominated by management issues, fighting the executive. There is a cynicism about how much leadership is coming from program managers or leaders. The general sort of feeling coming from a lot of people is that the troops, the front line troops, that is the extension officers, researchers, are the ones that are actually doing the hard yakka. Getting the job done. The other people are really just responding to the wishes of the minister or the executive." (9 4 2 1)

"So would it be fair to say that it (leadership) is largely 'keep the monkey off the back' rather than to open up new doors?" **(facilitator question)**
"Well the time constraints force you into the former. I think that our desire is we would want to see more of the latter." (9 4 2 2)

"We have to nurture (staff) but the responsibilities are there for them. They are as much responsible for their career and scientific development as anyone" (9 4 2 3)

Leadership can be provided from within the organisation and from person-to-person links with other organisations. (9 4 3)

"How many visiting Professors and fellowships would the (organisation) have at any one time? **(facilitator question)**
"Certainly more than what we did have in the past. I think we are looking at some of this leadership (coming) not from within our overall organisation but within other groups so the leadership will come from the team in which they participate. This has come partly through the CRC program, that is a good example."

"PhD students?" **(facilitator question)**
"More. We have visiting scientists from the US about rangelands."

"We have about 50 researchers at (the Institute) and we have about 10 or 12 masters or PhD students associated along the lines." (9 4 3 1)

" ....we're taking the boundaries away saying 'you run this'. There is incredibly wide boundaries in some cases. Then they come back and say well, we want more leadership from you." (9 4 3 2)

" ....I think that we need processes to allow individuals to express themselves creatively and then build on it from there." (9 4 3 3)

"...what I consistently find is that the cry for leadership comes from is for the professional leaders. The discipline leadership." (9 4 3 4)

The capacity of science leaders and managers to foster a creative research environment is constrained by the fact that largely they are divorced from the work-bench. Research leaders need to interact with their team members from a position of understanding the science of the projects being conducted. (10 4 1)

5. Funding and Direction

Financial limitations constrain creativity principally because of the consequent inability to pursue interesting and potentially worthwhile ideas and concepts arising from within funded projects. (4 5 1)

"What is happening now is that the creativity is being harnessed into something that has focused outcomes for somebody's benefit. The question that you ask is are we going too far on that and actually restraining people's creative outcomes to particular solutions. I think, in every scientist's life there should be 10% of their time where they are allowed to pursue a good idea and not be bound by these outcome oriented constraints." (4 5 1 1)

A clearly defined and implemented agency purpose, mission or focus is necessary to enable the agency to systematically identify and act on high priority issues in ways which avoid misuse of resources, over commitment and frustration. On the other hand it is necessary to enable persons to pursue interesting leads that may fall outside these boundaries, in part at least so that the boundaries can evolve to meet changing current and future needs. (4 5 2)

"One of the things that is a consideration is the boundaries that we form, and perhaps creativity, nurturing creativity is enhanced when you remove those boundaries, but when you are in an organisation which is outcome focused, then those boundaries seem to be in place. And I just wonder whether there is a need to get rid of the boundaries, let creativity occur, and then come back and start putting the boundaries back. Rather than having them in there and saying well, you can't work in that area." (4 5 2 1)

"You can't do anything about (an idea arising in the course of a project) simply because you haven't got the resources." (4 5 2 2)

"Is (the organisation) a service provider or is it a service provider that is there for economic development and therefore targets those as its clients who are going to contribute to that economic development. Sometimes (this confusion) gets in the way of creating ideas." (4 5 2 3)

"The research teams respect that concept (industry driven) much more when there is an industry board." (4 5 2 4)

"There is no better example of a research program that is national and is integrated across providers, across funding bodies and across industry organisations, I guess. But that fabulousness is also its limitation because at the end of the day you end up with one action plan with twenty items on it and if the money runs out at 12 the line goes across, so you automatically have got eight things that you are not even looking at!!" (4 5 2 5)

"I think the managers have to be creative in finding the right environment. I mean you have to find the money, you have to find the right people that will create the outcome that you are looking for." (4 5 2 6)

There is a need for creativity across the spectrum from development to the use of information and the latter requires a broader range of skills than is normally utilised. (9 5 1)

"The biggest problem that I see is that the current funding apparatus does not allow in agriculture, too much 'what if?' research. I mean, people just can't go out there and pursue the wild idea, the funding bodies very much constrain what you're allowed to do within often quite complex guidelines. That's all they are going to fund. Internally we've got to the point of so little discretionary funding. There is $200 000 within the (organisation) for R&D initiatives account to pursue new ideas. I think that is pretty useful. I think that what is lacking out there is some funding mechanism for strategic long term, blue sky new approaches; that's not now in the system, at least for horticulture anyway." (9 5 1 1)

"One of the frustrations I have as a manager is that we are risk averse for various reasons within the organisation, because we are political and so we tend to take the easier path with the less risk attached but it always is a frustration of mine that we can't seem to get the resources or the necessary people together to commit to doing something that is more creative. We seem to be dragged back to the pragmatics here and now problems. But I think most of us would recognise as scientists we would love to work more creatively on those problems which are going to confront us into the future." (9 5 1 2)

"...isn't there the need for creativity in ways in which we implement the current state of information to a point to where we exhaust that and are starting to look if you like for new information.. Not that the two can't go in parallel but it seems we are falling down badly in being able to impart the information in a way that people will adopt it." (9 5 1 3)

"If we take the whole spectrum of from basic work through to implementation, the more creativity that we're going to have over that span the better, and obviously it's going to be more effective to achieve things through that spectrum. But as scientists we tend to look at creativity at the basic level. We are looking at new products, the new way of doing things or interpreting things but once we get through to the implementation phase, creativity is more the human psychology and the motivation of people and how they take up ideas. So as scientists when we think of creativity we tend to fall into the trap of thinking (only) of the new product, the new model, the new mathematical formula." (9 5 1 4)

Most people undertake creative work outside their standard work program and this should be encouraged. (9 5 2)

"Everybody does do something which is a bit more interesting to them then what their standard work plan is. And our challenge I often see is we've got to create the environment as much as possible so they're not going to be jumped on for doing that sort of thing. I'm prepared to take the risk and take the flak, to let a person work a little bit off steam because I can see they are bending their mind in a different area, rather than the standard straight down the line." (9 5 2 1)

Research funding committees limit creativity as they don't sufficiently understand science. (10 5 1)

"I don't have a problem with having industry representatives. The problem is the (corporations generally) don't have any (scientists), they are dominated entirely by growers or farmers and really they have come up through the ranks and they are elected people and probably none of those Boards I can think of have any body who understands science." (10 5 1 1)

"The funding committees are predominantly dominated by growers or farmers and in my view they don't sometimes understand the science" (10 5 1 2)

"I think that there are certainly constraints to creativity in the way in which a lot of research is currently funded and so highly structured in its progress through a particular project." (10 5 1 3)

It is debatable as to whether the R&D portfolio balance should come from a R&D funding agency or from within the R&D institution. (10 5 2)

"... hasn't (the research organisation) got the theoretical capacity to balance the portfolio within (itself)? I wonder if we should expect the (corporation) to have a balanced portfolio ... as I see it, they work at one end of the spectrum if you like, generally the applied end of the spectrum anyway, and once you cut off your involvement in that sort of fund of competitive R&D the organisation should still fund a layer of more strategic fundamental work below that. I see the balance being at the (research) organisational level not necessarily balanced within each funding body or funds source or whatever. It's just a matter of where do you see the balance, I think. I see it at more at the organisational level." (10 5 2 1)

"... I don't think we're not necessarily creative at the moment but we're not doing the fundamental creative stuff." (10 5 2 2)

6. Management and Administration

Research management needs to be tailored to the researchers' individual personality, experience, skills and ability to work best with or without boundaries. (4 6 1)

"To me the phrase managing creativity is a bit of an oxymoron because we could argue at length about where those sort of intuitive ideas come from and often they pop up at the most inopportune times and you need a method to record them. So if you are talking about managing that sort of a process it becomes an absurdity. Managing the process is about putting in the circumstances or the support mechanisms that allow some of those ideas to be implemented in some degree of safety." (4 6 1 1)

Time limitations constrain managers and researchers, who become over committed because of pressures from government and industry to undertake additional projects. Bureaucratic accountability processes and some communication demands limit creativity because of their adverse impact on the time available for creative work and because they dampen enthusiasm. Considerable work loads arise from the need to consult and be consulted. This factor has grown in importance because of the use of easier and more rapid communications. (4 6 2)

"You need time to think strategically and not get caught up in the day to day garbo, that is a major difficulty." (4 6 2 1)

Managing creativity involves putting the circumstances and the support mechanisms in place that enable creativity to occur. This includes putting together, within or across institutions, teams with different experiences, expertises and personalities; people who are creative and people who harness that creativity to produce outcomes. It also involves creating a supportive yet challenging environment. (4 6 3)

"One of my concerns is that successional planning is not robust enough to have the key people who ensure that creativity is an energy that is fostered through the next ten years." (4 6 3 1)

"It is very often difficult to get a combination of someone who is highly creative and someone who has an ability to harness that creativity to the outcome. So it is about teams of people as well." (4 6 3 2)

"It is very difficult if you have a non-creative group. For them to become creative, it is not easy." (4 6 3 3)

"What it is that I would like to see, is more of us agency provider types thinking of ourselves throughout Australia as a pool of expertise and maybe you could go international if you like." (4 6 3 4)

"I really think that the latest (restructure) / is a very positive step towards allowing creativity to happen and the reason I say that is that I can't think of another time when a team within an institute or the equivalent of that group would have met to plan, implement and evaluate work as a group. So when you ask what would you like changed it is about each member of each team feeling safe to take risks to try to implement a new idea, a creative solution without fear of retribution or failure or perception of failure. For example, that perception of failure is real when you cannot get progression on the internal progression scheme because you spent eight years of your life pursuing an idea that in the end did not work." (4 6 3 5)

Administrative burdens, often associated with accountability limit creativity because of the associated workload and frustration arising from the perception that at least some administrative tasks are not useful. (4 6 4)

"The reallocation thing is pretty important because people say, look at the money you have currently got, you should be able to reallocate resources into those areas. Well, in theory you should be able to. The practice of actually doing that is not so easy." (4 6 4 1)

"Let's revert back to one of the boundaries. People will never let staff go into those alternate arrangements because ultimately their level of remuneration depends on the number of subordinates." (4 6 4 2)

"Providing the reporting mechanisms for all these different (organisations), then the outcomes get forgotten and then you get caught up in reporting." (4 6 4 3)

"There are things that impact on you and detract from your ability to focus on the work you need to do and generally it comes down from the higher levels of the organisation. " (4 6 4 4)

"As (RD & E) providers we want to control our own terms and conditions and how it is done." (4 6 4 5)

"Bureaucratic boundaries can really work against creativity if you let them get to you." (4 6 4 6)

"It is the accountability issue, really, right through the organisation." (4 6 4 7)

Short term demands on managers limit their capacity to manage their time effectively. (9 6 1)

"But if you're program leaders, managers or whatever, why can't you organise your own time to enable that to happen?" **(facilitator question)**
"Good question. Well the political reality, that's fine if there is no political interference from up high. Like I can say, I can go out and have a program meeting, a planning meeting. Then you get a ring from the minister's office and they want something by 12 o'clock. It's alright to say, well organise your time, but they are the constraints that we're confronted with."

"Perhaps we're being a bit hard on ourselves.... Because I'm sure that for all of us if we really thought it through, there are a lot of really positive things that are being done, or we have done, in the context of this creativity." (9 6 1 1)

"...as managers we really don't have the time often to sit down and take the time to be creative. I know that most of my time is really just putting out one bushfire after another. And they're coming in at a rate of about twice what I'm able to put them out."

"Who is lighting them? Who strikes the match? Are they internal bushfires or are they external - the industry clientele or that sort of thing?" **(facilitator question)**
"They are mainly outside problems that have to be dealt with."
"They come from the minister's office, a lot of them." (9 6 1 2)

The existing milestone structure constrains creativity because it prevents investigation in new directions. Additional funding to explore such leads is generally not available and/or is too delayed. The appropriateness and/or nature of project planning processes, and in particular the use of milestones specified as pre-determined outputs or outcomes, varies depending on the nature of the R&D, with less prescriptive approaches being preferred for R&D at the exploratory (basic) end of the spectrum. (10 6 1)

"As you say, they (milestones) are just reality checks or reminders. If they are things that you have a hard deliverable at each of those points it's much more, you feel much more constrained I think, because every 3 months or whatever it is you have to deliver something." (10 6 1 1)

"I think the existing milestone structure ... constrains creativity sometimes." (10 6 1 2)

"The CDK (Chief Doesn't Know) is the creative stuff, believe me it is the creative stuff." (10 6 1 3)

The effectiveness of R&D is adversely affected by the practice of RDCs not funding the full cost of research and of controlling how and by whom the research is done. (10 6 2)

"There are two issues. One is that RDCs won't pay the full cost of research, and I don't think they ever will even though (the research organisation) has said for years now it was going to try and convince them they should be funding them on a more commercial basis. I don't think they will ever do that .... The other problem is that the requirements in terms of grant proposals, budgets, milestones and in some cases control over how the research is done, I think is too high." (10 6 2 1)

The time scientists and their managers now have for creativity is more constrained than previously because of extension of their responsibilities into managerial and support areas, because of the need to seek funding, because of the need to complete projects quickly and because managerial procedures are more complex and demanding. (10 6 3)

" ... To be creative, you have to have mental space - you have to have time to be able to sit and ponder on things from time to time and that doesn't exist in my life at the moment. I think what has happened to a lot of senior scientists in our organisation is that they are so busy with the day-to-day management of the research projects in their portfolios and meeting the milestones that they don't have the mental space to think creatively any more and that is what I think is a major problem in creativity in research management." (10 6 3 1)

7. Communication and Teams

A substantial component of the communication between researchers should be face-to-face. (10 7 1)

8.   Recognition

There is a need for an institutional culture that recognises that change will happen and that persons who maintain and develop skills and who remain creative will be more likely to continue to be employed. (4 8 1)

> *"The fact is that your best people are hunting for contracts."* (4 8 1 1)

> *"All of your staff and particularly your best staff are considering their options all of the time, so they are out there in the market place."* (4 8 1 2)

Work satisfaction for managers arises from having improved processes and outcomes and from helping staff and clients. There is virtually no recognition from ministers, the executive or from research corporations. (9 8 1)

> *"Where is the recognition coming from now? From ministers, the executive, research corporations?   Is there institutional recognition?"* **(facilitator question)**
> *"Get no recognition back from that side of things."* (9 8 1 1)

Performance planning and evaluation procedures can affect creativity by imposing a risk of failure and hence a risk adverse environment. (10 8 1)

Appendix V

SUMMARY OF FOCUS GROUP DISCUSSIONS WITH RESEARCHERS

1. *Nature of Creativity*

Creativity involves thinking beyond the conventional paradigms. Creative thinking requires time and space and it is important that the ideas are not judged or constrained too early in their conceptualisation. Being creative is not a structured process and there is a need to let subconscious thoughts intermingle. (3 1 1)

> *"Creativity is really just the ability to think beyond our conventional square or paradigms or whatever and think of innovative solutions for things, or to be able to even generate possible solutions, without them necessarily being practical in the first instance."* (3 1 1 1)

> *"I don't believe that scientists work set hours, my head does not stop."* (3 1 1 2)

> *"Sometimes you don't know at the time that it is going to be useful, but five years down the track that may be something that is extremely useful to industry, and that is why you need a balanced portfolio of your strategic work and your basic research, you really do."* (3 1 1 3)

> *"Creativity is a very messy thing and that is where it gets difficult, because often it is at the limits of where normal thinking occurs is where you get the most creative thoughts happening. So it is a balance between trying to go in one direction to get something done as a team, but then making sure you are out on the edge enough in a sense where thought patterns and other processes are really breaking down. "* (3 1 1 4)

> *"It is not something that you can do in a structured way, you have to have that time to let subconscious thoughts intermingle."* (3 1 1 5)

> *"I truly believe that we would be most creative in the future in putting together teams of appropriate personnel to actually address specific issues; if you are going to do that seriously and with meaning then you really have to be coming from the position of knowing the system pretty well, so that's where I think creativity in the future is going to come from, in doing that and doing it well."*

Researchers acknowledge that there is considerable variation in the effectiveness of researchers and, to some extent, this reflects people's ability to deal with organisational cultures and processes, funding arrangements and the nature of their workplace in relation to management and leadership. (5 1 1)

There is a requirement for creativity in problem definition and resolving how the problem should be addressed. Processes that prescribe how a presented problem might be resolved constrain creativity. (6 1 1)

> *"...in terms of the external influences there is a problem specification component, there is a methological component, and there is a milestone/reward sort of component. Would you care as a group to discuss those different ones or not so much to rank them, because there are not black or white demarcations between them but in which of those areas are external stimuli particularly potentially disadvantageous to creativity?"* **(facilitator question)**

"I think the logical step thing....But the whole idea of we are going to make a better vaccine or build a better sugar cane, and we are going to it in 10 logical steps, almost precludes the creativity."

"I think we would be more comfortable if someone said here is the product (we want); we don't want to know how you are going to do it."

"...the more creative part in research, I think, is actually in that earlier part proposing a, or floating a proposal with a research organisation, sometimes there is a lot of creation there, and getting your team together and thinking how you might address that."

"There's always the learning curve. I think part of the creativity process is you can't make logic jumps until you know the literature and the circumstances in your field and you feel that you know what's possible and what's not." (6 1 1 1)

"There is much creativity in problem formulation, as much as in the problem solving area." (6 1 1 2)

"We've never had anything particularly imposed on us, we've actually discussed issues that we thought were relevant and have been commissioned to develop a project around that theme because it appealed to the particular potential funders, but it wasn't imposed on us. It was us approaching them in the first place." (6 1 1 3)

Knowledge of the domain and of the circumstances of the field are prerequisites for creativity. (6 1 2)

And that can be also an intensely creative time. When you have got this new finding, these facts, so how does that fit in with current knowledge, and how do you now change current knowledge? So you have got to go into databanks and into books." (6 1 2 1)

One idea of creativity is that it is to develop a new idea and find somewhere to apply it rather than finding a solution to a problem. (11 1 1)

"... my idea of creativity is that it is working out how to split the atom, not solving someone's problem. I mean you have to be creative to do both...my perception of creativity is something new, something innovative, a new idea that you can develop and then finding somewhere to apply it, not looking at a problem and working out a solution by being creative." (11 1 1 1)

"What is the relationship between creativity and productivity? Or don't you see them related? **(facilitator question)**
"Well they can be mutually exclusive or not."
"It depends."
"You can produce many bricks but not invent a brick. Or change a brick. You can keep producing them." (11 1 1 2)

2. Drivers of Creativity

The fun and enjoyment of research comes from developing new ideas and concepts, from a sense of discovery and from solving industry problems. (3 2 1)

"We like the science bit, what we don't like is being administrators. If we wanted to be administrators, we would have gone into the administration stream." (3 2 1 1)

"For me it is a sense of discovery, I get a real buzz out of that." (3 2 1 2)

"If they are on to something and pursuing that idea and they are trying to crack it, then you just go for it and it is very enjoyable." (3 2 1 3)

"We really enjoy a lot of what we are doing. It is just a sense of frustration about these other things that interfere." (3 2 1 4)

"There is a worthwhileness factor for a lot of (our) people." (3 2 1 5)

"So I mean the creativity process on its own is not, you know, for me, it has got to be something worthwhile." (3 2 1 6)

"There are a lot of people that work within the industries themselves (who) have fairly creative ideas and in fact a lot of them are creative because the only way they survive is by being creative." (3 2 1 7)

We need to both foster creative ideas and support persons to develop and implement them. (5 2 1)

The need to find solutions is a key driver of creativity. (5 2 2)

"I guess a scientific endeavour always has been to view a problem and look for solutions, so that has created the environment for creativity." (5 2 1 1)

"So you have got to have the basic training, you have got to have the knowledge, then you have got to have the work environment that creates, that allows for the development of new approaches, different ideas too." (5 2 1 2)

"I guess there are many motivations really. I guess most of us have an idea of the common good or the good of the industry. And we all need encouragement or rewards, whether it is monetary or a pat on the back, so that will just depend on the structure of the leadership, within any small project or any larger project so, it is just the luck of the draw." (5 2 1 3)

Creativity is primarily driven by personal intellectual challenge. Hence for creativity to occur, the challenge has to be internalised even if the problem requiring a solution is imposed from the outside. External limits, especially on time, can restrict this internalisation and hence the creative process. The motivation for pursuing the intellectual challenge is the joy, the buzz, the excitement of the personal satisfaction from discovery. (6 2 1)

"I think a lot creativity comes out of hardship, particularly if you have come up against a brick wall and you have got to find a way over it." (6 2 1 1)

"It is not necessarily adversity, it is just a difficulty or something that isn't working right, that has to be, that you see as a challenge and want to resolve. I suppose, from your perspective. It is not always adversity though, I don't think." (6 2 1 2)

"...you need a bit of pressure to be creative, but on the other hand it could be quite easy to have that stifled by external limits especially on time." (6 2 1 3)

"I prefer solving the problems I set myself." (6 2 1 4)

"I think you need an intellectual interest in the problem, I mean that's what keeps you up to speed, more time thinking about it. If a problem is deposited upon you by an external source you may have to solve it. But I think there is a mind-set and if you are genuinely excited or interested about something then you..." (6 2 1 5)

"Sometimes you have got a result that is so exciting that you can't not do anything about it, you have got to chase it." (6 2 1 6)

*"Why do you do that do you think, why?"***(facilitator question)**

"Just for the buzz of a new discovery, something that is unusual, something that is interesting."
"You want to know why, or how." (6 2 1 7)

"So is it because there is joy in that, or is it because you think that there is someone going to benefit from it, or is it peer recognition that you have done a good job?"(facilitator question*)***
"No, you are the first person in the world to have found a new fact."
"The real motivation in that is the joy of it. And all those other things are there. But that is really exciting, really joyful."
"Biology, bringing something together, new information together, that's the buzz." (6 2 1 8)

*"So can it be a creative action then if it is not recognised by anybody else?"***(facilitator question)**
"Well, you certainly make them recognise it five seconds after you've recognised it. I usually scream round the corridors for about ten minutes."
"I think it's the personal satisfaction."
"They certainly know about it." (6 2 1 9)

The satisfaction from science comes from the intellectual freedom, solving difficult problems, sharing an idea with others and having others adopt an idea. (8 2 1)

"I reckon the most satisfying part of the creative process is having an idea that someone else actually takes from you. That to me is the most satisfying part of creativity."(8 2 1 1)

"..... what makes my heart beat faster about science is solving problems that I find difficult. That's essentially what it comes down to." (8 2 1 2)

"I think having the opportunity to have some intellectual freedom (is why I do science) and science allows that more than other professions I think." (8 2 1 3)

"I mean I find that exciting too when you actually get an output that makes a bit of biological sense and you can explain it." (8 2 1 4)

"For me it's having the other people around me that, if I find something very new and very interesting, I can sort of call out to three or four people and get them to come and look down my microscope and share that. That to me is the buzz..... And that for me is the big buzz, sharing it with other people who are also interested." (8 2 1 5)

3.   Omnibus

The initial creativity or insight usually occurs when people are in the right mindset, are relaxed and are not constrained to achieving a whole series of steps that are already prescribed. There is also a lot of creativity required to resolve how the initial insight adds to or could change existing knowledge. (6 3 1)

"...you actually have to be in the right sort of mindset, like if you are really focused on just achieving a whole series of steps that are already mapped out, you are not necessarily in the right mindset for appreciating something is creative. You have got to be receptive, more relaxed." (6 3 1 1)

"I think creativity often comes when you are relaxed or you have the freedom to relax. I always joke that I gave up maths at university because I would struggle all night and then I would go to bed and the answers would come when I was lying in bed. But most often now I find I get a lot of creative ideas when I am either out running or riding my bike to and from work." (6 3 1 2)

"You will probably find you talk to a lot of field based agricultural scientists, you will probably find a lot of the creative solutions or good ideas, that come about driving the car just to field sites. And a lot of them are actually written on the back of beer coasters." (6 3 1 3)

"Basically the insight can come, but then there is a lot of work to do with that, you have got to check it out...." (6 3 1 4)

"...there are also the consequences (of the insight) and how the simple piece of information fits into the rest of the area, the film, the biology." (6 3 1 5)

The development and adoption of the (creative) ethic needs to be interwoven with processes to foster communication through non-threatening discussions, seminars and collaborative projects. This open and exciting exploratory ethic needs to involve and relate to all staff, including technical and administrative and advisory personnel. (7 3 1)

"I think that the area sort of splits itself into the external factors that we have been talking about, funding and that sort of stuff, but I thought that in order to give it a broad sweep we also need to talk about industry attitudes, institutional attitudes and sort of on the ground laboratory attitudes. We are talking about creativity. It is a personal sort of thing and I just don't think that two hours is very long (for this discussion), but there are things like communication within the laboratory, professional staff within the one section, talking to one another without the feeling of threat. Enhancing your own work by spinning off somebody else's work at the laboratory level, seminars, all that sort of stuff. I understand everything that is being said about these external funding factors but I think it is a broader issue than just that." (7 3 1 1)

"... no one would deny that the main thrust for creativity ought to be done by professionally trained people. But in my view and experience in hospital and the university, if somehow the ethos of creativity and research can be spilled and the technical staff can be made to sort of embrace or touch on that ethic, in my view we do get a far better laboratory attitude and performance so if you wanted to pursue the whole creative processes (don't confine it) to people who have got a PhD or MSc. There are spin offs from getting the technical staff involved in that sort of thinking as well, it really pays dividends at the bench level." (7 3 1 2)

"What are some of the good things?"(**facilitator question**)
"We have superb facilities."
"They're clean, they're pleasant, they've got a lovely outlook (the laboratories). We have got wonderful people and we have more reasons than most people to be creative." (Person very critical of the research environment generally). (7 3 1 3)

Creativity is very much affected by funding arrangements. Creativity is bounded by the specifications of the funded project requiring attention to a particular outcome which has a relatively high probability of being achieved in the shorter term. Furthermore funding bodies and hierarchical departments are inherently conservative. Creativity can occur within these specifications but lack of resources and time limit the opportunities to explore beyond those bounds. Criteria for promotion can also affect the capacity to develop and explore higher risk ideas. One solution is to have overlapping projects and having enough people to wander across directed projects. It is also important to operate in an environment characterised by flexibility. (8 3 1)

"It can take a while...to actually shape it (the idea) and show people."(8 3 1 1)

"The very nature of science, surely, is that somebody comes up with a new idea and everybody goes 'this is complete rubbish', and it requires a major paradigm shift for science to advance. These sorts of ideas that get rubbished 90% of the time I guess are some sort of survival of the fittest." (8 3 1 2)

"It's also the timing in the environment at the time. I mean an idea can be ten years ahead of its time ...." (8 3 1 3)

"... in terms of getting an idea up you need support from some parts of some sort of network, whether it's an administrative network or a scientific network or whatever." (8 3 1 4)

"I think creativity is these days very much constrained by funding sources." (8 3 1 5)

"... you have very little leverage to follow that line of thought to see whether it goes down a blind alley or not. That's part of what research and creativity is all about". (8 3 1 6)

"I suppose I will agree with one and take issue with the other. I agree that some of the major research creativity might be serendipitous but I think there are aspects of even directed research that if you had the time could actually lead up these alleys." (8 3 1 7)

"...we are basically industry driven or funded so it's normally two to three year projects and we've got to remain focused and that focus affects creativity, because you can't go on the side tracks... if you're looking for promotion you can't really afford to be side tracked on no win ideas... once you become industry driven, it makes it a lot harder to be creative." (8 3 1 8)

"I can't plan ahead as to (when) I am going to have an original thought, so having time to work on something theoretically or work on something directive in a way, I can't see that that would affect my actually having an original thought. I mean finding the time to work on it and explore it is maybe (the issue)." (8 3 1 9)

"You can be creative within those bounds, we're not saying that by directed you have no thoughts, but your creativity is bounded by the projects, aims, goal etc, and you tend to have to follow along a general path. Now there might be all sorts of potential tangents that you could wander on or along, that seem quite interesting, but they don't pertain directly to your funded project." (8 3 1 10)

"... I think there is an element here that the directed research develops an approach which is reasonably narrow, but I think the trick to having creativity comes from having more of those things that overlap and having enough people to be able to wander across the directing project. I don't like the idea that this directive somehow loops off creativity." (8 3 1 11)

"The problem we have got sometimes is that funding bodies and certainly hierarchical departments are quite conservative." (8 3 1 12)

"... more and more people are not prepared to take that little risk. They're always going for the positive outcome." (8 3 1 13)

"... you get to the stage where some problems can't be solved with the way we have been approaching them, they're bandaid solutions and they need a novel approach to them but many funding bodies are not willing to take up or consider a novel approach, if it is what they consider to be high risk, because at the end of the day they want a result. They put out money and they expect something in return and what they expect in return is more often than not a solution for the problem." (8 3 1 14)

"Perhaps the whole crux of this is the fact that the institutions themselves are basically fairly conservative." (8 3 1 15)

"I think it's also important to be in a micro-environment (characterised by) flexibility. So having your immediate boss and the people around you flexible to all kinds of things, whether it's the time you arrived or the time that you like to eat or the way you like to prepare your particular samples." (8 3 1 16)

As more work is reported on to clients, including RDCs, less work is being reported on scientifically in the public arena and there are greater delays in publishing. This has a

negative impact on self assessed excellence and recognition and hence on creativity. Additionally, the lack of scientific recognition adversely affects funding. Delays in publication usually result in inefficiencies in preparing manuscripts and an increased risk of information redundancy. (11 3 1)

4. Leadership

We need creative and visionary leadership supported by effective management. There is considerable variation between different parts of organisations in the flexibility provided by management and in the adequacy of the professional leadership. One approach that is effective is to have co-ordinated programs with good professional leadership and strategic accountability to and relationships with industry. (3 4 1)

> *"I see leadership more as having an idea, a vision of where you want to go and of being able to articulate that, but that has a lot to do with thinking. You have to have management to go with that, to provide the back up and support for that, but I see them as two very different areas, and if you are in science you are probably more into leadership stuff than you are in the management area because you are about thinking in different ways."* (3 4 1 1)

> *"What happened is that somebody has provided the leadership by thinking this is an important thing and this is something that we want done. Then they sought out and got the right person to do that job, somebody that is creative and thoughtful and they said O.K. we are going to take the lot of those day to day management tasks away from you. Just as long as at the end of x period of time you come back and show me what you have done and what has been achieved in the industry, and you don't break any laws while you are doing this."*

> *"Is that a typical situation do you think, in your own workplace or not?"* **(facilator question)**
> *"Far from it."*
> *"That is purely atypical."* (3 4 1 2)

> *"So I am lucky because I work with a guy that thinks and really encourages creativity and handles some of the management so between us we survive fairly well. We don't have a lot of the politics which you would probably have if you were (closer to head office). I think I find it an advantage to actually be geographically a bit away from where that stuff is happening.."* (3 4 1 3)

While there are industry people who understand and support research, these people become heavily committed and/or become entangled in industry politics. (5 4 1)

> *"There are some good people coming through from industry, industry leaders but they tend to get diverted by agro politics, and also industry people are very much focused on the latest bush fire. They tend not to have that long term view. And they get a long term view by talking with scientists and people like us."* (5 4 1 1)

The distinction between managers and leaders is felt sharply and there is a belief that the formal institutional structure, culture and processes incline people towards being managers rather than leaders. (5 4 2)

> *"We had to get permission to change our biros in 1964. And all that sort of thing. So I mean I have gone through all the various phases. But what we seem to lack these days is a sort of imaginative leadership that we had in various phases."* (5 4 2 1)

> *"I think a few of us here have been fortunate to have been in those creative working situations and most of them you can relate to the leadership you were given and the environment that leadership allowed you to develop. The leadership support might be subtle sometimes in terms of bringing in people with different backgrounds and ideas. The opportunity for staff to travel*

to interact with other people and so forth. I mean creativity is just ideas, ideas based on knowledge." (5 4 2 2)

"When the politicians get in and the administrators start to ape the politicians and think that all you have got to do is worry about tomorrow and the next three years at max. Well, that is the antithesis of what is required for resource management." (5 4 2 3)

"Maybe our organisations don't always want us to be creative ... all we need to be is organised at times and have these little flashes of creativity to keep the thing moving forward."(5 4 2 4)

"There is a layer of leadership that is missing, I reckon, in our organisation. And that is the people who make up a good scientific people bent and be creative and engender a sense of excitement. That gets knocked on the head in our organisation because this all invasive management culture sort of just depresses them. I really think that that is what is missing, that real excitement at doing something."(5 4 2 5)

"I think the problem in our structure is that team leader is seen as a quasi manager, rather than a blossoming scientific leader." (5 4 2 6)

"If you are looking for those type of leaders, you look for someone that thinks about the profession, the profession of agricultural science, your ecology or whatever you like to name your profession and service that, because then you will be really achieving yourself." (5 4 2 7)

The lack of effective organisational leadership adversely affects the research environment (7 4 1)

"If you are not really sure what the (organisation) wants, it's virtually impossible to sort of construct an ethic in an institute where, you know, how can you sort of design or have a situation conducive to an ethic if really you don't know what direction you should be heading off to in the first place anyway?" (7 4 1 1)

"...until you get into the groove and get the (research) ethic established there's got to be some driving force (leadership)." (7 4 1 2)

" The other thing is that if we are really going to continue as a research organisation in (our organisation), we've got to have people coming in behind us, which isn't occurring in most areas." (7 4 1 3)

"So I don't have a clear view of what the (organisation) wants. Even now." (7 4 1 4)

"We get messages coming down that perhaps treasury wants to wind back a little bit, therefore we can't get involved in the long term operational activities including long term research because that might hinder our ability to cut back. Again, a political conflict versus industry problem." (7 4 1 5)

"...in lots of cases (it) is lack of clear leadership, and I'm thinking about the...direction for funding and the ethos for attendance of seminars. Where does it come from? It should come from the top. It's all a question of leadership, isn't it?" (7 4 1 6)

"To defend the institution,...it is interesting talking to people in those other institutions and they have a poorer image of their institutions than we have of this one." (7 4 1 7)

"The interesting thing is that there has been this management and executive perception that there isn't a need for the individual (institute leader) to have a strong scientific background." (7 4 1 8)

There is a universal and strongly held view that the executive of the organisation does not provide effective leadership. Effective leadership was described in terms of being

visionary, flexible, knowledgeable of the organisation's achievements, potentials and constraints, tolerant of creative people and prepared to address identified problems. (8 4 1)

"The problem is that the guys who are directing research or the majority of guys who are directing research, don't have a major appreciation as to what research is about, lack a vision...." (8 4 1 1)

"Probably more dangerous when they (leaders) come from the background of science where they think they know it all and maybe therefore tell you how to do your research." (8 4 1 2)

"I think maybe if someone is really being cramped in their style and wants to be creative and bouncing around ideas and this sort of thing, and I think you need some of those people around, it's probably not the right environment for that sort of person." "Those people scare head office." "Yes they're scary and they probably scare funding bodies too." (8 4 1 3)

*"Is it too much then to say that professional, visionary leadership within the (organisation) isn't really a big issue, that is that those things you will get from your networks externally?"***(facilitator question)**
"Well we have to (get our leadership externally)."
"When I first joined the organisation I was talked at, at length by executives and also some people a bit further down the scale, and the central theme was you work for the government of the day. So whatever you want to do, it doesn't really matter, you work for the government of the day." (8 4 1 4)

"I think there probably are many such people, (good flexible visionary leaders) around, but once they get to (our) structure, which is quite rigid and ultimately a lot of what (is done) is constrained by the policies and politics of the day. So perhaps there are many people who could enter those roles, that have those criteria but once you place them in the positions of senior management and the executive etc; then they are probably constrained by the internal constraints." (8 4 1 5)

"I think (a person) does pretty well as director of (this place). He's not in the structure of the (organisation) he's sort of sitting over here outside but I find I can always go and talk to him about things, he's always prepared to listen to it and he does his best to make things happen. I mean this sort of thing (creativity project). He is very keen for this activity to happen. It might just be my experience with him, others I know have had different views." (8 4 1 6)

"We used to have that with the director of (a discipline), people who we could look up to and admire. I expressed the view the other day that the people at the top of the (organisation), we don't have respect for, we have fear of, rather than sort of working with them towards common goals ...." (8 4 1 7)

"I mean, I think we do a lot of very good work in this (organisation) which is not recognised by the executive and it is done in spite of the executive, in spite of the management within the (organisation)." (8 4 1 8)

"The only time we have the situation we described (good leadership) is when we had directors of research centres before, we've had that type of situation. We've now come back the full circle and gone back to that stage again, where it's starting to happen again. It will take another two years, or three years before it will evolve to be fully effective." (8 4 1 9)

"But once it starts getting effective they will disband it and go to another system that is unproductive. You can't have a system if it is too productive!" (8 4 1 10)

"Can I perhaps finish this with one question. I know you are here to help me! But that aside, why have you come, why have you stuffed your day, the afternoon. Anyway, it's not a topic that gets thrown around a lot, why would you bother?" **(facilitator question)**
"We are clutching at straws here. You are our final hope for some changes to occur from the top."
"It is something a little different and it intrigued me, creative research, what we were going to talk about and perhaps yes, that if we came up with something that was beneficial to us, that it might come back through (the system)." (8 4 1 11)

"Have you talked about the things that you thought we might talk about?" **(facilitator question)**
"To some extent, yeah."
"But I think there is going to be a difference between when the report comes out, and hits the desk of (someone in the executive) and there is recognition of the problem. The emphasis (should be) to do something about it and we all know that rarely takes place. Recognise the problem but try to brush it under the carpet."

"I'm just as cynical as everybody else and I've been with the organisation for fifteen years. External things will change, but internally rarely anything changes."

"... if you were a bureaucrat taking notes, I would have said, sorry but I've got too much to do. I was interested because you'll be using it for your own research. If I thought it was a report that you didn't think was important, it's just the job you were given to do, I'd not come." (8 4 1 12)

Mentoring is an important and beneficial workplace tool, as long as younger creative scientists are not stymied by their mentors and the existing funding procedures. (11 4 1)

"The younger scientists are less experienced in grant writing and grant getting. And consequently we have tried to, or I certainly have tried to, impress upon my section the importance of mentoring where the older scientists have to help the younger scientists come along." (11 4 1 1)

"... you are getting the less creative people putting in the grant applications and the more creative people not doing it because they are inexperienced. I mean, if we just say for the moment that people coming directly out of a University sort of at the peak of their creativity and full of all these ideas, ... well, maybe we are not harnessing that by saying maybe you don't really know how to write up an application, well, if you want to get funded this is what you do. And we are forcing them into a non creative pathway that we know gets funded, rather than applying their ideas." (11 4 1 2)

5. Funding and Direction

Research and development corporations are imposing an incremental approach to research and this reduces challenge and creativity. There needs to be a balance between incremental research building on previous work and work in less charted areas which may be longer term and/or of higher risk. (5 5 1)

"The current system is too constraining. Get a project, do the milestones, write them up and move on to the next one. Its just too constraining." (5 5 1 1)

"I mean, we have got to have outcomes, especially adoption outcomes, there is nothing wrong with that, but if you are looking at creativity as an entity then it is being pushed away." (5 5 1 2)

"I don't think the industry corporations are really challenging people to go for it, because of this incremental nature of the research that they are funding." (5 5 1 3)

"There is definitely more money around now, with this project driven stuff. So I'm not knocking industry funding, I mean it has been great in terms of injecting more money into the system, but it has injected a lot of work into the system. It is not conducive to creativity." (5 5 1 4)

"And I think this permeates throughout our whole project set up, in that we are trying to do work that we would like to do with insufficient funds." (5 5 1 5)

"Exactly, it (creativity) is being stifled. In that need to fulfil that mechanical role, you know apply for money, do the project, meet the milestones, write it up, it doesn't allow any lateral thinking. If you do, they say stop it, it is not conforming to the current culture of the organisation." (5 5 1 6)

Agricultural research and development funding practices constrain creativity because they favour incremental approaches with a high probability of successfully delivering predefined outcomes. It is virtually impossible to get up-front funding for long term studies and hence, to the limited extent they continue, they are camouflaged within projects with more predictable and shorter term outputs. (5 5 2)

"I think we are very constrained. I think we are very constrained by the process of funding that we work under, which is through the (RDCs) and they are accountable for their funds. So they are only willing to take incremental steps. I think what we do is very predictable, there is very little blue sky stuff that we indulge in. I think that the system does not encourage major leaps forward." (5 5 2 1)

"The starting part (constrains creativity): the bit that says, this is what you do for your money." (5 5 2 2)

"So really to be creative in the system that we have got at the moment, you need not only to be creative, but you need to be pretty strong minded." (5 5 2 3)

"In the current context of being creative, being able to do something, means that you have attracted the funds to do it." (5 5 2 4)

"The funding bodies are more and more into commissioned research., and I don't think there is anything better designed to kill creativity than that! With the federal funding bodies, they are all there for a period of, say, three years or whatever. So that is where the commission of research comes in. So the continuity there also has problems." (5 5 2 5)

"We had other things that he (a manager) could more identify with, that is, how you kill trees and all those other sorts of positive things! So that is how you could sell this more basic stuff which has a long term dividend. We could not have satisfied the industries' needs without that which was snuck in. But it would be very hard to get any funders to support that line of work today. The fact that it was there has enabled us to deliver, then because we could deliver we can attract funds that are around because they want the sort of instant gratification answers." (5 5 2 6)

"Obviously there is a balance there somewhere. I mean you wouldn't want to disband incremental research because it can build on years of solid research. But there just needs to be that opportunity to give people a go with a brand new idea." (5 5 2 7)

"I have found the very best way to get money from a federal funding body is, in your application you tell them a story and the story goes: this is the past history of this problem, this is the current situation, and now I am delivering to you the next step, and if that next step is new and they have not thought about it before you are right in there, you are going to get the money. You give them the next step that they haven't thought about and suddenly they say oh right, that is very logical. And we are into incremental research and Bingo you have got the money, works every time." (5 5 2 8)

The initial specification on what might be funded is a constraint to creativity particularly if these specifications are influenced by government and industry political factors. Creative ideas are not generated or they are lost because of presumptions that they would not be funded. (5 5 3)

> *"But the funding structure does not allow you to try something and if it doesn't work try something else. I mean the funding structure says you have a little amount of time and a little amount of money and you have got to deliver."* (5 5 3 1)

> *"Commissioned research can only add on to something that already exists whereas true creativity can create something that is totally new."* (5 5 3 2)

Creative ideas often are spinoffs of a particular line of work or project and these cannot be developed because funding is restricted to the prespecified outcome. (5 5 4)

> *"In our system, where funding applications have got to be put in twelve months out before you start work or that sort of thing, creative type people quickly lose interest, they have got to wait twelve months before they can start work."* (5 5 4 1)

> *"I think there are really creative people, they get their projects and they use the project to try out some of their ideas, so in a way the successful people subvert the system."* (5 5 4 2)

> *"Often you start off with an idea and if you follow it through you come up with quite a different outcome, but it is a spin-off of the original thinking process. It is those spin-offs that are not coming because of those constraints"* (5 5 4 3)

Researchers feel they are on a funding cycle treadmill with fewer funds than are required to tackle the issues and with time frames which don't enable full completion to publication of one project before the commencement of another. (5 5 5)

> *"I think a lot of people would prefer to have one project they knew was firm, and work on that. The reason we have two or three projects or we have Mega projects is because it is almost self protection."* (5 5 5 1)

> *"Takes an enormous amount of time looking after people and that is why I say people in that situation unless they are very good, or work all weekend or all night, just don't have the time to be creative as well as using their creativity to get around all the hurdles that are put in your way managing things. So that is where you are sort of relying on, for creativity, the sole operator. We don't give people time to sit there and think and that is where creativity comes. They are always busy doing things."* (5 5 5 2)

> *"You have got to start doing all of the writing up and interpreting of the research results, while also running another project. More workload."* (5 5 5 3)

The R & D focus is now much tighter than it used to be, owing to all expenditure being driven by tightly focused external funding leading, for instance, to researchers being more accountable externally (to industry) than to their employing organisations. (6 5 1)

> *"I certainly feel vulnerable about our project structure here. I'm in the (industry) project and to do work on (another industry) requires a fair bit of administrative hack work that may or not be possible. It is not just what the Corporations say but the organisation is saying to me to put the blinkers on about some of these things."* (6 5 1 1)

> *"One of these things maybe, it always helps to attract funding, to have a few preliminary results, so just check that it's feasible, so you do some sums for it just to check that your idea isn't completely off the planet and that it's more attractive to have some preliminary results, so*

that's one reason for doing some skunk work. The other thing is that some innovative ideas may be high risk and some people might say the funding bodies don't take a strategic enough view of strategic research, so a lot of this high risk type work is not attractive to funding agencies so that is another reason for this skunk work." (6 5 1 2)

"Yes, it is run by industries." (6 5 1 3)

"The small amount of externally funding that's required, really directs what's being done..." (6 5 1 4)

"So we're more accountable outside (to industry) than we are inside than we are to ourselves." (6 5 1 5)

"...(organisations), where they have a political agenda...generating some new knowledge is at best (only) one of the things they need to produce." (6 5 1 6)

"There is in our project structure a reliance on R & D Corporations for external funding plus others, that does impose - some limitation to creativity in that you are being asked to be creative within certain boundaries-financial and direction - whereas in the university system, sure in you still have that financial boundary but you don't have the other boundary." (6 5 1 7)

"I think the more open, free (less focused) one (for creativity) is more limited now than it used to be." (6 5 1 8)

Researchers believe there is a lot of potential for, and realised creativity outside, the tightly focused industry funded projects and programs. Tighter project management systems, both externally and internally, severely limit the scope for undertaking these unofficial exploratory R&D activities, variously called "skunking" or "CDK" (chief doesn't know). (6 5 2)

"I think to be creative is a different level above just solving problems. With the scope, freedom and ability to go out there and do things which aren't really the main focus of what we are doing or say we are doing." (6 5 2 1)

"The same kind of thing where you can free up enough time to, or possibly meeting enough milestones to give you the scope to go researching in areas that may be fruitful....there are a few people who are very artful in freeing up enough time or just deciding, I don't really care how much pressure they are putting on me to do this, I'm going to spend 30% of my time "skunking" irrespective." (6 5 2 2)

"There's a lot less scope though (for skunking). The project management systems are getting so strict." (6 5 2 3)

"A lot of the skunking is creative." (6 5 2 4)

"Lets just say there is room to be creative outside a lot of the currently funded grants, and that's what we find tough." (6 5 2 5)

"But there are still pockets of very good scientists within (these organisations) where they basically do what we've been talking about. Skunking is alive and well." (6 5 2 6)

The focus and quantum of creativity is constrained by funding being almost exclusively restricted to relatively short-term, applied, low risk projects with outcomes within prescribed boundaries. (7 5 1)

"So I don't think you really can do much about basic creativity. They (organisation and the funders) want outcomes." (7 5 1 1)

"... in most cases the groups we've been exposed to, at least the R & D Corporations, are looking for the here and now. Low risk, high probability of success." (7 5 1 2)

"They are looking for something that has a very short-term pay off, which means that it's got to be practical and applied." (7 5 1 3)

"But I think that you as a researcher when you put up that grant application, you need to have a mix of something that is quite applied in order for you to get the funding." (7 5 1 4)

"I certainly tend to do only what funding bodies are prepared to let me do." (7 5 1 5)

"Generally, funding bodies that I have worked with have run a hundred miles if you propose some blue sky concept. However they are prepared to indulge to some extent if things are going well, primary objectives, primary milestones, they let you dabble a little bit in something else and they are quite interested in the outcome. They certainly wouldn't support it as a primary focus of the project." (7 5 1 6)

"We could also throw in a couple of other terms, pro-active and re-active research... pro-active research is the one that is difficult to get funding for because it's usually prevention of something happening." (7 5 1 7)

"Yes, they (industry) are setting the agenda in so far as they are looking for developments, rather than research, really. They want a product process, some intellectual property, something that is an outcome of their research and they're not really prepared to put a lot of resources now into investing in some more fundamental sorts of areas which will give them a basis for further development in the future. That's one of the dangers I see, that we're making withdrawals on things that we've developed over a number of years and from external funding bodies anyway, we're not getting any investment into any ongoing fundamental research that's going to provide the foundations for more developments later on." (7 5 1 8)

In some instances members of research funding committees and industry organisations are not competent to set longer-term directions and evaluate proposals. There is insufficient use of peer review of proposals. The processes used to competitively allocate funds have substantial adverse impacts on creativity through, for instance:
- **the public nature of the advocacy of the research proposition, such as planning workshops, resulting in lack of openness**
- **prejudiced criticism and loss of intellectual property**
- **competition being restricted by the practice of inviting a selected group or groups to submit proposals. (7 5 2)**

"Now the problem is the calibre of the people that are on the (industry research committees). They really have no comprehension of research, there's nobody on that committee who can even head them ... they just don't understand. They put forward their recommendations which are usually based on this re-active research, reaction to whatever the problem is at that point in time.... There's no peer review whatsoever." (7 5 2 1)

"...so it's really up to the industry body itself in a lot of cases and as you say the calibre of person that is on the industry body ... I don't think that they have that long-sightedness in a lot of cases." (7 5 2 2)

"There are problems with peer review project application systems too ... So I don't think that it is an ideal system, anywhere in the world." (7 5 2 3)

"...we have to go out now and compete with other scientists very publicly. And that's not really conducive to a creative research environment. We are in an era where research budgets are small and there are quite a large number of research providers still, all of whom feel completely insecure and this doesn't go well with think tank sessions, if you like. One

research group that might have three or four people about to run out of contract money or are married with kids and need a job, is going to compete with another guy or lady who's trying to do the same with their research team. You don't get open session discussion of all relevant material. You get a lot of stuff being held back, you get a lot of unfair criticism, peripheral criticism rather than on the central target, and I don't think that that is a good thing either. It just reflects the really sad state of research in this country." (7 5 2 4)

"One of the things that's coming out of this is that creative environment depends on funding support and also sharing information within and between (organisations)." (7 5 2 5)

"I think a lot of projects now, certainly all the ones I have been involved in, are invitation projects. We invite you to submit a completed proposal. Especially with (two RDCs). It gives them an enormous amount of power over what you can do in that they dictate to a greater extent than ever the terms of the work. I don't have a problem with that because if you build a relationship with trust and communication thereby they influence you in your thinking and you influence them. It's unfair if you're not on the inner circle." (7 5 2 6)

*"I think we've always had a competitive environment in these sorts of areas, the arts field in particular, it is highly competitive in a different sort of way and in science haven't we traditionally, for a very long time, relied on competitively allocated grants?"***(facilitator question)**
"But that's not what's happening. It's not, it's restricting the opportunity to compete. The principle of competition is still there, it's always there, it's going to be there, what about those who become constrained (excluded) by invitation to that competition ... I am saying that competition drives creativity, it is the failure to have the opportunity to have competition that is restraining creativity, that's the way I look at it."
"Or is that a question of equity?" " There's no such thing as equity, if you have competition you will not have equity. Nothing is equal."
"...overseas now, research programs are tendered, that means that all the individuals have the opportunity to make a bid for it. Here is going the other way. With the proposals from (a RDC) coming to us and saying hey, look, there is a problem, you're trying to suggest that you can do this, so we put in a proposal. So that's what we do, we put in a proposal. Our proposals are one year, two year short-term projects with immediate outcomes..If we want a solution to this particular problem, can you do that? And we say yes of course, what else can we say because we want the money. And why we do that is that we call upon all of the information that we have had in the last five to six years, including basic, creative research ideas to use those and to exploit those to solve their problems, so we have no time to generate new creative options ... And also it (competition) opens it up for immediate peer review: because of the diversity of proposals coming in there is no way that the chairman of one organisation will be sufficiently knowledgable to be able to assess all the applications and you will have to call upon a team of peers to review all of the proposals. Usually when you start doing that, cronyism is very hard to establish. Now when you see cronyism ... I'll say is that people can nominate their referees and they can also nominate people they don't want to referee. But let's face it there are so many experts in so many areas." (7 5 2 7)

"You have either got to do it yourself (influence the funding body) or you've got to have somebody higher up above who's got influence with the funding bodies who will do it for you." (7 5 2 8)

Creativity is constrained by reductionism, leading to a focus on outputs or outcomes rather than a solution to the issue. While creativity can occur within these constraints something novel and potentially useful may develop if they are removed. (8 5 1)

"That's exactly it, survival of the fittest (ideas) under the current constraints. If you get rid of those constraints something else may develop."(8 5 1 1)

"...we may be constrained in (our organisation) to some degree to be creative, but we are perhaps more creative than the guy who pumps petrol or an accountant."(8 5 1 2)

"You are normally focused on one particular outcome and that outcome tends to restrict. Doing some off the beat type experiments or tests and hypotheses, it may have not less opportunity but a lower risk of being successful. So you're doing research into things that are more a higher risk of success." (8 5 1 3)

"I think that is in part where the restriction is in our (organisation), that we don't have enough opportunity to take that broader view and put all of those things together and look at an issue rather than, too often it is too narrow and specific experiments or projects...." (8 5 1 4)

"... in some respects we suffer from too much reductionism into outputs or outcomes rather than a solution to the issue." (8 5 1 5)

When R&D funding agencies limit their funding almost exclusively to issues they have specified and for prescribed R&D processes they lose potential creativity in relation to issue identification, specification and resolution. (11 5 1)

"... they (the corporation) said, this is the work we want done and they listed everything that they wanted done exactly and they said, O.K, give us a price and we'll see who gets it. That left no creativity on our behalf to put up projects." (11 5 1 1)

"So then is it the definition of the problem or the prescription of the procedures to solve the problem that is the problem?" **(facilitator question)**
"I would think both." (11 5 1 2)

"If you were going for medical funding you would certainly have a greater chance of being a lot more creative going for that kind of funding than we do going for the type of funding that we go for." (11 5 1 3)

"Our biggest problem is that a lot of what we do is based on what industry would like to have done, so that limits the things that you can do." (11 5 1 4)

Researchers need to be very risk averse when submitting an R&D proposal for funding because industry seeks solutions to short term problems and researchers cannot risk failing to deliver agreed outcomes. (11 5 2)

"So you are really stifled by putting up things that you are 98% sure will succeed and that constrains your creativity because you can't take risks, because if you fail on a project enough times you won't get funded by that body again." (11 5 2 1)

"If you have a proposal that is more basic, it won't succeed. So that really is a big constraint." (11 5 2 2)

"We tend to be somewhat more constrained here (than elsewhere in the organisation) because of our industry funding (about 70%) So that really is a much bigger constraint." (11 5 2 3)

"... as the projects became smaller, more shorter term, more accountable, the creative effort has dwindled with that." (11 5 2 4)

"It is not so much being creative to get something that is innovative (but to be) creative to do something in the most economical or most efficient way. That's how we apply our creativity." (11 5 2 5)

"No, because we are always with the constraint that the industry wants to solve the problems of now. They are very short sighted." (11 5 2 6)

"I don't think that really people who work here now feel they have to have a flair. You know, you come to work, you do what is asked of you and you go home again." (11 5 2 7)

Greater use should be made of peer review, as industry representatives on funding committees and boards are not sufficiently trained in science and staff of funding organisations are not expert across their areas of responsibility. (11 5 3)

"It is largely political, agriculture. The people who have the clout, have the final 'yes' or 'no', tend to be people for one reason or another have got into that position with limited scientific background and so when we come to them, if we're too scientific they're scared and baulk away." (11 5 3 1)

"... the producers who comprise part of the board are really largely driven by advice they get from staff." **(facilitator question)**
"They (funding organisations) have their own internal scientists...."
"And so are you also saying?" **(facilitator question)**
"The staff giving advice aren't competent." (11 5 3 2)

6.   Management and Administration

Our organisation agrees in principle with an outcome focused approach but its adoption of a prescriptive approach to process reflects that it has difficulty putting that principle into practice. (3 6 1)

"Ad hoc industry and government pressures to change priorities and add additional workloads limit creativity. " (3 6 1 1)

"The setting of desired outcomes and the formation and leadership of teams to achieve these outcomes are important determinants of creativity. " (3 6 1 2)

"I would go along with the concept that internally within our organisation that prescriptive process has never been adopted, in fact. The ethics of the profession have been relied upon to actually carry the day and I think in fact they will become with our new institute systems, they will be probably even more extreme. " (3 6 1 3)

With the increasing adoption of commissioned based research projects, some research corporations are becoming more prescriptive about how research projects are done and this prescriptive approach, rather than the specification of an appropriate outcome, is limiting creativity. Furthermore it is beneficial if the research clearly documents and explains why it identifies certain outcomes as being of high priority and if corporation staff adopt a leadership and coordinating role rather than a managerial approach. (3 6 2)

"It does seem to me the funding corporations are becoming more prescriptive. " (3 6 2 1)

"It seems to me the whole integrated nature of what we do, if we are going to truly be applied researchers, then in fact we have to have a bit of flexibility in our creativity of assimilating how do we go about putting teams together. That is the creative thing that we do, that's where we can have some creativity about making leaps and gains that we otherwise might not have made. That's the creativity that I think you stifle when you start telling an R & D provider about how we should do it. " (3 6 2 2)

"The area we are talking about in farming systems research the funding body could argue that in fact that was not commissioned by them. So yes, it is the prescriptive approach. (limiting creativity)." (3 6 2 3)

"I think it is the prescriptive nature of process that would cause a problem rather than saying that this is the outcome we want. " (3 6 2 4)

"It is the R&D corps that worry me (in relation to prescription)." (3 6 2 5)

"I would be encouraging, people from the funding bodies to spell out to me why they had taken a particular position and why there is a policy and leave it at that." (3 6 2 6)

"I think there is a variation between industries. You talk to those (experienced) guys and they say, the past couple of years, the past five years, have been the best years in their career in terms of having teams put in place and working with funding bodies and being able to do what they want to do and co-ordinate it. But both of those teams have a fair degree of autonomy, the corporations are not telling them what to do." (3 6 2 7)

There are many very creative people in industry but some funding organisations are managing organisations rather than being innovative. (3 6 3)

"The creativity usually occurs on the side of or outside externally funded projects. Funding bodies have short term goals." (3 6 3 1)

"We'll talk about the projects. They are often externally funded these days of course. Is the creativity occurring within those projects or is it sort of happening on the side? " **(facilitator question)**
"It is on the side a bit, isn't it. "
"Definitely on the side. "
"You put a bit of money on the side in these projects for high risk stuff that you don't tell too many people about unless it comes off. "
"But you have to do that. "
"The funding bodies don't tend to look too far ahead, they have got short term goals really. " (3 6 3 2)

"Taking away the person looking over your shoulder ... your work creativity just blossoms if you've got somebody looking over your shoulder the whole time, I think that just stifles your ability to think and move in whatever direction you see fit." (3 6 3 3)

"The corporation is more a managing organisation at the moment than one that comes up with an innovative idea. That may change in the future but at the moment it's that." (3 6 3 4)

"They (organisational managers) are busy answering administrative enquires or restructuring a restructure or something rather than having time to sit back and be creative about how they are going to manage or lead organisations. "

"If they (corporation managers) are doing a leadership rather than a beancounting role they can be useful. " (3 6 3 5)

Lack of sufficient time is a major constraint to creativity. Stepping back and not being on a treadmill is a valid way of progressing. (3 6 4)

"The biggest constraint to creativity for me is lack of time to think about what I am doing." (3 6 4 1)

There is too much administration (e.g. milestones, head office enquiries, financial arrangements) and the administrative load is increasing. The time required for administrative tasks is important as is the frustration resulting from these tasks appearing to be irrelevant and not aligned to the skills and aspirations of scientists. (3 6 5)

"The reason we don't have enough time is that we are spending too much time doing unnecessary administrating tasks, and it is just getting worse." (3 6 5 1)

There may be a long lag period between discovery and application, so there is a need for a balanced research portfolio. (3 6 6)

The hierarchical accountability chain limits creativity. (5 6 1)

> *"We are all so scared of accountability that we don't tend to try anything."* (5 6 1 1)

> *"We have been indoctrinated over the last few years about this outcome culture and accountability and there is less slack in the system to develop creativity /accountability and outcome oriented stuff has focused everyone and there is no room to move."* (5 6 1 2)

There is virtually a universal view amongst researchers that they are managed by people who lack creativity and/or the environment within which they could express it. Additionally researchers, with some exceptions, believe they lack professional (discipline) leadership. (5 6 2)

> *"We are being managed by people who lack creativity."* (5 6 2 1)

> *"I've got far more money today than I have ever had in my life in terms of projects, because of different sources and the capabilities of accessing all those different sources. But that doesn't mean that the leadership or that freedom or that encouragement to go and do your thing, to trust you and so forth, is there."* (5 6 2 2)

> *"In terms of leadership it is a matter of people being willing to be led by somebody who is working for the good of humanity and not relate to somebody who is working for themselves."* (5 6 2 3)

> *"But in actual fact he (a past leader) was spending all of his time working for you. So you could say he was a servant leader type. And people really related to that."* (5 6 2 4)

> *"He was always working to support his team. So the team related to him and I've never seen anything like that before."* (5 6 2 5)

> *"I have never seen in all my life (someone) come out and say so blatantly we are here to serve the politicians. I mean that might be a fact, but it is not the way to keep the staff motivated and doing biological R&D, I tell you."* (5 6 2 6)

> *"Some people evolve naturally, you know, and other people flock to that guy with the specialist knowledge; it is accepted. Other people, reluctant leaders, have to be nominated, and say O.K. we have nominated you. So it depends on the personality of the person who is the expert."* (5 6 2 7)
> *"It is fine to have these discipline leaders but communication, particularly for the young staff who might be out at woop woop, they don't get to know these discipline leaders unless they get the opportunity to travel and meet these people."* (5 6 2 8)

> *"You can with the right sort of leadership. We didn't have to have an agreement to go interstate, you would just go. And when there was a conference anywhere that was relevant to our zone, whether it be in Perth or Geraldton whatever it be, we were there. We were just taken and the teachers come in and oh you live out there and we need such and such and such and such. Then we got into the situation where we had all these guys writing text books, professors from the states coming through. We were on a circuit and we are all just amateurs gone out there with a basic degree. It turned out that because of that 6 or 7 PhD's came out of it."* (5 6 2 9)

The administrative environment within which managers operate limits their ability to interact effectively with researchers and to remove administrative constraints on researchers. (5 6 3)

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Creativity can be stifled by requirements to solve problems by a particular time using a prescribed method and by stress unrelated to the problem, for instance, stress related to institutional issues, administrative procedures or job security. (6 6 1)

"If the problem is imposed upon you, it is hard to get, to do much productive on it until you get excited by it. And that can come, someone can give you a problem it's possibly hard anyway to do it quickly, if someone gives you a problem that looks really horrible and boring but you have got no option, then you sort of find ways of getting interested in it. And probably the quality of the solutions will be related to the degree to which you took that to heart and so it has to be personal I think. But there are ways of taking external things and bringing them internal." (6 6 1 1)

"So obviously, if somebody gives you a general area, you can pick out things in that that really touch you better than if they give you very little room to move." (6 6 1 2)

"OK, so a lot of this environment is determined by external stimuli. I'm now talking in the sense external, out of (the organisation). We said earlier I think that we can be creative on externally identified problems, so long as we identify with them and become enthused by them. So let's just then help me understand what are the particular characteristics of these external stimuli that might be good and bad in relation to your own work environment?" **(facilitator question)**
"Well, frequently, when you are writing up a grant, the problem is an industry problem ... when you actually writing up the grant you have to also outline the methodology that you are going to take to achieve that problem and you impose milestones. So those things, while not precluding creativity, can stifle creativity because you are agreeing to solve a particular problem using a particular method by a particular time."

"Yes, but there are also different ways of putting the tension, to have a big administrative load and a low technical support, but the other thing is, if you have two scientists talking together about a topic, they can be challenging each other and you can generate a lot of internal tension without having the adversity, external adversity."

"... it's the intellectual challenge that leads to the creativity, I think that the other things can quite often be disruptive to creativity, 'cause you are so worried how you are going to pay for this piece of equipment, whether you are going to have a job next week, whatever..."

"... I think one of the things in terms of an environment for creativity is some sort of secure or well-defined environment where you know you are comfortable at least for a space of time, and you can get on with the job, and you are not worrying about the fact that the division is getting re-structured for the fourth time in three years ..." (6 6 1 3)

Creativity requires time and intellectual and personal space, which are being constrained principally by four factors. First, the project funding arrangements necessitate scientists having overlapping projects at various stages of development, leading to a project treadmill. Second, competition for funds results in an undercharging for projects, leading to further pressure on time. Third, the tasks involved in being a scientist have broadened to include, in particular, administrative and technical aspects. And fourth, increased accountability, more rapid communication and the information explosion also restrict the time available to do research. Underpinning all these factors is a failure to appreciate just how long it takes to do creative research. (6 6 2)

"... I personally don't feel there is a lot of time or room for, in our current environment, intellectual creativity." (6 6 2 1)

"So you need to have so many projects going just to bring the money in, so you actually have to do the work on most projects, we actually don't have a lot of technical staff left any more, so

we are actually washing the glassware and everything else as well, and on top of that you've got projects you're writing up, like dream ones for grants, you've got the ones you're starting, the ones you're actually doing, the ones you're trying to find the time to write the papers for, plus trying to get a few students going somewhere. It is just crazy!" (6 6 2 2)

"But the problem is that we're competing with other organisations who are not doing full cost recovery either, so all the corporations in industry who are funding projects for which public organisations don't know what the full costs are and if we start levelling the playing field and no-one else does, none of our projects will get funded. So you always undercut your resources to actually solve the problem regardless of how set you are." (6 6 2 3)

"All the corporations do it, though, They would always like to have another project. So you go through the preliminary round and they come back and say 'look we really like this project, you knock $20,000 a year off it' . There goes your 1/4 or half technician." (6 6 2 4)

"I just think people's reality with respect to what is achievable in writing grants and writing applications and trying to get funding, is totally (out of kilter)." (6 6 2 5)

"I guess one of the things along those lines that we haven't touched on is the job of being a scientist has changed over the last few years." (6 6 2 6)

"And I guess a lot of people still think to some extent that's what being a scientist is. Nowadays, there's a great deal of accountability, there's just administration that's being devolved down to a fair way into the project, so we've got a lot of our time is taken up with management things." (6 6 2 7)

"I have not had time ever since I have been at this organisation to really think of any elegant series of experiments, that would be really hot shit! There's just not the time to do that." (6 6 2 8)

There is a heavy and increasing administrative burden. (6 6 3)

"This work (administration) taken to its logical extent could really exterminate all creativity." (6 6 3 1)

"Some of the reportings are onerous, really some of the people are reporting every 3 months." (6 6 3 2)

"At the moment, you have to get fairly prescriptive yourself about how you're going to get there which stifles you. It also creates a hell of a lot of administrative overheads." (6 6 3 3)

"In terms of accountability, it is definitely grown substantially in recent times." (6 6 3 4)

"It's not just this strategic plan stuff, it really is the reporting. Really the manner of reporting of this organisation, I am stunned by it." (6 6 3 5)

There is insufficient recognition of the time and space required for creativity. (7 6 1)

"... one of the factors which influence your creativity to some extent is the incredible demand placed on your time. I think it is inevitable that most people today process a hell of a lot more information and work in 24 hours than people did twenty years ago." (7 6 1 1)

There is insufficient time to be creative because of the treadmill resultant from the need to continue to seek external funds and hence to be involved in multiple projects at varying stages of development or completion. The problem is particularly acute for researchers managing short-term contract technical support staff and for researchers who themselves are employed on a contract basis. (8 6 1)

"... you've got a particular job to undertake, program, something that needs to be researched and you don't have time to go off on tangents anymore." (8 6 1 1)

"There are all sorts of reasons for lack of time. Everyone is on deadlines based on generally external funds and the funding bodies, when you put in a submission to say that you will do so much work in so much time and will cost this amount of money and so there is a deadline to produce an outcome within a time and that's what you have to do. You can't halve the outcome and say well I can only do this much in three years because you won't get funding...." (8 6 1 2)

A further cause of lack of time to be creative is the institutional tendency to begin new initiatives and programs without due regard to existing work loads. (8 6 2)

"One of the big problems though is what (another person) highlighted, is the creativity versus sort of the implementation and the pressures we come under are really on the implementation, that's what all of the managers within the department, funding bodies and all that sort of thing, they want the implementation and they want the milestones and they want the outputs. That's what I find frustrating ... I think it's really a necessity there to build more time in to be able to do that sort of thing." (8 6 2 1)

"One of the problems we've got, you mentioned why you do more projects.........If you've got technical support staff you've got to keep them going. You're chasing funding all the time. It doesn't let you focus enough on the past work you've done to get it finished off. Whereas if you had a team environment with let's say, five researchers and four technical staff, you've got the opportunity for the technical staff to float around those five people, and they can write up." (8 6 2 2)

"And I think the other thing that happens within the (organisation) is that there's always new things being lumped on people, research and advisory people. But there's always new things they might put on but there are never things being taken off at the other end. It's always additional things ...." (8 6 2 3)

Creativity is constrained by administrative processes which irk because they are perceived to be unnecessary and/or poorly conceived and executed. Administrative processes which are perceived to be well based and executed generally are not perceived to be constraining creativity. (8 6 3)

"I find the daily, hourly encroachments on my time quite frustrating and that's an encroachment on the little ideas, on the little things that you are working on or the way you work on a review paper on a novel synthesis of somebody else's work or someone else's history of work and the same sort of limitations, the same sort of influences from head office affect that creativity as they do the big stuff." (8 6 3 1)

"I think we've got a danger of learning to live with it (bureaucracy). And all the comments so far are a reaction to that. All this administration stuff, all the restrictions that are imposed on us, anything really that irks you can restrict the creative process." (8 6 3 2)

"... it is hard to put a direct finger on some of the ways that head office does niggle at us. For instance every time I want to do something there is a different form." (8 6 3 3)

"At the moment I am more or less required to publish the results so that's probably a good thing happening. These checks in place." (8 6 3 4)

"Deadlines for me are a good thing. If I don't have a deadline I will tend to just follow what I consider to be interesting ideas and not produce the results for other people to use. I will satisfy myself that I have solved the problem but if you're going to be a professional scientist

you have to learn to take the next steps to publish the results so other people can evaluate the results and use or cite." (8 6 3 5)

Business managers can be very useful in helping scientists obtain and manage resources and links with clients. (11 6 1)

"But I think that we have to start selling, putting pressure on the funding body to get information back behind them because I think it stops with them, and I'm speaking on behalf of some of the stuff that we do and it doesn't really filter back to the people who pay those levies .." (11 6 1 1)

A substantial amount of time is absorbed in seeking funds. (11 6 2)

"... because we have to spend an incredible amount of time on paper work, finding creative ways of looking for money. Many times we don't have time to produce a really creative idea." (11 6 2 1)

In response to a question to why people participated in the discussions given time constraints **(facilitator question)**:
"Maybe we just want a bit of a break from the hum drum."

"Well, that is not a bad comment. Do you say that totally in jest or is that a serious comment?" **(facilitator question)**
"I think it is part of the reason."

"Is there too much routine, is there too much hum drum in your work places these days?" **(facilitator question)**
"Maybe it is our creative minds rebelling about not being creative. Wanting to do other things. Probably scientific curiosity."
"I personally found that maybe it would give me more ideas how to implement more of an environment of creativity."
"Sharing amongst the group. It is very rarely that you would see this many people (8) from all three sections together in one place at one time." (11 6 2 2)
"I think we are probably feeling that (time constraints) a lot now too ... there have been a lot of extra roles put on people and they were busy before. But they are going to be more busy. And learning the new role is really tough, because some people haven't had any training. And now you've got the financial and organising a group and then worrying about getting proposals out. It just sucks up all the time." (11 6 2 3)

7.   Communication and Teams

Creativity is assisted greatly by interactive communication, especially with people from other disciplines or organisations. Communication provides triggers that help complete the jigsaw.   There is insufficient communication within organisations. Some organisations actually encourage employees to spend time discussing their work with colleagues. (3 7 1)

"Creativity comes about more easily, I think, if you start talking to other people in other disciplines." (3 7 1 1)

"A lot more is achieved by talking to people." (3 7 1 2)

"The more interactive it is the better because, that way, you can go off at tangents and explore possibilities and you don't have time to sit down and think and constrain yourself." (3 7 1 3)

"The point too about different disciplines and organisations. I reckon that is really important, people in the other disciplines are thinking differently about the same problems. And then with other organisations, the same thing because they have different cultures and they do things in a different way." (3 7 1 4)

"The external view brings in either new knowledge or a new way of looking at that knowledge which you may not have had. And that is often a trigger. That really helps." (3 7 1 5)

"I think there is also a lot of variation even within organisations. I don't think we communicate enough within (the organisation)." (3 7 1 6)

"Some of the private enterprise companies are encouraging employees to stop and talk in corridors to linger over smoko tables so they can have much more interaction. (they are) not really concerned about the process about whether people sit at their desk or sit around a coffee table, what they are interested in at the end of the day is an outcome for that company. I think (our organisation) for an example agrees with that philosophically, where it has troubles is with putting that into practice." (3 7 1 7)

Communication between researchers, particularly those in the more remote areas, has deteriorated because of lack of a recognition of the importance of interactive communication and the consequent allocation of time and funds for this purpose. (5 7 1)

"The funding process is not amenable to keep the teams together either." (5 7 1 1)

The opportunity for researchers to be creative is often limited to a window of opportunity between being skilled and moving out of research. This phase will be more productive and prolonged if researchers operate in appropriately comprised teams of people. The difficulties in maintaining teams of sufficient expertise and critical mass is particularly acute at smaller and more remote research establishments. (5 7 2)

"So there is a narrow window of opportunity where people have got the experience and the confidence and if they have got the creativity, well you have got the combination there, and I think that is the point where those people need to be supported in teams. There are no hard and fast rules, but how do you identify the people that should be supported is the key I guess." (5 7 2 1)

"The development and maintenance of strong disciplinary teams has been so dissipated over the last ten years of management restructuring that there is a real problem there." (5 7 2 2)

"That really, to be creative from a research point of view, you need to aggregate those people." (5 7 2 3)

Interaction with other people from the same or different perspectives is important for creativity. The interaction often needs to be sustained so that different perspectives can not only be developed and appreciated, but become truly integrated and evaluated. (6 7 1)

"Whether it is because other people have viewed the problem from a different angle or not, but I find a lot of synergy in discussing problems with other people." (6 7 1 1)

"The most creative time that I have spent is being with a group of other people all working in the broad area and all committed to making progress and also with enough space at the time so that if there is an issue you could always stop what you are doing and thrash it out for a while." (6 7 1 2)

"There is a difference of having multiple perspective versus integrating that evaluation ... and one of the issues there in that situation is the conflict between different disciplines even just different perspectives ...." (6 7 1 3)

"I'm most creative with groups of people working on the same problem in a lot of different ways...." (6 7 1 4)

The organisation's values, policies and practices related to conference attendance are major blocks to creativity for they both restrict professional communication and recognition and militate against the establishment of a sound R & D ethic. This was one of the most commonly mentioned counter-productive policies. (7 7 1)

"...I guess because I am old fashioned, I will defend a little bit management but not in some of these areas and that's one (attending conferences) where there is a blatant over statement of policy and a perception you have got to fight tooth and nail to get approval to attend conferences and there's no question what everyone has said is accurate. So you can tackle that one when you go." (7 7 1 1)

Face to face communication is critical to creativity so working in teams, participating in seminars and conferences and developing associations outside the organisation are all very important. Participation in conferences is particularly important. The organisation's long standing restrictive and obstructionist policy on conference participation is a major constraint on research creativity and productivity. (8 7 1)

"... but I would firmly support from my experience that actually having at least one or more people on site that you can talk to, is a hundred times more valuable than having access via E-mail." (8 7 1 1)

"It (seminar) might lead to a discussion and we do have those inputs to expand our creativity. We do have that interaction amongst ourselves. That is one good way of generating discussion and from that creative thoughts, that is just one way and we do have that here." (8 7 1 2)

"I think probably conferences, whether they be national or international, are probably a better way (than seminars)." (8 7 1 3)

"Sadly the (organisation's) stand on conferences is deplorable. It is one of the most annoying things that I have come across." (8 7 1 4)

"I think that (conference) is an unfortunate system, it should be if you can provide the money, I mean these days you can't expect to have CR funds I don't think for all of those things. But a lot of people go out and get their own funds. Now if you can go out and get your own funds, then you should be at liberty to use them." (8 7 1 5)

"I think in my own case, all professional links are essentially outside (the organisation), apart from the team and it is quite a substantial team. All the professional linkages are outside through funding bodies, through networks of people in the same disciplines. I suppose, I hope I don't get crucified by the group here, one of the advantages that we've got in the (organisation) is that provided you out-last most people you can actually create a bit of space for yourself. You can have that sort of tolerant, hands off thing, keep out. It's all right if you have got some sort of strength with the association outside, that works well. The only downside is that you are never going to be cringing while your manager speaks in glowing terms about what you are doing because he hasn't got a clue." (8 7 1 6)

Generally but not universally, researchers believe they are more creative if they work in teams comprised of persons who complement each other in terms of experience and expertise. (8 7 2)

"... I think there needs to be a situation where you can bounce your ideas off your peers and that is fine if you're working together as a unit with similar backgrounds, similar aims and objectives, and you can bounce ideas about. A lot of those (discussions) can lead to creative thoughts." (8 7 2 1)

"... the danger in it is that if you have the one person at the helm is that they won't be doing any thinking after a while, they'll just be managing the project. So you have got to have a team of people who are at different stages of their development and they will contribute to the creative process and the outcome process as well." (8 7 2 2)

"... it is important to have a group that is interacting together because everybody has got different strengths and weakness and if you've got a group, even if it's a group of three or four versus one person ... an idea being generated, that's only one step of the whole creative process. You've got an idea being generated that's been perhaps investigated a bit more or investigated in different ways and then actually putting it together and putting it into place or implementing it in the way that it is useful for industry. It's a bit difficult I think to expect one person who is going to be very good at all of those steps and you're much more likely to end up with some good results out of an original creative thought if you like, but the whole process is really creative because you created different things at different stages in that process." (8 7 2 3)

"Some people seem to cope quite well with working on their own. But I think in my case I can reach a point where I just hit a brick wall basically and I need something from outside to get me over the wall and keep me going a bit longer." (8 7 2 4)

"I've been isolated and I've still felt I've done some good research.... Other people probably do need to sit down and talk and generate ideas together." (8 7 2 5)

R&D management approaches based solely on projects tend to stifle communication and collaboration. Additionally they can lead to an undesirable level of job insecurity and poorly structured work teams. Alternative 'pool' systems, where the focus of the research contract with a client is at the institutional level rather than at the level of a specified researcher or research team, would remove these problems at least to some extent, as well as some of the intra-institutional communication constraints related to confidentiality requirements. More broadly, scientific research might be being too personalised by funders and possibly it should be seen more to be a team or institutional activity. (11 7 1)

"I found that going to a project basis is a definite stifler to creativity. In the past we would get together, there weren't such defined projects and little clusters, there might be a project of one or two people and, there has been a great decline in intellectual intercourse, in other words, we'd get together ad hoc. There was ... it goes back to time constraints ... there was more time to get together ad hoc and just throw things around with others. This seems to be missing because so and so is working on this project and he or she is flat chat and so and so is there and they're not getting together to cross fertilise." (11 7 1 1)

Communication between researchers is helped through relatively narrowly focused 'journal' clubs but communication systems suited to a more broadly based exchange of ideas are necessary, yet difficult to sustain. (11 7 2)

"We are fairly open in our group. You know we will go and talk to anyone about any project and what we are doing and we will keep in touch with what everyone else is doing. But it needs to be broader than that it, needs to be more between the disciplines, it needs to be between our sections and the other sections within the place ...." (11 7 2 1)

Competition within research teams and between research teams within an institution and between institutions, constrains the flow of ideas and information. (11 7 3)

> *"And I think the key question (in communication between researchers) was that we were not competing. And that's the key question. We were working with this person on different projects and it was a sort of natural thing, because we were good friends and we were not competing, that we help each other."* (11 7 3 1)

Conference participation is important for recognition, for marketing research capability, for information flow and for building confidence and personal relationships. However R&D funders generally consider conference attendance to be a frivolous activity. (11 7 4)

> *"None of the funding bodies will fund conferences. They think they are frivolous.*
>
> *"Frivolous?"* **(facilitator question)**
> *"Yeah, they think it's fun. It's a reward and it's not, it's part of our job."*
> *"I think communication between scientists throughout the world is always beneficial to creativity, because you learn how other people are applying their ideas or their creativity in situations and you think."* (11 7 4 2)

8.   Recognition

There needs to be greater recognition of the importance to creativity of professional encouragement through, for instance, leadership, good internal communication, encouragement, the absence of discouragement, conferences and sabbaticals. In many but not all situations, there is virtually no positive feedback either from the research corporation or from the R&D organisation. There is virtually no meaningful feedback from corporations on milestone and final reports. (3 8 1)

> *"All the scientists and industry people get together every year. So there is strong accountability. That is fairly honest and open debate. You get very good feedback. I think that is a great approach."* (3 8 1 1)
>
> *"I think that those are the sorts of professional encouragements, that I see a distinct absence of right now."* (3 8 1 2)
>
> *"Give people or provide people with the opportunity. And again encouragement comes up a bit or non-discouragement to do things a bit beyond the square. And not, if somebody makes a mistake, not to go bang and squash them like a maggot."* (3 8 1 3)
>
> *"It is extremely important professionally and personally that you are valued for what you are doing."* (3 8 1 4)
>
> *"Up until now there has been absolutely none (comments on milestone and final reports)."* (3 8 1 5)
>
> *"You might expect to get some feedback from the corporation that says, well, you met those milestones and not only did you meet them but you have actually made a difference to this industry. But surprisingly you get very little feedback at all ..."* (3 8 1 6)

Recognition from peers, from one's organisation and from the broader community/industry helps sustain motivation. However recognition within the organisation is generally perceived to be based on inappropriate criteria and/or too frequently non existent. (8 8 1)

"But there's two types, aren't there. There is recognition by your peers, which is when someone quotes your work in subsequent papers. I get a buzz out of that. The other one is recognition from just above you. Those direct lines just above you. Which is a quite rare commodity in this (organisation)." "And of little value to me anyway." (8 8 1 1)

"I think one of the things that I find satisfying about it is actually taking it through and particularly the analysis part and writing up and being able to present something that other people find useful. Now those other people can be other scientists or people in the industry. There's two different levels to that and both of those I find very satisfying." (8 8 1 3)

"And I think the recognition systems within the (organisation) are very much out of whack with how researchers deal with that issue (quality of publications)." (8 8 1 3)

9. Training

Researchers appreciate the benefits of mentoring schemes and the synergy inherent in supervisor - student roles. (5 9 1)

"I mean some of the best kicks I have had in the last few years is being able to work with young people. One of the better things that I think the (organisation) done in recent years is to start this mentoring system but it is not something that is actively being promoted." (5 9 1 1)

"And the problem is it is the young people that are out there on their own." (5 9 1 2)

"While we talk about all the holistic approaches and all these interactions, we still need the basic discipline skills to even be able to interact intelligently, it's that dissipation of that discipline is the message that I get at the operational level that has occurred through most of our disciplines in the organisation and it needs some urgent addressing." (5 9 1 3)

It is arguable that an increasing proportion of PhD graduates are not sufficiently creative. This may reflect a change in the those being trained and/or a change in the training. (6 9 1)

"... I've certainly seen a lot of PhD students coming through that I don't think by my standards are creative." (6 9 1 1)

"... I think the trainers have fallen down as much as the students." (6 9 1 2)

"Because a lot of the PhD scholarships are actually grants which have pre-defined milestones and a lot of the creative thought is gone." (6 9 1 3)

"I think creativity has to be underpinned by good skills in whatever area you are. But I don't know whether you actually train for creativity - you know you can train people in being creative but it must be underpinned by really good skills and knowing what you are doing. And the environment that you work in may well engender creativity." (6 9 1 4)

"I think there are time issues, not just the science training but also the sort of people ending up in science in agriculture." (6 9 1 5)

"I think there's scope for everyone, you need some pragmatists in their as well." (6 9 1 6)

Science training at universities is not conducive to developing creative attributes and skills. (8 9 1)

"I reckon you can (be trained to be creative) but and I think that's where scientists lose out .... You do creative art or you do science." (8 9 1 1)

"Well your entire university career if you do science is: whenever you do an experiment, just write it up, aim, materials, methods, results, conclusions. And you never think outside those perimeters ...." (8 9 1 2)

"I don't think our education system is very good at producing people that are creative .... It's just the way I was taught, was never to think the way I think now. It was actually to spit back what I was taught." (8 9 1 3)

10. Personal

Creativity is affected not just by workplace factors but also by the social and personal environment within which the scientist lives. It is necessary to look at the complete researcher. (8 10 1)

"Oh sure, that's all very good (pressure to produce from contract employment), but there's also a social and personal element to a scientist. It's not just outcomes. You need to consider where you are going to live every three years. Your friends, your family, perhaps where your children might go to school. Except for all of those things, I think if you're looking at a person, you should be looking at the complete researcher and a researcher presumably in their home and their social environment produces good research as well." (8 10 1 1)

"It's not simply just to get money. There is an element of fear in all of this. If you've got two or three people who are totally reliant on money, there is pressure to try and keep that going. And you keep looking over your shoulder at people who haven't attracted money and they tend not to be working here anymore. There is a fear there, but it's not going to make you sleepless at night. But it's certainly important, particularly if you have got people who have just got married or just moved house or something." (8 10 1 2)

"I suspect you'll probably get two answers to some degree based on whether you have permanency or not .... We (on contract) have to produce something, so you can't really afford to be too far out of your boundaries. .... So I think you should bear that in mind and I think most young researchers will be on contract. Contracts for two or three years create a different type of person." (8 10 1 3)

PRINTER'S INSTRUCTIONS FOR RIRDC REPORT 99/128

Back Cover Blurb

This report examines the nature of creativity and presents the views of agricultural scientists and their managers on factors affecting creativity in research, including how the work is conceived, funded, managed, and communicated and applied. It is thus a valuable resource for all those interested in improving research outcomes.

The report concludes by proposing several principles whose application would remove existing constraints on creativity in agricultural research without diminution of the relevance and accountability of the work.

It is the newest addition to RIRDC's diverse range of almost 400 research publications, Most of these publications are available for viewing, downloading or purchasing online through our website:
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