Department of
Primary Industries

Technology Uptake by the Food Manufacturing Industry

Human and Organizational Factors Affecting Technology Uptake by Industry

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Executive Summary

While there are numerous models for technology transfer into different industries, including licensing agreements, co-operative R & D agreements between government laboratories and private companies, the formation of spin-off companies and other mechanisms, there is also a growing body of information that human factors and organizational/environmental factors play a very significant role in determining the success or failure of technology transfer and commercialization ventures.

This report attempts to capture the current knowledge on the human and organizational traits, thinking patterns, attitudes and behaviours towards innovation and new technology uptake, with a view to identifying interventions to support change behaviours (of both the R & D sector and industry) to promote innovation in the Australian food manufacturing industry.

The key "take home messages" are:

- Senior management commitment, encouragement and involvement, in terms of both financial and 'political' support for technology transfer, are critical. Such senior management support is the most critical factor in the success of technology transfer / uptake.

- Skills needed for effective technology transfer not only include knowledge of knowledge (i.e. scientific expertise), but also knowledge of people and organizational knowledge …*"Know how"*, *"Know who"* and *"Know where"*.

- Long-term relationship building between R & D organizations and industry – on a personal level between individuals, to build trust and credibility in both directions, is very important. Industry will give trust to individuals and project teams, but generally do not trust research organizations or universities.

- Industry should be involved in all stages of the innovation process to maximize the chances that the innovative product or process developed by the R & D organization will satisfy industry needs. Inclusion of industry in the development process will also help to ensure the success of commercialization efforts. Communication with industry must be on equal terms and *not* one-way (i.e. just from the R & D organization to industry). Technology transfer activities should focus on the *mutual* benefit to both the R & D organization and the industry partner. All future research projects should have technology transfer objectives firmly in place. Technology transfer plans should not be an *"add-on"*.

- Two-thirds of major technological changes in organizations fail because of *resistance to change*. Most of these failures are due to *emotional* and not technological issues. *Effective* communication is very important to minimize such resistance to innovation/change. Development of a culture that accepts change as a *continuous* activity is a key factor in managing the diversity and innovation within a complex organization. Employees may look forward to change and innovation *if this is linked to a promising future.*

- Cross-functional teams (with skills in science, communication, marketing and finance) have been shown to be effective in facilitating technology transfer/uptake. Important roles within such teams are identified. The importance of the inclusion of a technology

"champion" from the industry partner's plant in such teams is discussed.

- Transfer/secondment of people is a very effective mode of technology transfer/uptake as it facilitates the effective uptake / implementation of the technology by industry, but also results in the transfer of *tacit* knowledge (informal knowledge which is not documented/codified…*"the way people do things"*). Tacit knowledge from an R & D organization to industry and vice-versa is a very valuable resource for both parties.

It is the author's view that the skills required within an R & D organization described in this report for effective technology transfer are currently available within Food Science Australia, however, an increased focus could be put into coordinating these people/resources to maximize the effectiveness of Food Science Australia's technology transfer efforts. Food Science Australia would be ideally placed to become the *Technology Transfer Information Centre for the Australian Food Manufacturing Industry,* if there was such a need within the Australian Food Industry.

Introduction

Technology transfer includes a range of formal and informal co-operations between technology developers and technology seekers. Technology transfer involves the transfer of knowledge and technical-know how, as well as physical devices and equipment. This usually involves moving a technological innovation from an R & D organization to a receptor organization such as a private company. While there are numerous models for technology transfer into different industries, including publication of science/technology, the formation of spin-off companies, licensing agreements, and co-operative R & D agreements between government laboratories and private companies, there is a growing body of information that human factors and organizational/environmental factors play a very significant role in determining the success or failure of technology transfer and commercialization ventures.

While market forces and economic factors are known to affect new technology uptake by industry, the objective of this report is to capture the current knowledge on the human and organizational factors that can influence behaviours towards innovation and new technology uptake, with a view to using this information to promote innovation and new technology uptake in the Australian food manufacturing industry.

Much of the information in the literature covering behaviours, attitudes and values of individuals and organizations towards innovation and new technology uptake appears under the headings of individual and corporate entrepreneurship.

During the CSIRO Business Development and Commercialization Forum, in 2003, Dr.Geoff Garrett, Chief Executive of CSIRO was quoted as saying that *"technology transfer travels on two legs"* which encapsulates the view that technology transfer is mostly about people. This view very succinctly captures the focus of this report.

Individual/Human Behaviours to Innovation and New Technology Uptake

The Nature of Entrepreneurship

The term "entrepreneurship" has resisted precise definition for over 200 years. The traditional emphasis was on the efforts of an individual who goes against the odds in translating a vision into a successful business enterprise. More recently however, entrepreneurship has been conceptualized as a *process* which can occur in organizations of all sizes and types and which is distinct from, but dependent on, specific individuals. In this sense, entrepreneurship can be defined as a process of creating value by bringing together a unique package of resources to exploit an opportunity (Morris and Lewis, 1995).

The entrepreneurial process has attitudinal and behavioural components. Attitudinally, it refers to the willingness of an individual or organization to embrace new opportunities and take responsibility for effecting creative change. Behaviourally, it includes a set of activities required to evaluate an opportunity, define a business concept, assess and acquire the necessary resources and then to operate and harvest a venture (Morris and Lewis, 1995). Flexibility is also fundamental in entrepreneurship, and to facilitate this, larger organizations need to become increasingly knowledge-based, with information flowing freely to support sharing and learning (Thompson, 1999).

Skills needed for effective technology transfer not only include knowledge of knowledge (i.e. scientific expertise), but also knowledge of people and organizational knowledge (Balazs, 1996).

Entrepreneurial Personality Traits?

The field of entrepreneurship has fewer long-standing controversies than the one surrounding the question of what distinguishes entrepreneurs from non-entrepreneurs. Numerous definitions of what constitutes an entrepreneur are available in the literature (reviewed by Begley, 1995). In general however, entrepreneurs have been characterized as founding new, or running younger, smaller companies with higher return on assets than non-entrepreneurial managers, having shorter tenure in their positions, having previous work experience in the same industry, and having higher risk-taking propensity (Begley, 1995).

There is evidence that psychological traits are remarkably stable over time, influence behaviour in certain situations, and may lead people to choose different situations (Stewart et al. 1999). During the 1950s, personality traits became popular as an explanation of both entrepreneurial behaviours and intentions (Llewellyn and Wilson, 2003). It was argued that entrepreneurial behaviours involved a high level of risk, creative solutions and a certain level of ambition (Stewart et al. 1999). These descriptions of the behaviours all sounded like personality traits, the corollary being that a certain kind of person would be attracted to these behaviours, whereas other people would choose safer, more conformist avenues of employment (Llewellyn and Wilson, 2003). Many researchers therefore simply assumed that entrepreneurs had different personalities.

While it has been suggested that entrepreneurs may possess specific personality traits such as Type A behaviour, described as tendencies such as impatience, time urgency, driving ambition and competitiveness (Friedman and Rosenman, 1974), with associated stress, tension, anxiety, anger and predicted coronary heart disease (reviewed by Begley, 1995), case-controlled discriminant analyses do not support the value of Type A as a source of difference between entrepreneurial and non-entrepreneurial managers (Begley, 1995).

Conclusions regarding the psychological attributes of entrepreneurs should be treated with caution. The Framington Type A scale assessed the hard-driving, impatient and competitive dimensions of Type A behaviour, but not the hostility dimension that has received more attention in recent years. Furthermore, assessments of orientation towards innovation (a dimension sometimes included in definitions of entrepreneurship) and other factors such as organizational structure, process and decision-making are not always included in analyses (reviewed by Begley, 1995).

Informal observation however, suggests that entrepreneurs are different from other people in terms of their personal traits. It has been, and still is, widely assumed that entrepreneurs have an above average willingness to take risks, their desire to excel, their personal optimism, their tolerance for ambiguity, and in their powerful preference for shaping their own destiny. Perhaps surprisingly then, efforts to uncover differences between entrepreneurs and others with respect to these and other aspects of personality met with only modest success. Researchers could not identify clear-cut differences between entrepreneurs and other people with respect to what seemed to be the most relevant dimensions of personality and it has been concluded that *"30 years of research indicate that there are no personality characteristics*

that predict who will be a successful entrepreneur….successful business owners and entrepreneurs come in every shape, size, colour and from all backgrounds" (Baron, 1998). By the end of the 1980s, opinion had clearly shifted away from explanations centred on individual traits, towards theories that stressed the environment and the social backdrop to entrepreneurial behaviours (Llewellyn and Wilson, 2003).

As a result of this "disappointment", a growing number of researchers have recently adopted a different approach - one emphasizing the role of cognitive factors and processes in entrepreneurship (Baron, 1998). So "Why do some people recognize opportunities whereas other do not?" and "Why do some try to develop such opportunities whereas others do not?". It has been proposed that the answers to such questions lie in the way entrepreneurs and others think – how, in terms of cognitive psychology, they attempt to make sense of the complex world around them. Such a cognitive perspective in the behavioural sciences has added to the understanding of how we reason, form judgements and reach decisions (Baron, 1998).

How do Entrepreneurs Think?

While entrepreneurs and non-entrepreneurs have been reported to not differ in overall risk-taking propensity, they have been reported to differ in terms of how they think about business situations, with entrepreneurs tending to categorize such situations as having more strengths, opportunities and potential for gain than did non-entrepreneurs. It has also been reported that entrepreneurs make bold or unreasonably "rosy" forecasts about future business results and that they tend to focus on the specific, current situation while largely ignoring the outcomes of previous, related situations that may inform their current judgements. This has been described as adopting an "inside view", a judgement that focuses on the current situation and reflects their personal involvement, rather than an "outside view" that compares the current situation dispassionately to the results of relevant past ones (reviewed by Baron, 1998).

Studies on entrepreneurs decision-making styles (defined by the Kilmann and Herden model and tested by the Myers-Briggs Type Inventory (used by CSIRO in the Project Leaders Programs) have reported that entrepreneurs carried out high levels of 'boundary spanning' activities (ie. the number and type of outside contacts sought) and that such networking and information seeking correlated positively with an organization's financial performance (reviewed by Buttner and Gryskiewicz, 1993). Furthermore, successful entrepreneurs appear to be higher in social competence - the ability to interact effectively with others (e.g., they are better at social perception and adapting to new social situations) (Baron, 2000).

Research does not support the common perception that money is the only, or even the most important, motive for entrepreneurs' decisions (Amit et al. 2001). Wealth attainment was significantly less important to entrepreneurs relative to an aggregate of 10 other decision dimensions, and entrepreneurs did not rate wealth as any more important than did non-entrepreneurs. Other motives, such as innovation, vision, independence, and challenge were reported to be more important and much more salient (to the sample of entrepreneurs in this study). Therefore, not all entrepreneurs found a business venture for personal wealth reasons, and one need not be motivated by personal wealth attainment to be a successful entrepreneur. Theoretical models that assume money is the primary motive for entrepreneurial activity may therefore require re-examination.

Critics see entrepreneurs as people prone to rule breaking, self-promotion, and unwarranted risk taking, while proponents view them as enterprising leaders (Borins, 2000). Evidence strongly supports the proponents' views and suggests that they are usually proactive in that they deal with problems before they escalate to crises. They use appropriate organizational channels to build support for their ideas. They take their opponents seriously and attempt to win support for their ideas through persuasion or accommodation (Borins, 2000).

When people imagine being better off than they currently are, they experience intense dissatisfaction with their current state of affairs. However, when they imagine being worse off, they feel much more satisfied with the *status quo*. While entrepreneurs are less likely to engage in such counterfactual thinking (Baron, 2000), an aspect of such counterfactual thinking directly relevant to entrepreneurship involves the relationship between counterfactual thinking and the experience of regret. Studies have indicated that people are better at coping psychologically with the effects of actions that turned out badly than they are at coping with missed opportunities or failures to act (Baron, 1998).

It has been hypothesized that entrepreneurs are more likely than other people to engage in "if only…" patterns of thought, especially in situations where they experience negative outcomes. As a result, they are more likely than others to experience regret, or more intense regret, over past failures to act that they construe to be missed opportunities. This may be one reason why they are more likely than others to search for, identify, and act upon perceived opportunities (Baron, 1998).

Extrapolation of such thinking to an (industry) organizational level provides some interesting "food for thought" with respect to technology uptake. For example, the question could be raised as to whether a company would search more vigorously for, and implement new technology / innovations in their manufacturing plant, if it had previous regrets of missed opportunities, or would company decision-makers be more innovative in technology uptake if they had previous regrets of missed opportunities at their present or past companies?

Entrepreneurial Attitudes and Behaviour

Entrepreneurial attitudes and behaviour have been reported (Johnson, 2001) to include:

- the motivation to achieve and compete
- taking ownership and being accountable
- making independent and self-directed decisions
- being open to new information, people, practices etc
- being able to tolerate ambiguity and uncertainty
- creative and flexible thinking, problem solving, decision making
- the ability to see and capture opportunities
- awareness of the risks attached to choices and actions
- the capacity to manage and ultimately reduce risks
- persistence and determination in the face of challenge or lack of immediate reward
- considering, discussing and formulating a vision, and
- the capacity to make an impact.

While not everyone needs to be, or could be, an archetypal entrepreneur, everyone can display facets of entrepreneurial behaviour that can combine and add significant value to an organization. It is important however to view this list of attributes as attitudes and behavioural preferences and *not* competencies, as the challenges inherent in a changing environment require flexibility in a way that cannot currently be defined. To restrict human resource development plans to competency lists is wholly inappropriate at a time when it is impossible to predict what an organization will be doing in five years time (Johnson, 2001).

While the above list represents the paradigm of the independent, pragmatic, opportunistic and competitive entrepreneur, not every entrepreneur fits this pattern. Some present a softer image, they operate in a more informal manner, they are strong on communication and they sell their vision to engage and motivate others. Interestingly, many successful female entrepreneurs adopt a facilitative style to encourage participation. It has been suggested that this may be because women face opportunity blocks in many large organizations, a major reason behind them becoming entrepreneurs in the first place, and as a result they appreciate the important contribution that people can make to an organization's success (Thompson, 1999).

The results of a qualitative analysis of female entrepreneurs' accounts of their role in their organizations indicated that the women used a interactive relational approach in working with employees and clients. Relational skills included preserving, mutual empowering, achieving, and creating "team" (Buttner, 2001).

Academic Entrepreneurship

Academic or technological entrepreneurship in developed industrial countries has strong links with scientific progress, economic success and competitive markets. Until the 1960s, academic research was institutionally isolated from industry and generally well-funded by governments in many countries (Balazs, 1996). However, even under good funding conditions, some researchers in the applied sciences developed a professional interest in implementing research results in, or working with, industry.

Recently, national research, technology and development (RTD) policies in Europe have converged on a number of initiatives aimed at transforming universities into central components of the knowledge infrastructure for innovation. These initiatives have subsequently given rise to the phenomenon of the entrepreneurial university (Jacob et al. 2003).

Some universities generate more new companies to exploit their intellectual property than do others. Studies have compared different explanations for cross-institutional variation in new company formation rates from university technology licensing offices (TLOs), the availability of venture capital in the university area, the commercial orientation of university research and development, intellectual eminence and university policies. The results showed that intellectual eminence, and the policies of making equity investments in TLO start-ups, as well as maintaining a low inventor's share of royalties increased new firm formation (Di Gregorio and Shane, 2003).

The academic entrepreneur has been described as an academic who commercializes his/her research or as a senior researcher who is successful in attracting large research grants and has

become an employer of large numbers of post-doctoral and other researchers. However, the contemporary concept of entrepreneurship is distinguished from previous definitions in at least two important points. The first is that there is a shift in the perception of entrepreneurship from 'serendipitous and individual' to 'social and organized'. The second and related distinguishing feature of contemporary understanding of entrepreneurship is that there is now a strong belief that entrepreneurship is a skill that can be learnt and taught (Morris and Lewis, 1995; Fiet, 2001; Jacob et al. 2003).

Many universities worldwide are now teaching courses in entrepreneurship, actively promoting entrepreneurship among faculty and students, establishing liaison and technology transfer offices which bridge the gap between industry and academia and offering incentives for adjusting lines of study and the allocation of research budgets to the demand in the private and public sectors (Jacob et al. 2003). This has extended to *'economic development through technology transfer'* becoming a *'third academic mission'*, on a par with the traditional missions of teaching and research with essentially all universities in countries such as Germany having their own technology transfer office (Krucken, 2003).

Corporate Behaviours Towards Innovation and New Technology Uptake

Corporate Entrepreneurship

Some of the world's best-known organizations have had to endure painful transformation to become more entrepreneurial. These organizations had to endure years of reorganization, downsizing and restructuring. The (entrepreneurial) changes altered the identity or culture of these organizations, infusing a new entrepreneurial spirit throughout their operations …. change, innovation and entrepreneurship became highly regarded words that described what successful organizations must do to survive (reviewed by Kuratko et al. 2001).

There are many factors that affect an organization's success when using entrepreneurial actions to implement a corporate entrepreneurship strategy. The most important factors are the organisation's ability to establish a vision, and for senior management to support it, to organize people and tasks in ways that make it possible for entrepreneurial actions to flourish, to have sufficient resources to support entrepreneurial actions, to use rewards and compensation systems that reinforce an individual's or team's entrepreneurial actions, and to encourage risk taking, as measured by an individual's willingness to accept risks and tolerate failure (reviewed by Kuratko et al. 2001).

Studies of Japanese corporations have revealed that these organizations have a facility for gathering knowledge from the outside, and an ability to then share and develop this on the inside, which forms the basis for developing new products, processes and technologies. Knowledge creation is therefore the basis of the process and provides the platform for the *continuous* innovation that constitutes the competitive advantage of certain Japanese firms (reviewed by Burton, 1999). However, certain organizational conditions seem to be necessary to allow a positive knowledge spiral to take place. These include:

- organizational aspiration/intention

- a sufficient degree of autonomy for individuals to examine as-yet unexploited opportunities

- the deliberate managerial deployment of 'fluctuation' and 'creative chaos' to break down rigid routines and cognitive frameworks

- intentional overlapping of information about business activities, management responsibilities, and the company as a whole in order to promote the sharing and internal transfer of tacit knowledge, and

- necessary access to information, spread throughout the organization, to cope with environmental complexity and change.

While it has been argued that entrepreneurship is obsolescent, and has been replaced by organizational routines/searches (i.e. continuous innovation), it has also been argued that in the absence of entrepreneurial alertness/awareness, then organizational routines and knowledge creation may simply lead up 'blind alleys' in terms of *profitable*, *commercial* outcomes (Burton, 1999). So where is 'the' entrepreneur in the company or organization? Is this the CEO, the Director of R & D, or elsewhere in the organization? The answer to this question is not obvious.

Some have concluded that the locus of the entrepreneurial function in the modern (large) corporation is (always) that of the marketing department, because it is concerned with new products and their market potential. Although this proposition may be attractive in some ways, we cannot – and should not – categorically state that this is always the case. In principle, entrepreneurial alertness could emerge from a variety of functions and levels in an organisation which has led to the concept of *diffused entrepreneurship*. While an organization may be led by a (or a few) dominant individual(s), some of whom may also have entrepreneurial alertness, entrepreneurship is commonly dispersed or diffused throughout a modern business enterprise, and this may especially be the case in knowledge-creating organizations (Burton, 1999). It has therefore been suggested that human resource (HR) departments consider making changes in areas such as job design, recruitment, selection and training to develop values and activities needed for corporate entrepreneurship (Jones et al. 1995).

The term *intrapreneurship* is widely used to refer to the development of new business ventures within an existing organization where the new venture is owned by the parent organization. There appears to be increasing consensus among management and organization theorists that internal entrepreneurial (i.e. intrapreneurial) behaviour is a significant factor in organizational effectiveness. Despite the fact that intrapreneurs are expected to function in an entrepreneurial manner, they operate in a context very different from independent entrepreneurs. For example, intrapreneurs must operate within an existing organizational structure in accordance with established corporate systems while reporting to hierarchial supervisors. In order to be successful, intrapreneurs need somewhat different competencies than do independent entrepreneurs. For example, research indicates that intrapreneurs need to be fairly adept at corporate politics, while many independent entrepreneurs deplore such behaviour and resist traditional organizations in order to avoid it (Davis, 1999).

Studies have shown that managers perceive intrapreneurs to be more creative, innovative, ambitious, aggressive, enthusiastic and resilient than their managerial counterparts,

perceptions that are consistent with the popular image of intrapreneurs as unconventional managers, or renegades, who acquire their training and experience independently through trial and error rather than through academic institutions and traditional corporate structures. Unlike entrepreneurs who generally "self-select", intrapreneurs are selected (or at least partially endorsed) by organizational managers, and studies have reported that managers do not always base their decisions exclusively on valid criteria (Davis, 1999). Of particular concern, research has suggested that managers that ascribe attributes (including age, marital status, race, gender) to successful intrapreneurs would subject their organizations to liability if used as a basis for selection decisions (Davis, 1999).

During the last decade, the role of the middle manager in corporate entrepreneurial activity has been recognized in the literature, although the empirical research on the internal organizational factors that may foster middle manager activity has been limited, both in volume and scope. However, the literature (Hornsby et al. 2002) does converge on at least five possible factors.

- The appropriate use of rewards. The literature stresses that an effective reward system that spurs entrepreneurial activity must consider goals, feedback, emphasis on individual responsibility, and results-based incentives. This factor, therefore, highlights middle managers' role in this regard.

- Gaining top management support. The willingness of senior management to facilitate and promote entrepreneurial activity in the organization, including championing innovative ideas as well as providing necessary resources, expertise or protection. This factor captures middle managers' role in this area.

- Resource availability. Middle managers must perceive the availability of resources for innovative activities to encourage experimentation and risk taking.

- Supportive organizational structure. The structure must foster the administrative mechanisms by which ideas are evaluated, chosen, and implemented. Structural boundaries tend to be a major stumbling block for middle management in corporate entrepreneurial activity.

- Risk taking and tolerance for failure. Middle managers must perceive an environment that encourages calculated risk taking while maintaining reasonable tolerance for failure (Hornsby et al. 2002)

There have been reports in the literature that have attempted to distinguish between 'the entrepreneur' and 'the manager', although previous research on the psychology of entrepreneurs has found that personality traits failed to distinguish entrepreneurs from managers (Chen et al. 1998). Distinctions between entrepreneurs and managers can be made at the conceptual level – management (conceived of as the conduct of efficient administration), is distinguishable from the notion of entrepreneurial alertness (to opportunities as yet unforeseen by others). However, this conceptual distinction misses a vital point, and especially in the case of knowledge-creating companies – the real trick is to blend the two together, so that entrepreneurial *attitude* is spread throughout the entire (and, especially management) structure of the organization (Burton, 1999).

Organizational Factors Affecting Innovation and Technology Uptake

While innovation (ie. change) can have many positive spin-offs for a company, it has long been observed that many managers prefer the comfort of the familiar and are resistant to organizational and technological change. In general, the fear of loss is stronger than the attraction of potential gain (Gray, 2002).

There can be numerous reasons for an individual's resistance to change within a company such as loss of hard won status or privilege, fear of the unknown, lack of trust, cultural or age-related conservatism, different perceptions of external dangers, or disagreement over the proposed strategy or changes. It has been claimed that only one-third of major technological changes in organizations succeed, mainly because of resistance to change (Gray, 2002). Three main levels of resistance to change have been identified:

- *Informational* – where there is not enough information or understanding of what is required
- *Gut reaction* – emotional, psychological and even physiological individual reactions
- *Cultural* – when there is a past history of failure or problems and strong negative organizational memory

Most 'failures' (to introduce technological change) have been reported to be misunderstood by managers in that they generally believe change problems to be informational, whereas most are emotional. Hence effective communication is very important to minimize such resistance to innovation/change.

Presenting a good argument is often not sufficient to change people's minds. Often you must repeat the argument again and again in different forms and in different environments to slowly bring the audience around. The decision-theory approach to understanding adoption helps to explain this; a single hearing of an argument may slightly reduce one's uncertainty about an innovation, but hearing the argument repeatedly, especially from different sources, is likely to reduce uncertainty and increase confidence to a much greater extent (Pannell, 2003). Hence, there appears to be a need in some cases to temper the traditional 'hardware' focus of operational/technological innovation with the 'reality' of human behaviour (Genus and Kaplani, 2002).

Researchers understand that radical innovation within an organization is very different from incremental innovation and that it is critical to long-term success of companies. Unfortunately, research has also shown that it is often difficult to get support for radical projects in large companies, where internal cultures and pressures often push efforts toward more low risk, immediate reward, incremental projects (McDermott and O'Connor, 2002).

To make organizations and people more enterprising, it is necessary to foster creativity, innovation and learning. Managers will need to adopt a coaching instead of telling style, take initiatives and accept responsibility for the decisions they take. Many people already have ideas, but they have neither the will, nor the confidence to pursue them. They remain ideas, no actions are taken. In such cases, effort on the people and resource elements - attempting to harness the talents of the right people - suggests the ideas will follow (Thompson, 1999).

However, it is also worth noting that effective mechanisms for collecting and sorting ideas, as a prelude to finding ways of exploiting the potential winners, have to be found.

Studies on the introduction of entrepreneurship in the public sector have defined three dimensions of managerial entrepreneurship in public and private organizations:

- product-based entrepreneurship (enhancing customer satisfaction)
- process-based entrepreneurship (reducing the level of red tape), and
- behaviour-based entrepreneurship (promoting the propensity for risk-taking).

The data suggests that the three sets of organizational characteristics, namely structure, culture, and environment are each significant in different ways to dimensions of managerial entrepreneurship. It also indicates that organizations need to promote structural as well as cultural reform to pursue different dimensions of managerial entrepreneurship simultaneously (Moon, 1999). It therefore appears that the organizational complexities associated with innovation, plus the non-economic personal motivations of individual managers present real external and internal psychological barriers to sustained entrepreneurial behaviour and innovation in small to medium enterprises (Gray, 2002).

However, the acceptance of change as a *continuous* activity is a key factor in managing the diversity and innovation within a complex organization (Jarrett, 1999).

The pace of technological change is usually faster than the rate at which organizational changes can be assimilated and institutionalized. This poses a problem as employees have to be sensitized and prepared for change, and organizational systems and procedures have to be modified to deal with the change. A culture of action orientation, risk taking, receptiveness to internal and external breakthroughs, and a high tolerance for failure should be present in the receiver organization (Willis and Ashworth, 2002).

In recent times, another issue to potentially affect technology transfer to a particular organization is the short(er) tenure of senior management as the management may not be willing to support long-term technology development when they will not be in a position to enjoy the benefits (Willis and Ashworth, 2002).

A ‘new venture’ team is one way of organizing people to promote entrepreneurial actions. The collective talent of a new-venture team can be particularly effective when its members come from different functions (eg. science, engineering/manufacturing, marketing) and when senior management actively support the team’s efforts. When forming such new-venture ‘cross-functional’ teams (described later), organizations should draw on their entire talent pool, as the most effective entrepreneurial actions sometimes surface from individuals or teams from whom such output wasn’t anticipated. Unexpected, yet valuable, contributions surface because, most, if not all, members of an organization have untapped talent and potential (reviewed by Kuratko et al. 2001).

The very nature of being an established company can create barriers with respect to the implementation of innovative processes. A company’s survival and success are based on its ability to satisfy market demands, to develop a competitive advantage over other companies offering products to the same markets and on the establishment of a set of internally

consistent throughput processes that ensure that the output and competitive advantage demands are met (Ahuja and Morris Lampert, 2001).

While a company must satisfy market demands, its ability to provide reliable high-quality outputs in an efficient and predictable fashion is likely to be a key to its success and survival. Similarly, from the perspective of obtaining a competitive advantage, a company needs to develop a distinctive competence/capability that differentiates it from its competitors, and from the perspective of internal consistency, it is important that a company's structure and systems conform to its strategy (reviewed by (Ahuja and Morris Lampert, 2001). By developing and refining a competence, by providing reliable outputs and by operating a set of internal controls and processes that ensure the above outcomes, a company can enjoy the benefits of internal and external consistency. However, these attributes can also limit a company's effectiveness at innovation.

The stimulus to provide reliable and predictable solutions focuses a company's attention on mature technologies. The stimulus to develop a competitive advantage favours the retention of routines that lead to distinctive competence and specialization, rather than experimentation, and the necessity to establish control leads to bureaucratic procedures and structures that favour searching proximate domains of technology rather than searching more uncertain or unknown solutions. Therefore, it has been argued that established companies focus on the familiar, the mature, and search for solutions near to existing solutions. However, it has also been argued that a company can overcome these traps by experimenting with novel (technologies in which a company lacks prior experience), emerging (technologies that are recent or newly developed in an industry) and pioneering technologies (technologies that do not build on any existing technologies), resulting in the creation of innovative processes (Ahuja and Morris Lampert, 2001).

Organizational orientations are social learning and selection mechanisms that aim to maintain a coherence between management's strategic intent and operational activities. They shape the way organizational members process information and react to the environment through the nature of control systems and rewards they engender. They create internal environments in which desired behaviours are encouraged and supported (Atuahene-Gima and Ko, 2001).

The management literature focuses on entrepreneurial orientation (described in part as a propensity to pioneer innovations that preempt the competition), while the marketing literature is focused on market orientation (described in part as a responsiveness to market intelligence to serve customer needs). It has been argued that this divergence in the literature is counter-productive because a link between the two orientations is beneficial, and that organizations with high market and entrepreneurial orientations will out-perform other organizations (Atuahene-Gima and Ko, 2001).

Market orientation has been reported to encourage and support the refinement and adaptations of current innovations to meet current needs rather than the development of new products targeted at emerging new needs. That is, market orientation engenders a reactive response to customer needs and current competitor actions thus reflecting a reactive approach to collecting, disseminating and responding to market information (Atuahene-Gima and Ko, 2001).

In contrast, entrepreneurial orientation has been described as a learning and selection mechanism that engenders exploratory and risk-seeking behaviours involving the creation of

new resource combinations that may require competencies not currently available within the organization. Entrepreneurial orientation therefore is a proactive strategic orientation that leads to aggressive initiation of innovation with high levels of financial uncertainty and risk, the danger being that unbridled entrepreneurial orientation may blind an organization into the wrong belief that technological superiority is a sufficient condition for new product success. Entrepreneurial orientation may manifest itself in the introduction of new products to the market that are far in advance of customer experiences, and therefore less likely to generate sales and profits, or if such unfamiliar products are sold to customers, it is likely to result in an increased level of customer complaints (Atuahene-Gima and Ko, 2001).

A case can therefore be made that market orientation and entrepreneurial orientation are synergistic and combine positively to affect innovation activities and performance by enabling an organization to adapt to, and manage its market environment and emerging customer needs. Conversely, the adoption of either market or entrepreneurial orientation, to the exclusion of the other may be a less effective strategy in achieving effectiveness and success in product innovation (reviewed by Atuahene-Gima and Ko, 2001).

Perhaps surprisingly, prior experience in an industry has been reported to not be a good predictor of entrepreneurial/venture success, although cases for and against this point are available in the literature. Several studies have suggested that prior industry experience may often be a liability rather than a benefit, with such entrepreneurs suffering from biases, blindness and strong ties, which may make it difficult to navigate the uncharted waters of a new venture (Gartner et al. 1999). Furthermore, it has been indicated that potential entrepreneurs who are perceived to "not have all the answers" (i.e. are not experts) at the beginning of a new venture are more likely to have flexibility and the ability to recognize and react to the completely unpredictable. Such flexibility, along with an understanding of their customers and competitors have been reported to be key descriptors of successful entrepreneurs (Gartner et al. 1999).

Educational experiences have also been reported to influence entrepreneurship, with entrepreneurs being reported to have a lower level of education than managers. This lower educational level, it was reported, could lead entrepreneurs to feel limited in traditional organizational career paths. Frustrated by an inability to achieve their desired level of success in established organizations, they choose to pursue a venture in which their own assessment of their abilities is more relevant (Morris and Lewis, 1995).

A study of the winning companies of The Canada Awards for Business Excellence Program for invention and innovation showed that the innovative companies use, or have more of the following than the less innovative ones: calculated risk taking; management commitment to entrepreneurial activities and innovation; integration and intermingling of talents in teams and task forces; group and collective orientation; and a reward system that reinforces entrepreneurial behavior (Saleh and Wang, 1993).

The CSIRO Experience

CSIRO has a number of government-set performance indicators which emphasize technology transfer and industry interaction. In earlier times, publicly funded research institutions such as CSIRO carried out research they felt was most appropriate and, when discrete innovations emerged that had commercial potential, they would offer them around to industry - the so-

called “science push” model. More recently, relationships are being entered into with industry at a very early stage so that they can influence the direction of research and increase the probability of commercial products or processes emerging - the so called “market pull” model (CSIRO, 1997).

In general, the modes of technology transfer from CSIRO to research users has been in the form of non-commercial transfer (seminars/workshops, informal contacts, publications, secondments, staff exchanges and training), commercial transfer (collaborative and contract research, consulting, licensing and sale of IP and technical services) and new company generation (direct and indirect spin-off companies, technology transfer companies) (Upstill and Symington, 2002).

Until the mid-1980s, non-commercial transfer was the main mode of technology transfer in CSIRO. In the decades following the second world war, technology transfer primarily took place through direct industry contacts, publications, seminars and courses, government-funded rural extension bodies and informal interactions with industry. In a study of industry interactions, some CSIRO groups were found to be involved in over 300 industry-initiated informal contacts per year (reviewed by Upstill and Symington, 2002).

During the 1980s, commercial transfer featured more prominently in technology transfer due to pressures for closer links with industry. Towards the end of the 1980s, CSIRO faced an external earnings requirement imposed by government as a spur for, and an indicator of, increased interaction with industry. This led to a growth in formal commercial agreements and contracted and collaborative research with industry. It also led to the recruitment and expansion of commercial staff in each of CSIRO’s operational units, development of standardized commercial policies, streamlined intellectual property managements and industry-led priority setting processes (Upstill and Symington, 2002).

Since the mid-1990s, there has been increased interest in new company generation as a preferred mode of technology transfer (Upstill and Symington, 2002). CSIRO has spawned a large number of spin-off companies that places it almost on a par with universities such as King’s College, London and MIT (Massachusetts Institute of Technology). While analyses of the formation of over 60 CSIRO spin-off companies has been documented (Thorburn, 2000; Upstill and Symington, 2002), it was reported that CSIRO appeared to have paid relatively little attention to staffing issues (Thorburn, 2000) and therefore, in the context of this report, there is limited information on the “human” factors that have played a role in this aspect of technology transfer.

Despite the high failure rate of new companies in general (75% in the first 5 years), CSIRO spin-off companies have had a very high rate of survival (88%) (Thorburn, 2000). One reason for this high survival rate has been reported to be the high rate on ongoing formal or informal research linkages with CSIRO and other research institutions. The level of such networking was 11-fold greater than the usual level of links/networking formed by Australian companies with research institutions (Thorburn, 2000).

Furthermore, the transfer of people from CSIRO to the spin-off companies was seen as another key reason for the high survival rate of CSIRO spin-off companies. A founder of one CSIRO spin-off company has been quoted as saying *“I believe you can’t transfer technology without transferring people. You can put as much as you like down on paper but unless*

you're transferring people you're not transferring technology. You are not giving away successful people. You are utilizing them for maximum" (Thorburn, 2000).

One aspect of such "people transfers" is the transfer of tacit knowledge (ie. informal, undocumented knowledge, "the way people do things"). Tacit knowledge is difficult to transfer from one organization to another because of its complexity, its continual evolution, and its embodiment in personal skills, which vary from person to person. It is the transfer of the tacit knowledge embodied in the human capital that differentiates this technology commercialisation mechanism (i.e. formation of spin-off companies) from technology sale, licensing or joint ventures and alliances (Davenport et al. 2002).

The success of formal technology transfer can therefore be increased when tacit knowledge is also transferred at the same time. This has now been recognized and many business support programs aim to support the tacit links between research institutions and industry (reviewed by Thorburn, 2000).

While such "people transfers" have been shown to be of significant benefit in the formation of CSIRO spin-off companies, shorter term "people transfers" or secondments from research organizations to industry may also maximize the effectiveness and success of other technology transfer processes.

Recent changes have therefore required a degree of entrepreneurialism from scientists and others to get out and sell their capabilities, either as individuals or as teams of problem solvers, often combining several different disciplines. This has also required a degree of knowledge and familiarity of *"the ways of companies"*. These are not necessarily skills that come naturally to specialist scientists, who must therefore be accompanied by others with commercial skills. More fundamentally, it has required closer and earlier relationships between users and providers to ensure that *what is wanted is produced* and *what is produced is wanted.*

Technology transfer within CSIRO has been acknowledged as a traditional weakness, although it is clearly improving (CSIRO, 1997), particularly due to a more recent strong focus on technology transfer, commercialization and "going global" across the organization (CSIRO, 2001). It is clearly evident that this focus and key messages are getting through to the CSIRO Divisions with a recent forum (CSIRO, 2003) on technology transfer and commercialization receiving (among other) suggestions that:

- CSIRO needs to be less risk-averse and respond faster to technology transfer and commercialization issues (Health Sciences and Nutrition)

- A need for dedicated staff with a technical background and commercialization skills (Minerals)

- Commercialization needs to be a key activity/core business within CSIRO, not an "add on" (Exploration and Mining)

  and a very insightful comment that

- Technology transfer is basically a targeted relationships business. In the past, CSIRO Technology Transfer activities were mainly passive and awareness raising models that

have not turned awareness into action. A process requiring more engagement is required. The reality is that we are dealing with social forces (attitudes and values), not technology (Livestock Industries).

Environmental Factors Affecting Innovation and Entrepreneurship

Entrepreneurial activities of a region reflect its business climate and habitat for innovation (Suzuki et al. 2002). Entrepreneurship cannot therefore be fully understood without taking into account the social, cultural, and economic contexts that surround the entrepreneur. It has been reported that the key *social* factors that affect entrepreneurial behaviours include family and social support systems, financing sources, employees, customers, suppliers, local community, governmental agencies and the cultural, political and economic environments (Suzuki et al. 2002).

A survey of 396 Japanese companies and 188 Silicon Valley companies concluded that Japanese entrepreneurs are more group- and society-oriented than are entrepreneurs from other countries and therefore entrepreneurship in Japan demanded different personal values to those in other countries. Furthermore, given the emphasis of Japanese society on technology and human factors, it was found that human and organizational risks were more highly perceived by Japanese entrepreneurs relative to Silicon Valley entrepreneurs, with Japanese entrepreneurs recognizing human-side problems as more serious potential management obstacles. Although human-issues are becoming more important than before in Silicon Valley, this study implies that such "human issues" should be handled with great care in Japan. Furthermore, in this large study, no single item got a higher rating than did "customer focus" as a critical growth factor by both Silicon Valley and Japanese entrepreneurs again emphasizing the importance of human issues in entrepreneurial activities (Suzuki et al. 2002).

Environmental hostility relates to the intensity of market competition, lack of market opportunities, and unfavourable, harsh business climates with an organization having little or no power to influence the environment. The degree of hostility of environment has been reported to affect the link between entrepreneurial orientation and organizational performance. In this context, it was found that conservative top management style was more effective in benign environments, whereas entrepreneurial top management style style was more effective in hostile environments. A study of 500 Australian companies, 70% of which were manufacturing companies, including food and beverage companies, highlighted the importance of the role of management in creating an environment conducive to product innovation (Atuahene-Gima and Ko, 2001).

Historically, environmental turbulence has been a factor in a large percentage of new product and technological innovations. Rapid change in the technological, economic, customer, competitive, legal and social environments has produced both threats and opportunities for those in industry. Managers can be confronted with short decision windows, diminishing opportunity streams, changing decision constituencies, lack of predictable resource needs, fragmented markets, greater risk of resource and product obsolescence, and a general lack of long-term control. It has been reported that the more dynamic, hostile and heterogeneous the commercial environment, the higher the level of innovative, risk-taking and proactive behaviours that will be be exhibited by industry (Morris and Lewis, 1995). The conclusion is that *change* is a catalyst for entrepreneurial activity.

Research has indicated that indigenous companies are more likely to perform innovative activities locally and are more embedded in the local economy than their multinational counterparts, as they exhibit higher R&D intensity, have a larger proportion of scientific, technical and managerial employees, adopt innovative inter-firm practices more extensively, and are more likely to source innovative ideas from local sources. The multinational companies, in contrast, tend to exhibit lower R&D intensity, are more reliant on their in-house marketing units, and continue to rely on their parent companies as a primary source for innovative ideas. These results suggest that local context still exerts a significant influence on the nature and extent of innovative activities in the knowledge-based economy (Gertler et al. 2000).

Studies have concluded that entrepreneurship is a self-reinforcing process. That is, individuals who are able to observe entrepreneurs, and perceive these people as positive role models, are more likely to undertake entrepreneurial activities (Morris and Lewis, 1995; Bygrave and Minniti, 2000). The implication of this for an R & D organization and/or a company, is that positive role models in innovation/entrepreneurial activity within an organization are likely to encourage and enhance similar innovation and activities by other individuals within that organization. Furthermore, the degree of entrepreneurial activity within a group is the outcome of a dynamic process in which social habits are as important as legal and economic factors (Bygrave and Minniti, 2000).

Factors Affecting the Rate of Technology Uptake

A company can make a strategic choice as to whether it wants to be "first to market", an "early follower", "late follower" or "late entrant" with respect to new product introductions. While the decision may reflect an aspect of innovativeness, with early entry indicating a greater degree of innovativeness, the timing may also reflect the company's internal capabilities to deal with market and technological uncertainties associated with its entry strategy (Atuahene-Gima and Ko, 2001).

The adoption of an innovation consists, in large part, of the collection, integration and evaluation of information. An innovation is evaluated in terms of its ability to meet the decision makers' objectives, based on current perceptions about the innovation's performance compared to existing practices. Early in the process, uncertainty about the value of the innovation is high, and the quality of decision-making may be low. As the process continues, if it proceeds at all, uncertainty falls and better decisions can be made (Pannell, 2003).

The phases of awareness or knowledge that affect the adoption of innovation and that may or may not be reached by decision makers (Pannell, 2003) include:

- Awareness of the innovation. In this context, "awareness" means not just awareness that an innovation exists, but awareness that it is potentially of practical relevance. Reaching this point of awareness is a trigger that prompts the decision maker to open his or her ears and eyes - to begin noting and collecting information about the innovation in order to inform the decision about whether or not to go to the next step of trialing the innovation.

- Perception that it is feasible and worthwhile to test the innovation (usually achieved via small-scale trials). In agriculture, the trial phase has been reported to be perhaps the most important phase in determining final adoption or not. Where an actual trial is not possible, evidence from a virtual trial (i.e. a detailed desktop analysis, or experience reported from another context or another state or country) may be sufficient.

- Perception that the innovation promotes the decision maker's objectives. There is compelling empirical support that the final decision to adopt or reject is consistent with the producer's "self interest".

Studies of the adoption of innovations (Pannell, 2003) have indicated that, in general:

- Most potential adopters considering an innovation are sensibly cautious, and hence uptake is often slow.

- Where decision makers do not have personal experience with an innovation, they rely to some extent on external sources of information. Therefore, as decision makers gain personal experience, this tends to have a dominant influence on their perceptions and their actual behaviour. This means that those attempting to transfer the innovation are more likely to have an influence early in the debate, before perceptions are firmly formed.

- External sources of information are given more or less weight depending on factors such the expertise and credibility of the information source, the relevance of the external information to the decision makers circumstances, and the number of external sources reinforcing the message with similar information.

Factors which influence the speed of adoption of an innovation (Pannell, 2003) include:

- the extent to which adopting the innovation is *actually* superior to maintaining existing practice (this depends on a great diversity of issues, and is often difficult to determine)

- the ease with which the innovation can be observed and evaluated

- the number of other potential adopters who have already adopted it, and the similarity and proximity of those actual adopters to those who are now considering adoption, and

- the intensity and quality of efforts to promote the innovation.

The speed of technology diffusion has been reported to be positively related to the profitability of adoption, that innovation diffuses more rapidly in less concentrated industries and that smaller firms adopt new technologies more slowly (Diamond Jr, 2003).

A receptor organization's capability to absorb new technology is influenced by the level of prior, related knowledge and expertise (i.e. basic skills, shared language, technological acumen, functional specialists) in the receptor organization. The extent to which the

technology is understandable, demonstrable and unambiguous, the greater the probability of uptake by the industry. The relevance of the innovation or technology to the receptor organization's needs, the organization's interest in the subject matter, project goals and demonstrated usefulness of research results will also significantly affect technology uptake (Willis and Ashworth, 2002).

Uptake of new technology by industry has been reported to be significantly enhanced when the technology was highly recommended by respected authorities outside the transferring organization (i.e. a neutral party) (Willis and Ashworth, 2002).

Studies have also examined how the organizational context variables of age, size, resources and competitive strategy affect entrepreneurship and in particular, innovation, pro-activeness and risk-taking. Results from a sample of 233 companies showed the significant influence of organizational resources and competitive strategy on entrepreneurship. However, size and age of the company were not significant (Entrialgo et al. 2001).

One traditional method of measuring innovativeness of a company is based on the time of adoption of a single product. Segmenting an industrial market based in this measure has recently been reported to be predictive of a company's relative time of adoption of related products (Fell et al. 2003). In contrast however, another study has reported that holding firm size and profitability constant, early adoption of one technology is not a very good predictor that a company will also be an early adopter of later technologies. An extension of this work to international technology transfer concluded that countries that invest more in R & D are quicker at adopting other countries' innovations (Diamond Jr, 2003).

The benefits of spending a significant amount of time with the "first adopter" of a new technology or process have been reported. Close supervision of other early adopters has also been recommended in order to prevent mistakes which could cause a new method or innovative technology to fail (Grandin, 2003).

Networks Bring Companies and People Together

Situational/environmental factors and social function are integral components of the entrepreneurial process (Stewart et al. 1999), and the value of networks as an integral part of entrepreneurial success is widely acknowledged (Elfring and Hulsink, 2003). Networks are patterned relationships between individuals and groups and can help an entrepreneurial venture establish legitimacy and develop a desirable reputation in the marketplace. It has been reported that manufacturing companies, but generally not 'service' companies (i.e. those providing a non-material product), have external networks and the relationships developed within these networks were of great importance to innovative activities (Sundbo, 1997). Studies of technology transfer processes at 57 universities in the UK showed that the more successful universities were found to possess greater networks (that may be important in fostering spin-off companies) (Lockett et al. 2003).

Entrepreneurs have widely been reported to be good networkers. In addition to having "know-how", they "know-who" and "know-where" to obtain the resources they require (Thompson, 1999). Entrepreneurial ventures find both personal networks and more formal organizational networks to be of value in competing successfully in the marketplace. The strongest personal networks are based on trust between partners, while less effective

networks are framed around casual relationships. For entrepreneurs leading new ventures, developing and enhancing social skills, perceiving others accurately, making a favourable first impression, and being able to adapt effectively and quickly to a wide range of social situations are important sources of strong and successful personal or social networks (reviewed by Ireland et al. 2001). Even weak social ties can promote ideas, and entrepreneurial behaviours leading to the development of innovative opportunities (Floyd and Woolridge, 1999) and social networks have been shown to have a significant positive impact on the success of new technology implementation (Johnston and Linton, 2000). Furthermore *higher-level* technology transfer can be achieved as relationship duration increases (Kotabe et al. 2003).

The importance of getting to know "decision makers" *before* they are in positions of influence has been reported (Pannell, 2003). Once these people are in positions of influence they tend to be very over-worked and they rely on contacts and information they have acquired beforehand. Given the difficulty of anticipating who will become influential "decision makers" in the future, perhaps the appropriate response to this recommendation is to establish and maintain strong professional networks generally.

Perhaps a form of indirect networking is by the use of consultants in technology transfer. Consultants can play a role in experience sharing, either implicitly or explicitly and in some ways, act like bees, cross-pollinating between companies, carrying experiences and ideas from one location or context into another (Bessant and Rush, 1995).

Technology parks have been suggested to play an important role in the improvement of entrepreneurial culture and offer an ideal environment for technological start-up companies. Close networking between carriers of different competencies and with external partners in R&D, finance, and industry has been reported to be the basis for the high success rates of start-ups (Von Waldkirch, 2000), particularly in technology parks such as the Technopark ® Zurich that was created over 10 years ago to facilitate technology transfer from science (Von Waldkirch, 2003).

Organisations have several ways to internationalize their operations to create wealth, such as licensing, strategic alliances and direct foreign investments. However, regardless of the process used, organizations entering foreign markets should always treat those with whom they become involved with respect, especially network partners, and should focus on finding ways to promote mutual interests (reviewed by Ireland et al. 2001).

Rapid transfer of knowledge is vital in entrepreneurial ventures, particularly in international markets. It has been reported that organizations that have the capability to learn and transfer knowledge quickly by effectively using their human capital rely on this skill as a source of competitive advantage (Ireland et al. 2001).

The encapsulated message from research in this area is that building relationships and supportive networks are as important to successful entrepreneurship as technical innovation (Harris and Jackson, 1999).

Personalised Technology Transfer/Uptake

Technology transfer is a communication process (Rogers et al. 2001) and people are the key to successful technology/knowledge transfer (Willis and Ashworth, 2002). Research has shown that the individual plays a critical role in the process of knowledge transfer and that relationships form an integral part of this process (Lindsay et al. 2003).

Individuals make decisions about whether innovations are adopted and transferred to new uses or locations. Relational competence is therefore critical for innovation management and technology transfer and personal communication, formal and informal, is the core component in such competence. Research has shown that 'close ties' and communication are critical to innovation, particularly given the changing nature and role of technology management in the context of rapidly increasing globalization (Irwin et al. 1998).

Event history analyses of company start-ups exploiting MIT (Massachusetts Institute of Technology) innovations have also shown that new ventures with founders having direct and indirect relationships with venture investors are most likely to receive venture funding and are less likely to fail, and it was concluded that the social capital of company founders represents an important endowment for early-stage organizations (Shane and Stuart, 2002).

Individuals actively pursuing technology transfer continue to rely heavily on a personalized, informal pattern of technology transfer/uptake with the majority of technology transfer projects being achieved through informal links. This holds true for both industry and academic researchers. Recent research from universities, technology transfer offices and industry is now revealing some of the underlying reasons for the heavy reliance on personalized technology transfer patterns.

Technology transfer/uptake first and foremost requires a high level of trust between those involved. This is particularly clear from the industry side of technology transfer partnerships. Industry may grant trust to individuals or to research units, sometimes even to organizational departments, but not to scientific institutes or universities. Furthermore, researchers typically trust their concrete industry partners without stretching that trust too far. Instead of simply an 'information gap', research has suggested an underlying 'cultural gap' between universities/institutes and industry. This has led to a high degree of uncertainty and even distrust which was only ever overcome by trust in individual people. The 'cultural gap' was widely expressed in terms of institutional differences and stereotypes between 'those in the ivory tower' and 'those only interested in short-term results'. It is therefore clear that those engaged in technology transfer/uptake cannot do so on the basis of institutional trust. Only trust in individual people reduces these uncertainties and therefore personalized modes of interaction are a prerequisite for effective technology transfer/uptake (Krucken, 2003).

Credibility and reputation of the people or teams involved in technology transfer is also very important. It is therefore important to strive to be scrupulously honest and balanced in communications with clients and hope that this is recognized (Pannell, 2003).

When new technology is 'imposed' on an organization without ensuring internal receptivity, it is bound to fail. A very real factor influencing technology transfer is employee attitudes or resistance to change, which has also been referred to as the "not invented here syndrome". Therefore, it is important that the people in the receptor organization are well informed about the process, are consulted about their needs, concerns, perceptions, attitudes and expectations,

and trained/mentored to understand and utilize the technology to its fullest (Willis and Ashworth, 2002). Feedback and positive reinforcement (behavioral interventions) could therefore be of value in improving technology transfer (Andrzejewski et al. 2001).

Training of employees to understand and use new technology will have a direct impact on the capability of an employee to accept and implement new technology. There is therefore a need to move beyond the translation of training material and to design training programs that contain material relevant to the end users. As employees progress in their training, personal satisfaction, and recognition by the organization and their peers will provide further incentive. Furthermore, mentoring is an essential ingredient of technology transfer. There is no substitute from learning from someone who has already been through the process (Willis and Ashworth, 2002). The importance of such personalized technology transfer has also been highlighted in a recent CSIRO case study (CSIRO, 2004).

Direct overseas investments of multinational firms, has been instrumental in energizing the economies and altering international trade patterns in Eastern Asia. One of the keys to productive results has been reported to be the emphasis on human factors in technology transfer which targets the development of human resources through strong inter-personal contact. This has led to sustainable economic development via integrated production systems and viable export programs in this highly dynamic part of the world (Hiraoka, 1995).

Studies from human service fields, also indicate that interpersonal strategies are dramatically more effective in achieving the individual and organizational behaviour changes needed to achieve technology transfer (Brown and Flynn, 2002).

The world's first complete food irradiation technology transfer project between Canadian and Thai private food companies and government agencies (also discussed later), involved a cross-functional team including specialist scientific staff and technology transfer staff and included day-to-day personal contact between the Canadian and Thai counterparts (Kunstadt, 1993). The summary of the successful project outcomes stated that 'the cooperation and accommodation between the people of the organizations made possible the successes achieved. The language, cultural and distance barriers were reduced and the friendships that have been fostered will continue past the life of the project'. This case study further emphasizes the effectiveness of personalized modes of interaction in successful technology transfer/uptake projects and supports the views that personal and active technology transfer i.e. through people, has proven more effective than passive efforts to disseminate information (Willis and Ashworth, 2002).

Cross-functional Teams for Technology Transfer

Some inventors fail to persuade industry to take up their idea. Critics will then dismiss the idea as ill-conceived, but there are definite cases of a good idea being lost or wasted through poor technology transfer mecahanisms. Studies have also suggested that stereotypical views of scientists/inventors held by potential business adopters, coupled with the often weak marketing communications and interpersonal skills reportedly possessed by some scientists/inventors present very real barriers to the adoption of new ideas by the business community (Wright and Narrow, 2001). In such cases, the inventor(s) need(s) partners to provide marketing, financial and general commercialization skills (Thompson, 1999).

The use of cross-functional teams as a tool for technology transfer and commercialization of new food products has been suggested (Patil, 2003). A cross-functional team was defined *as "a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable"*.

Typically such teams are composed of representatives from science, engineering / manufacturing, marketing, finance and other functional areas and therefore such teams possess diverse knowledge sets. Integrating knowledge from team members' different functional areas increases the likelihood of the team's success, but this will only happen if the team members feel free to use their knowledge, intelligence, skills and creativity while working together (Pfeffer, 1998).

Studies of the performance of cross-functional teams on innovation have shown that organizational context, specifically senior management team support and organizational politics, has a more significant influence on team success than internal team characteristics. While teams generally experience positive beginnings with few differences between team members, conditions can rapidly deteriorate because of a lack of senior management support and dysfunctional organizational politics. The key is to support and integrate the divergent and often contradictory forms of knowledge from separate functional specializations (Hitt et al. 1999).

Difficulties can occur when innovation within organizations is accomplished in a sequential manner. Organizations using a sequential innovation process where a design is developed by scientists, then transferred to an engineering/manufacturing group for input and then transferred to a marketing group to take to the marketplace. In this model, communication is largely one way, from design to manufacturing and from manufacturing to marketing. Unfortunately, errors and problems often occur with this sequential and one-way communication process (Hitt et al. 1999) and therefore recommendations have been made to move corporate communications beyond one-way transmission of information to achieve a genuinely interactive medium for the effective facilitation of behavioural change (Chitty, 1996).

More organizations are now seeking to replace the sequential model with other processes, such as the use of cross-functional teams. While the application of cross-functional teams may not always be necessary, in general, for complex, highly novel innovations, cross-functional teams should be utilized at all stages of the innovation/commercialization process (Hitt et al. 1999).

In order to achieve the necessary integration and potential synergy available within a cross-functional team requires effective communication. Such communication is particularly necessary for technical and marketing synergy to achieve a common team 'mental' model and shared values in order to maximize input from all team members and thus team productivity as well as the speed of accomplishing tasks (reviewed by Hitt et al. 1999).

Enhancing (equal) communication between functions is crucial to successful team synergy. Research has shown that marketing managers can either communicate too little or too much with non-marketing managers. If they interact too infrequently, they run the risk of not understanding the way to most effectively communicate market information. If they communicate too much, they may overload the manager with too much information and

erode the overall quality of the information sent. In addition, some modes of communication are more effective in improving perceptions of the quality of market information, For example, regular e-mail sent by marketing managers seems to have no effect on perceived information quality. On the other hand, e-mail sent, with supporting documentation can have a strong positive effect on perceived information quality. Impromptu phone calls by marketing managers have less positive effects than scheduled phone calls (Maltz, 2000). The ability of organizations to become more entrepreneurial is therefore heavily dependent on breaking down functional barriers and encouraging teamwork (Jones, 1998).

The world's first complete food irradiation technology transfer project (mentioned earlier) between Canadian and Thai private food companies and government agencies has been documented (Kunstadt, 1993). This successful project involved a cross-functional team including specialist scientific staff and specialist technology transfer staff. Furthermore, a need for a Scientific Coordinator – to assure efficient communication and coordination of efforts across geographically distant sites was identified. The coordinator reported to the Technology Transfer Manager and was responsible for the coordination and timely completion of the project tasks, and had responsibility for the preparation of all reports, data and regulatory submissions. Upon successful project completion, it was concluded that such continuous coordination was critical to the success of the project and the parties involved were convinced 'that this is the only way to achieve success'.

Senior management support has been reported to be critical to innovation and commercialization processes. The primary support offered is usually in the form of resources to the project team, including both financial and political resources. By developing, communicating, and emphasizing specific shared values among organization members, senior management effectively establishes an organization culture. A strong culture facilitates simultaneous coupling of the functions (Hitt et al. 1999). Conversely, if there is a lack of senior management support (eg. little financial support, or transferring key team members to new positions without encouragement to remain active in the group), politically motivated conflict is likely to flourish between the functional groups.

It has also been reported that early and extensive involvement of industry in project/process development should improve the chances that the new innovative product/process will satisfy industry needs and will help ensure success of commercialization efforts (Hitt et al. 1999). The traditional deficit model of one-way information flow from the laboratory to the user is therefore now being replaced by a contextual model involving two-way dialogue (Clarke, 2003).

There is also information in the literature suggesting that geographically dispersed cross-functional teams are difficult to manage with respect to communications and coordination which can lead to the process being dominated by particular team members or functional groups. In such situations it is critical for senior management to ensure that the team has effective leadership and the necessary financial support, along with providing oversight of team operations to ensure that team processes are indeed effective. Organizations could also benefit from the establishment of processes to capture learnings from disappointments (Hitt et al. 1999).

The effect of job satisfaction of a project team on the relationship between team cohesiveness and project performance has been studied with the outcomes demonstrating that social satisfaction of the team mediated the relationship between team cohesiveness and project

performance (Nerkar et al. 1996). Social interaction and the quality of the social interaction within entrepreneurial teams has also been reported to be crucial for new venture success (Lechler, 2001).

Developing a Technology Transfer Team

Not all R & D groups can afford the luxury of a person or group of people whose primary or sole responsibility is technology transfer, although it is considered a very important function. All too often, the tasks are simply added to the responsibilities of one of the scientists / investigators, or of the Director. Research by the UK Government has indicated that it is not possible to turn the majority of (public) scientists into entrepreneurs and disputes the premise that this should be an objective (Tomes, 2003).

A survey of laboratories across the USA showed that the amount of successful technology transfer accomplished was determined primarily by whether there was a person specifically designated to do only technology transfer (Sacks, 1996).

Technology transfer involves many disciplines and many fields of expertise. It is therefore a team sport, and has also been referred to as a "contact" sport, as so much of it revolves around personal contacts and personal interactions. Given that technology transfer must be a team effort in most cases, it is essential that the members of the team respect each other, as well as the investigators and their work, and that they work well together. There will certainly be people in the organization that "like to fly solo", but these people do not generally contribute as much to the technology transfer effort as others (Sacks, 1996).

As technology transfer is largely based on communication skills, experience and personal contacts, as well as technological knowledge, it is not easy to identify the best types of people for a technology transfer group. It is generally seen as beneficial to have people that are technically trained and who have also had personal experience in some aspects of technology transfer (eg. running a business, developing and licensing a product, taking out a patent, or developing and transferring a product of their own design). The ability to give technical presentations is also seen as very beneficial (Sacks, 1996). Other studies have reported that *highly qualified younger people, who were found to be especially effective in achieving a match between scientific and technological knowledge and market needs by capitalizing on their technological competencies and "relational assets"* were effective role players in technology transfer (not including the formation of spin-off companies) (Fontes, 2001).

Some of the more subtle, although very important, requirements in technology transfer are the ability to communicate in laymans terms with people unfamiliar with the field, the willingness and ability to strike up conversations with likely collaborators or licensees who may be total strangers, and the ability to see connections between people or organizations (and their technologies) and what they may be able to accomplish together (Sacks, 1996).

It is very important to understand the mindset of the client, the problems they are dealing with, the objectives they are trying to pursue, and then tailor the communication process in a way that presents the client with prospective feasible solutions. It is also very important to maintain the social equity of communications - ie. communication on equal terms (Pannell, 2003). The importance of effective communication processes with the industry should not be

underestimated. Research has clearly indicated that effective communication is as important, and in some people's views, more important than the information being communicated.

Knowledge-based organizations will have an increased emphasis on the relationship between technical knowledge and customer needs and wants. This means that marketing personnel will need to become more technically literate and technical personnel will be required to be become more people oriented (Earle, 1997).

Documentation is extremely important in any technology transfer activity. As the entire process depends upon contacts, discussions, agreements, the timing of events, especially inventions and the actions relating to them, it is absolutely critical that anyone involved in technology transfer be able to keep accurate, complete and reliable records. Furthermore, as these activities relate to money (or the prospect thereof), people tend to take them very seriously (and sometimes to court!) (Sacks, 1996).

Although the above skills and qualities are of very significant value to anyone involved in technology transfer, a number of role players with distinct responsibilities have been identified as being integral to successful technology transfer (Willis and Ashworth, 2002). These include the:

Researcher/Inventor

Researchers frequently perceive the exchange of information as not central to the work they do. However, they can enhance the transfer of technology by:

- Communicating the importance of the technology to an organization's representatives
- Transforming raw data into information useful to the target audience
- Being responsive to the input and suggestions by industrial sponsors
- Defining research goals clearly as obscure or vague project goals may cause disillusionment on the part of the organizations who expected more from a project than was possible.

Technology Transfer Facilitator

The technology transfer facilitator acts as an intermediary between the researcher and the receiver of the technology. In brief, the technology transfer facilitator:

- Takes care of the personal, organizational and cultural issues of recipients in order to achieve effective technology transfer
- Evaluates the environment for technological opportunities that could be translated into R & D projects
- Identifies a technology implementation "champion" in the receiver organization (see below)

- Emphasizes the relevance of the project to the industry's needs

- Demonstrates the relevance and usefulness of the research results

- Provides training sessions or seminars, and encourages potential implementers, users and researchers opportunities to interact

- Creates a climate in which problems/issues may be addressed and solved at an early stage

- Develops and implements the technology transfer plan

Technology "Champions"

Effective technology transfer requires a "champion" on both the sending and receiving ends of the process, although a champion is probably more important on the receiving side. Studies in the literature show that a primary breakdown point in the technology transfer process is not within the exchange of information, but at the point of implementation. The role of the implementer or technology champion is complex but this person would be responsible for:

- Ensuring that the Senior Management Team gains a better understanding of the technology transfer process, as support for innovation begins at the top

- Seeing that effective communication takes place early and continuously throughout the life of a project and emphasizes personal interactions

- Acting as the liaison between researchers and receiver organization employees

- Providing assistance with respect to implementation of the technology and training

In general, the champion is a person/team who understands technical aspects, who is familiar with human aspects and who can communicate effectively with the end users or the workforce. In a recent case study, it was reported that the most significant determinant of initial adoption of the new technology was the support of a champion, while the presence of an intra-departmental champion strongly influenced continued use (Pollard, 2003). It was also reported that surprisingly, intentions to use the new technology were the same for continued and discontinued users, leading to the conclusion that some discontinued users are in reality "stalled" users who should not be classified as rejecters of the technology.

Given the nature of short(er) tenure of senior staff in many industries in recent times, it would be prudent to identify a succession plan (i.e. a second champion) to fill the role and to ensure that the urgency or rate of technology implementation is maintained in case the original person is redeployed or leaves the organization. A recent case study within CSIRO has also highlighted the need for scientific (internal and external), commercial and executive *champions* to drive technology transfer processes (CSIRO, 2004).

While the above roles have been reported to be integral to successful technology transfer, the benefit of a technology transfer facilitator has emerged very strongly and recommendations have been made to promote such a role more strongly (Willis and Ashworth, 2002).

Perhaps analogous to the role of technology transfer facilitator, is a role referred to in the literature as the "gatekeeper". A gatekeeper is essentially an internal and external communication star. In general, gatekeepers are able to gather and understand external information, and they are then able to translate or de-code this information into terms that are meaningful and useful to people in their own organization. Therefore, gatekeepers should be strongly connected to external sources of information and networks, and at the same time have frequent communication with staff in their own organization (Harada, 2003). Translation between different (internal and external) scientific languages or coding schemes requires a special capability that is hard to obtain and therefore not common among an organization's staff. In the absence of gatekeepers, such external information searches and internal communication can be performed by different individuals. It may take several years to become familiar with an organization's different scientific/technical languages and therefore the translation capability requires a certain period of organizational tenure and experience (Harada, 2003).

Technology Transfer/Uptake - Case Studies

While detailed case studies of the processes involved in technology uptake by industry are beyond the scope of this review, a number of recent case studies are described below in outline, as these highlight a strong focus of technology transfer/uptake processes which critically depend on people contact and the establishment of social/personal relationships and trust between researchers and industry members.

(i) The Norwegian Food Research Institute

The Norwegian Food Research Institute (MATFORSK) has developed a program for effective technology transfer to small and medium sized (food) enterprises (SMEs) in Norway. The program is financially supported by the Norwegian Ministry of Agriculture and has an objective to improve innovation and competitiveness in food SMEs. An external evaluation of the program carried out after 2.5 years indicated that the program was one of the few government-supported food industry interventions with documented positive results (Baardseth et al. 1999).

In this program, companies are recruited directly through invitations or through seminars organized on specific topics of interest to the industry. The program is run as several individual projects (called networks) with each network consisting of 5-10 companies and 20-30 people and tailored to a particular branch of the food industry. Participants meet 3-4 times per year for workshops, reporting, discussions and exchange of knowledge and experiences. Each company pays a participation fee and covers the costs of their own labour resources, travel and so on. Each company is also assigned a "chaperon" (an expert with knowledge of typical problems in the particular branch of the food industry) that stays in close contact with the company during the network period, serving as an advisor and "key account" (Baardseth et al. 1999).

Good communication between supplier and respondent is critical for successful technology transfer. The literature on technology transfer has focused on equality (in terms of mutual respect and acknowledgement of each others competencies) as a basis for communication. When individuals communicate on equal terms, they more easily reach a state of mutual

understanding. This is often referred to as the reason why SMEs prefer to collaborate with customers and suppliers and are skeptical as to the usefulness of collaboration with researchers (Baardseth et al. 1999).

The lessons learnt from this program, from a "people focus" point of view are that active support from the management of each participating organization is the most critical point of success as well as getting the right people to participate. The role of the chaperon from the R & D organisation, who follows each company during the network period and gives support and advice, is of vital importance.

Companies have reported a number of positive outcomes from participation in this program which include improved communication with their managers. SME managers were also reported to be taking R & D more seriously, by working out R & D plans and strategies for their company. Furthermore they have been able to build cross-functional teams in their company (across sections and departments) and have increased their competence in systematic product development (Baardseth et al. 1999).

A very important outcome of this approach is the positive relationships established between the SMEs and the Norwegian Food Research Institute (Baardseth et al. 1999), with a resulting high likelihood that the SMEs will continue their relationship with the participating research institution(s).

(ii) The Showcase Centre for National Computational Innovation, USA.

This case study illustrates entrepreneurial behaviour within the US public sector. It involves a range of well-established, and large institutions, and widespread networking and alliance building. The Centre, launched in 1999, is part of an alliance of scientific institutions, including more than 50 academic, governmental and industrial organizations. The alliance was formed to prototype a 21st century information infrastructure known as the National Technology Grid, with key financial support coming from the National Science Foundation (Harris and Jackson, 1999). The alliance consists of teams that are building tools and applications for the Technology Grid and disseminating highly innovative computing and communications technologies to new audiences, as well as sharing and transferring knowledge across the whole alliance network.

A critical factor for success included the high level of inter-institutional co-operation in promoting knowledge transfer/uptake and innovation. Furthermore, the ability to work well together, as a team, in pursuit of a common vision was seen as the foundation upon which the venture was based. This was made easier in this case given that those involved had previous experience of working together, and knew and trusted each other (Harris and Jackson, 1999).

In addition to the management of team dynamics, emphasis was also placed by the Centre's team on managing relationships with the different academic, governmental and industrial organizations. Considerable *emotional* energy and relationship-building skills were viewed as essential. It was stated that such a venture takes 'lots of will power – you've got to pull people in' and that 'a tremendous amount of energy' is involved. The skills in team-building and relationship management, as well as the ability to secure appropriate resources and establish institutional support, were seen as central for such technological and organizational

innovations, even involving, and perhaps especially involving, large and established public sector institutions (Harris and Jackson, 1999).

(iii) Xerox Palo Alto Research Centre (PARC), USA

The importance of organizational "architecture" for a continuously innovating company has been reported in the case study of the Xerox Palo Alto Research Centre (PARC) (Brown, 1991). While PARC scientists in the 1970s had a technical vision, in the 1990s, anthropologists, sociologists, linguists and psychologists complemented PARC's traditional research staff of scientists, physicists and engineers, and the center is increasingly focusing on the interrelationships between technology and "work".

Doing 'original' research isn't enough – the research must be useful, appropriate and actionable by the industry. It must somehow influence the way business gets done, by improving a product, or opening up a new way to approach a process (Fillis, 2002). Research cannot just produce innovation – it must "co-produce" it by the development, with partners, of a shared understanding of why the innovations are important. Therefore, corporate research must prototype new mental models of the organization and its business (Brown, 1991).

An R & D organization's future competitive advantage will depend not just on selling information/technology products *to* customers. It will depend on co-producing these products *with* customers, by customizing technology and work practices to meet their current and future needs. Without giving up the focus on state-of-the-art technologies, Xerox PARC is also studying the human and organizational barriers to innovation (Brown, 1991).

One of the interesting lessons learnt from working with teams made up of people from both the R & D organization and the industry is just how long it takes to create a shared understanding amongst the members of such teams - a common language, a sense of purpose, and the definition of goals (Brown, 1991).

By learning how a company rejects certain ideas, Xerox PARC hopes to uncover those features of the corporate culture that need to change (Brown, 1991).

(iv) The Australian Cheese Technology Program (ACTP)

The ACTP was formed in 1995 and was originally a research coalition between Food Science Australia (CSIRO and DPI-V), the Australian Starter Culture Research Centre and the University of Melbourne. The broad objective of the Program has been to carry out research in order to improve the performance of the Australian cheese manufacturing industry by improvements in process efficiency, cheese quality and increased demand for Australian cheese in local and export markets (Sutherland, 1998).

Between 1995 and 2001, the ACTP put a very significant effort into extension activities with extension services (communicating to industry the latest research outcomes/knowledge in relevant and easily digestible forms) being one of the 3 streams of work within the ACTP.

Note: As the author was involved in the ACTP extension activities, the account of this case study has been confirmed by the current ACTP Director (Prof.B.A.Law).

The ACTP extension services included a quarterly industry-focused newsletter addressing known industry issues/problems, conducting industry days/workshops as well as carrying out some research trials in industry manufacturing plants. While the sustained communication and interaction with the industry over these seven years had positive outcomes with respect to disseminating research outcomes to the industry in a timely, relevant and useful manner, the most valuable outcome was the close relationships that developed between the ACTP researchers and the industry people. The exchange of knowledge was in both directions with the industry communicating their issues of concern on manufacturing matters and the researchers communicating research outcomes that may have helped to address some of the industry issues. The most effective communication was when the researchers were on-site at the industry manufacturing plants where all parties could communicate equally while addressing issues in a hands-on manner. Despite these excellent communication lines, the operations of the ACTP researchers and the industry remained separated.

During this period of time, the ACTP research team remained stable in terms of the staff involved, and for the most part, many of the industry people remained in the industry (albeit at sometimes different companies). The direct personal contacts/networks that developed were thus maintained for several years and, for the most part, are continuing. This has resulted in a high level of respect and trust between individuals over these years.

In 2001, the relationship between the industry players and the ACTP researchers took a large step forward with a restructuring of the ACTP that involved the companies becoming investors and stakeholders in the ACTP, with their involvement primarily at the business strategy level. Research tactical decisions are still made by the researchers, but they work strictly within a set of desired outcomes defined by the cheese business strategy. The ACTP also has the flexibility to bring in other resources (including researchers) to facilitate the best outcomes for the investing companies.

Research output/outcomes are presented by the ACTP researchers directly to industry, at industry plants via the *"roadshows"* which occur a number of times each year. This personal communication and interaction is maintaining and enhancing the direct communication lines between the ACTP researchers and the industry which has been demonstrated in the recent undertaking by the industry to continue their membership for a 3 year rolling period. As each company pays a significant participation fee to the ACTP, the relationship between the researchers and the industry provides a win-win situation for both parties.

The above case studies support the view that, although technical problems are often blamed for technology transfer failure, they can generally be easily overcome. However, if technology transfer is to be successful, the primary focus must be on the human and organizational factors (Willis and Ashworth, 2002).

Recommendations…..and *"take home messages"*

1. **Senior management commitment, encouragement and involvement, in terms of both financial and 'political' support for technology transfer, are critical.** There is a need to develop a culture supportive of technology transfer in a research organization, and a culture supportive of technology uptake and innovation within the industry. Senior management support is the most critical factor in the success of technology transfer/uptake.

2. **Skills needed for effective technology transfer** not only include knowledge of knowledge (i.e. scientific expertise), but also knowledge of people and organizational knowledge…***"Know how"***, ***"Know who"*** and ***"Know where"***.

3. **Involvement of industry at all stages of the innovation process to maximize the chances that the innovative product or process developed by the R & D organization will satisfy industry needs.** Inclusion of industry in the development process will also help to ensure the success of commercialization efforts.

4. **Long-term relationship building between R & D organizations and industry – on a personal level between individuals, to build trust and credibility in both directions is very important.** Industry will give trust to individuals and project teams, but they do not generally trust research organizations or universities. Networking on an *individual / personal* level (as opposed to an organizational level) should be encouraged as it provides effective (and usually longer-term) links between R & D organizations and industry. Individuals in such roles should ideally have scientific / technical knowledge and high-level relational (people) skills. They do not need to represent the paradigm of the independent, opportunistic, competitive entrepreneur, as a softer interactive relational approach and facilitative style to encourage participation and mutual empowerment has been shown to be effective.

5. **Communications processes must be on equal terms** and <u>not</u> one –way (i.e. just from the R & D organization to industry). Technology transfer activities should focus on the *mutual* benefit to both the R & D organization and the industry partner. There should be no winner and no loser, since good agreement is usually the beginning of a good (potentially long-term) relationship.

6. It has been reported that two-thirds of major technological changes in organizations fail because of **resistance to change**. Most of these failures are **due to *emotional* and not technological issues**. Resistance to change has also been shown to have a *cultural* component - when there is a past history of failure or problems, and strong organizational memory. *Effective* communication is very important to minimize such resistance to innovation/change. Development of a culture that accepts change as a *continuous* activity is a key factor in managing the diversity and innovation within a complex organization. Employees may look forward to change and innovation *if this is linked to a promising future.*

7. **Establish a framework to plan future research projects with final technology transfer objectives firmly in place.** Technology transfer objectives should form part of the project plan and should not be an *"add-on"*.

8. **Transfer/secondment of people is a very effective mode of technology transfer/uptake.** Transfer of people not only facilitates the effective uptake / implementation of the technology by industry, it also results in the transfer of *tacit* knowledge (informal knowledge which is not documented/codified…*"the way people do things"*). Tacit knowledge from an R & D organization to industry and vice-versa is a very valuable resource for both parties. Such people secondments, will also encourage the development of *personal* working relationships that have been shown to be important in the building of mutual credibility and trust between an R & D organization and industry (see item 4 above).

9. There are definite cases of a good innovation being lost or wasted through poor technology transfer mechanisms. If scientists/inventors possess weak communication, marketing and interpersonal skills, or *are perceived to be weak in these skills by industry*, partners to provide specialist communication, marketing, financial and general commercialization skills should be recruited. Such **cross-functional teams have been shown to be effective in facilitating technology transfer/uptake**. A team including people with skills in science (the inventor), communication, marketing, finance and including a Technology Transfer Facilitator and a technology implementation "champion", from both the R & D organization and from the company taking up the technology, would likely be very successful in implementing new innovations in industry.

10. It is the author's view that **the skills required within an R & D organization** (described above) for effective technology transfer **are currently available within Food Science Australia**. Several staff are involved in different aspects of knowledge gathering, marketing and industry liaison, but an increased focus could be put into coordinating these people/resources to maximize the effectiveness of Food Science Australia's technology transfer efforts. This could be achieved by the appointment (from internal resources) of a Technology Transfer Facilitator to form cross-functional teams with the required skills, and coordinate/facilitate the uptake of new innovations by the food industry. Food Science Australia would be ideally placed to become the *Technology Transfer Information Centre for the Australian Food Manufacturing Industry,* if there was such a need within the Australian Food Industry. Models for such technology transfer centres (eg. USDA) are available.

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Addendum

During the course of this literature review, several thousand references dealing with technology transfer/uptake were evaluated. An electronic database was established that contains approximately 800 specific papers/documents on different aspects relating to technology transfer from R & D organizations and technology uptake by industry. The database was set up using the *Procite* software system which is supported by CSIRO and is compatible with the CSIRO e-journal collection. The database is available to the Department of Primary Industries - Victoria, to Food Science Australia, and may be available to other interested parties, subject to agreement by the funding organization (DPI-Victoria).

About the author

Dr.Peter Roupas received his PhD from the Department of Medicine, Monash University, Melbourne, in 1988 and then accepted a 3-year Post-Doctoral Fellowship from the University of Michigan Medical School to continue his research in the USA. In 1991, he returned to Australia to take up a position within the Royal Children's Hospital Research Foundation in Melbourne. In 1996, Dr.Roupas joined the CSIRO Division of Food Science and Technology (now part of Food Science Australia) as a Project Leader within the Cheese Science and Microbial Biotechnology Section and the Australian Cheese Technology Program. He has completed CSIRO courses on "Developing and Maintaining Client Relationships" and "Managing and Leading Teams" and has had a primary role in technology transfer to the Australian Cheese Industry for the past 8 years – being the Foundation Editor, and the current Editor of the Dairy Australia / Australian Cheese Technology Program industry newsletter "Cheeseworks". He has been a primary organizer and member of the scientific committee of the international Cheese Science conferences held in 1998 and 2002, in the latter as Chair of the international Scientific Committee. Dr.Roupas was appointed by Elsevier Science U.K. as a Scientific Editor of the International Dairy Journal during 2002 and is a member of Australian Science Communicators, and the Society of Editors.

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