

# Centre for Technology Management

***Value Generation in Science and Enterprise:  
University-Industry Collaboration in the Case of  
CAMPATH-1***

Elizabeth Garnsey & Vivian Mohr

No: 2011/05, October 2011

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## **Abstract**

A key question in knowledge-based economies is how universities and industry can work together effectively. This paper identifies sources of difficulty in the interactions between scientists, entrepreneurs and corporations and suggest ways in which these could be overcome. Evidence is presented on the experience of scientists who sought to turn their findings into a useful medical innovation. Disparate theories of innovation in enterprise and science, are integrated in a conceptual framework which explains how value is generated when research findings are translated into use. Our evidence shows why collaboration difficulties are greater when the business collaborator involves a corporate laboratory rather than an entrepreneurial bio-firm.

## **1. Introduction**

A key issue in knowledge-based economies is how universities<sup>1</sup> and industry can work together successfully<sup>2</sup>. We explore this question by following scientists seeking to turn their breakthrough research into a useful medical innovation. The coming together of science and business has enabled important innovations. But although many major firms regard universities as a critical source of knowledge and skills and seek to strengthen their relationship with such outside parties under “open innovation” strategies, the relationship between academics and big companies is fraught with difficulties (Cyert and Goodman, 1997; Chesbrough, 2003). These occur even when academic researchers are strongly motivated to turn their discoveries into innovations, e.g. by generous revenue sharing arrangements. In this paper we investigate sources of difficulty in translation processes by comparing relations between academic scientists and entrepreneurial businesses with relations between scientists and big corporate collaborators.

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<sup>1</sup> We include under „university“ government funded research institutes such as the Medical Research Council Laboratory for Molecular Biology in Cambridge.

<sup>2</sup> For instance, several recent government reports stressed the relevance of such linkages, e.g. DTI, 2003; Lambert, 2003; House of Commons, 2006; Sainsbury, 2007.

Contrasting cultural values and conventions in science and commerce are often viewed as the source of difficulties that scientists experience in working with industry. But this explanation is imprecise and difficult to render operational in empirical research. Nor does it tap into incentive structures in the different spheres. In this paper we examine detailed evidence from a history of the long-term development of a breakthrough medical application, which involved a series of collaborations between medical research scientists and a variety of companies. We interpret this evidence by conceptualising creative activity as involving the generation and capture of diverse kinds of value and we apply the conceptual scheme to a case exemplar. Evidence from the case history is aligned with these conceptual constructs to reveal conflicts between the priorities and practices of scientists and those of corporate organisations. Creative affinities are found between the scientists and the smaller entrepreneurial businesses with which they collaborated. The conceptual scheme throws light on the sources of collaborative difficulties for research scientists and their corporate partners and suggests some solutions.

## **2. Theoretical Development**

In this section we review prior work on university-industry links and go on to survey the literature on value creation in science and enterprise, connections between which have previously been overlooked.

### ***2.1 Prior Research***

Despite far reaching roots, research on university-industry links is a relatively new and rapidly evolving field (Plewa, Quester and Baaken, 2006). In the 1970s, the National Science Foundation was calling for stronger links between commerce and academia. With increasing emphasis by business and government policy makers, management and organizational scholars have taken increasing interest in university-industry collaborations (Lee, 1998; Shane

and Stuart, 2002; Plewa, Quester and Baaken, 2006). Scholars of university-industry links have pursued multiple threads of enquiry (Table 1).

**[Insert Table 1 about here]**

One stream of research has been on university policies on links with industry and the impact of these interactions on academic work (Steenhuis and De Bruijn, 2002). A central concern is that academics involved in commercial research may shift their focus towards applied rather than basic research and patenting rather than publication, but there is little evidence to support these concerns (Murray and Stern, 2007; Buenstdorf, 2009; Rosell and Agrawal, 2009).

A way in which universities can directly commercialise their knowledge is through the formation of spin-out firms. This has attracted much attention, including research on spin-out formation, the characteristics of spin-outs founders and the nature of technologies commercialised by spin-outs (e.g. Shane and Stuart, 2002; Nicolaou and Birley, 2003; Lockett, Wright and Franklin, 2003; Lockett and Wright, 2005). An extensive review of this work is provided by Djokovic and Soutaris (2007).

Management research stresses the importance of access to academic knowledge to maintain a firm's competitiveness in fast changing environments and the difficulties of such collaboration (e.g. Perkman and Walsh, 2007; Harryson, Kliknaite and Dudkowski, 2007; Burnside and Witkin, 2008).

Several scholars have investigated the university-industry-government triad and policies aimed at improving these relationships (Dzisah and Etzkowitz, 2008).

Detailed evidence on cooperation between enterprises and academics is still scarce (Lee, 2000; Plewa, Quester and Baaken, 2006). Among the most useful work is that of Zucker and others who have highlighted the role that 'star scientists' play in bridging science and

enterprise (Darby and Zucker 2001; Zucker *et al.* 2002). Contributions focusing on university-industry linkages have highlighted cultural differences between the realms of science and industry that follow from the institutional separation of these two areas (e.g. Cyert and Goodman, 1997; Plewa, Quester and Baaken, 2006).

Culture is, however, a very broad explanatory variable and is difficult to operationalise through empirical research. In the following, we focus more closely on certain elements of culturally influenced behaviour – the practices of the various actors involved in university-industry linkages – as a basis for our conceptual model. We build a conceptual framework to summarise innovative activity in science and business enterprise and apply this to a case exemplar which provides empirical evidence corresponding to our conceptual constructs. This enables us to draw generalisations from our findings.

## ***2.2 Creative Processes in Scientific Research***

The culture of science reflects efforts to separate science from the pressures of commerce (Merton, 1942). Science and technology have nevertheless been closely linked, with commercial problems providing a stimulus to scientific research (Rosenberg, 1994). In what follows we draw on evidence that science is in key respects a form of enterprise, and go on to show that innovative practice in science has important similarities to innovative business enterprise.

### ***2.2.1 Scientific Opportunity***

Just as enterprise fills unmet needs in the web of exchange, so gaps and anomalies in the web of knowledge are stimuli to scientific work on the natural world. In both cases gaps provide opportunities. A phenomenon that is not understood is a scientific challenge and an opportunity. “Questions which are initially raised in a special context have a way of raising new questions of much greater generality” (Rosenberg, 1994, p. 261). Scientists often

advance knowledge through the juxtaposition of apparently diverse frames of reference, as where Darwin combined Malthusian theory with his observational evidence. Many advances occur at the intersection of disciplines, just as they do at the intersection of technologies in industry.

In science, experimentation, intuition and chance together lead to the discovery of new analogies or contexts for knowledge and the rearrangement of ideas into a new pattern of thought (Koestler, 1964). Many of the features of thought identified by Koestler are to be seen not only in creative discovery and invention in science, but among entrepreneurs who find a new way out of an impasse by reconfiguring their ideas for a new product, a new technology or a new channel to market.

The timing of opportunities is important in science, just as it is critical in business. Scientists succeed when they address problems ready for solution. Timing is critical as competing teams are likely to have detected the opportunity (Watson, 1969). Secrecy often prevails in the laboratory while the race is on to achieve a contested scientific breakthrough, no less than in the business enterprise prior to a product launch (von Stackelberg, 1934; Watson, 1969).

### *2.2.2 Resources in Science*

The advance of scientific knowledge depends in part on the resources available to the scientist. Like entrepreneurs, scientists often run short of resources and must economise and gain leverage from those they have. Resource constraints can stimulate innovation<sup>3</sup>. Scientific breakthroughs have often been achieved with teams facing resource constraints, which encourage unconventional methods. Moreover, scientists are adept at recognising new resources in what has been overlooked – often in waste. Fleming was alert to the remarkable properties of the contaminant which ruined one of his experiments; though it was many years

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<sup>3</sup> For example, astronomers used the world's most powerful radio telescope to search for and discover an unknown pulsar with planets in an 'unpromising' direction while the telescope was under repair and immobilised (Aczel, 1998; Dyson, 1999).

before the commercial potential of the mould he called penicillin was realized (Hobby, 1985; McKelvey, 1996). Petroleum was a waste product of kerosene production, identified as a resource by chemical analysis and intuition before being exploited by entrepreneurial innovation (Rosenberg, 1994).

### *2.2.3 The Resourcing of Research*

In many areas, scientists require costly resources and must raise the equivalent of major capital to proceed. Whereas discretionary science conducted by small groups tends to be entrepreneurial, over the past century, expenditure on science has moved beyond small labs and small entrepreneurial teams of scientists to large established laboratories and large managed projects, where science is managed like big business (Franklin, 1988). These projects have become organised on a massive scale and financed by highly regulated research trusts and councils (Aszodi, 2007). Just as there is a rationale for managed innovation in large corporate R&D units with extensive funding, so are arguments mounted for economies of scale in big science (Pavitt *et al.*, 1987). Certain findings suggest that there are diminishing returns to size in the organization of science as in business and that some features of the management of large laboratories are said to be bad for research (Franklin, 1988). Commentators point to the decline of scope for initiative by scientists in managed labs (Dyson, 1999). As with the trade-off between size and flexibility in business, economies of scale in science achieve benefits, but at the cost of reducing innovative diversity (Fiegenbaum and Karnani, 1991).

Scientific research benefits from well-managed and methodical procedures. But it is hard to plan or estimate the time required to realise a scientific opportunity or where unexpected opportunities for breakthrough may emerge as theory is confronted with experimental evidence. Entrepreneurs also face uncertainty and proceed through business experiments of another kind.

#### *2.2.4 Enlisting Others*

Networks and partners are essential to success in science, as in business enterprise. Modern science is a collective effort with learning taking place in research teams and the wider network (de Solla Price, 1986; Oliver, 2004). The network provides not only resources but also the basis for propagating new discoveries and recognition (Oliver, 2004). The difficulty scientific outsiders like Elaine Morgan or James Lovelock in gaining recognition for a key idea can be contrasted with the advantages of insiders (Lovelock, 1989; Metcalfe, 1998). The successful scientist builds a research group of members who share a common intellectual outlook and way of working, the equivalent of the entrepreneurial team.

Key scientists, those who make the bulk of scientific discovery, assume a central position in scientific networks (Kuhn, 1962; Koestler, 1964; Zucker *et al.*, 1998), as do leading entrepreneurs in the business world. Star scientists have “skill in locating those ideas in the fabric (of science) that have the potential for setting off domino-like chains [...] and the ability and energy to make those repercussions explicit” (Buchanan, 2000, p. 183; Rosen, 1981). Star scientists not only activate scientific networks but link science and industry (Zucker *et al.*, 1998). These scientists used persuasive tactics (termed “translations” by Latour) to make their case to outside resource providers that they could meet their own goals better by meeting the scientist's needs (Latour, 1987, p. 113). Patronage by reputable partners can have a major impact on funding availability in science, just as venture capitalists’ or corporate endorsement can promote the success of the new venture (Maula, Autio and Murray, 2005; Nicholson, Danzon and McCullough, 2005; Gompers and Lerner, 2006).

#### *2.2.5 The Selection Regime in Science*

Whereas new firms face competitive selection pressures in the economy, scientists face their own selection regime. For research findings to achieve the status of knowledge they must survive a series of selection mechanisms<sup>4</sup>. These are different from the selection processes of the market that award or deny resources to business entrepreneurs, but a form of evolutionary selection operates in both spheres. This type of evolutionary process is not 'blind' since in the human sphere human actors can recognise and influence the selection regime to which they are subject. Findings must be robust enough to achieve the validity and replicability required for peer endorsement, and dissemination through peer review in gate-kept journals and leading conferences; these play a role similar to that of institutionalised bodies regulating trade and industry. Once endorsed, scientific findings go through a lengthy process to achieve the status of undisputed facts (Latour, 1987). A few scientific discoveries have disproportionate significance, just as key innovations have knock on effects (Buchanan, 2000). Though the primary motivation is to achieve new understanding, there are many secondary rewards for scientific success: reputation, grants for further research, awards, power, and remuneration. These rewards fuel the knowledge-generating cycle.

We turn now to orientations and practices associated with innovation in business enterprise. This is an area of inquiry that has received extensive attention in recent years. Our approach involves a new focus on value creation and capture as creative processes embodying orientations and practices that have features in common with those of innovative science. Key similarities are summarised in figures one and two.

### ***2.3 Creative Processes in Business Enterprise***

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<sup>4</sup>The rigour of the selection processes applied to scientific knowledge is striking in comparison with neoclassical economics which does not allow of empirical disproof. Neoclassical economic theory cannot incorporate the entrepreneur except as an exogenous factor because this would disturb the consistency and coherence of the integrated neoclassical model of resource allocation (Baretto, 1989). In contrast, Kepler forced himself to respond to evidence. He abandoned nine years of labor on a coherent theory of the rotation of planets in concentric circles around the sun because observation showed that the theory did not fit the evidence by eight minutes of an arc. This attention to evidence led him to understand that the earth's orbit is elliptical (Koestler, 1964, p. 130).

### *2.3.1 Value Creation through Entrepreneurial Ventures*

The idea of value generation through enterprise is more familiar than the application of this notion to science. Definitions of entrepreneurial activity usually emphasise the recognition and exploitation of opportunity (Shane and Venkataraman, 2000; Shane 2000; Eckhardt and Shane, 2002). This should not divert attention from the ingenuity entrepreneurs exert to resource their venture (Garnsey, 2004). Indeed an early definition emphasised that entrepreneurs are those who pursue opportunities even when they do not control the resources needed for exploitation (Stevenson and Jarillo, 1990).

Entrepreneurs usually have to enlist others in support of their venture (Hugo and Garnsey, 2005). To enrol resource-providers without becoming subservient to them, they offer resource-providers a stake in prospective returns (Drucker, 1985; Packer, 1985). Attempts to minimise dependence while obtaining needed resources encourage networking (Redding, 1997; Reynolds and White, 1997). Resource constraints both limit and enable enterprise, restricting obvious options but encouraging new thinking outside conventions (Hugo and Garnsey, 2005; Koestler, 1964).

Entrepreneurs are credited in the literature with coordinating resources and reallocating them from less to more efficient uses (Casson, 1982; Schumpeter, 1928). But entrepreneurs also create new economic resources (as scientists create new knowledge). They frequently put to use factors not currently recognised as valuable, moving unused, disused or untraded resources into the economy, just as scientists recognised value in waste products like penicillin (Best, 2000)<sup>5</sup>. They enlist unpaid help from family and friends, recruit neglected talent and find ways to convert knowledge into economic resources (Redding, 1997; Reynolds and White, 1997). Faced with insufficient resources to purchase inputs, or unable to find solutions in the market, entrepreneurial firms develop in-house solutions to create resources.

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<sup>5</sup> Often entrepreneurs move activities into the markets which were previously carried out in the household, laboratory or community. But only if those who need the newly monetized services have purchasing power or are subsidized (e.g. by advertising revenue or grants) or provided with credit arrangements will innovations be profitable.

Value creation gives rise to output more useful than resources expended to produce it. For entrepreneurs, creating value for users is what makes it possible to capture returns from value (to appropriate rents). Value creation is what enables entrepreneurs to enlist the support they need for their venture<sup>6</sup>. Combining resources, creating resources, finding ways to reduce resource requirements and gaining leverage are connected forms of problem solving (Hugo and Garnsey, 2005; Koestler, 1964). They are ways of minimising uncertainty and dependence on others while obtaining the resources needed for a value-creating activity. As attempts are made to access, mobilize and create resources, it is necessary to innovate with the resource mix, to enlist new partners, to find new routes to market and to target new customers. Because resource-constrained entrepreneurs are so often thwarted, the entrepreneurial process moves beyond a simple circuit into iterative attempts at problem solving (Hugo and Garnsey, 2005). If output cannot be sustained, entrepreneurs reconfigure their resources and search for opportunities using a different organisational base. Figure 1 illustrates the experimental mode of operation of the entrepreneurial problem-solver.

**[Insert Figure 1 about here]**

### *2.3.2 Value Creation by Established Companies and the Paradox of Enterprise*

Successful exploitation of an opportunity through value capture enables firms to pursue further opportunities. Reinvestment of captured value enables firms to overcome the liability of newness. They can thereby realise further growth in their chosen market and address other sectors and segments (Stinchcombe, 1965). However, realising further scale effects from an expansion of operations requires standardization of formerly flexible processes. Increasing complexity as a result of multiple markets and scaled-up operations requires the establishment

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<sup>6</sup> The concept of value, its creation and its capture is broad and contentious in the literature but for our exploratory purposes, a standard 'accounting' approach is sufficient (Lepak et al., 2007). It is usually measured in terms of the payment received or expected. A key question is: Value for whom? Bowman and Ambrosini highlight this by distinguishing between 'use value' and 'exchange value' (2000).

of centralised coordinating functions (Weber, 2006). In an effort to reduce complexity, departmentalisation occurs. With the need for coordination, new levels of hierarchy emerge and managers are concerned with enforcing endorsed procedures (Dougherty and Heller, 1994). Previously entrepreneurial organizations introduce penalties for unendorsed innovation (Jackson and Dutton, 1988). An organisational bureaucracy aims to protect a firm's established resource base and existing revenue streams, reputation and market position. These developments give rise to different orientations and practices between entrepreneurial ventures and established firms, with managers increasingly assuming a stewardship role for a firm's resource base (Stevenson and Jarillo, 1990). Key differences between entrepreneurial ventures or young businesses and established corporations, as they relate to this theme, are summarised in table 2.

**[Insert Table 2 about here]**

By the 1970s, the performance of large corporate research labs in bringing forth market-ready innovations was in question (Florida and Kenney, 1990). Along with deregulation and the break-up of the monopoly position that had underwritten extensive R&D, capital markets were increasingly focused on share price, and top managers faced stronger incentives to attend to value capture to boost current share performance. Corporate boards questioned how much of the research that was taking place in corporate labs was actually being implemented in new products, processes and services. R&D had from the 1940s been set apart from the commercial divisions of the company, ostensibly to ensure high scientific standards. But many such labs were no longer addressing the applied problems that had earlier stimulated creativity in commercially focused labs (Garnsey and Wright, 1990). Innovations that enlarged existing markets were occasionally made by existing companies (e.g. float glass technology at Pilkington, MRI scanners at EMI), but few competence-and market-displacing

innovations were emanating from the corporate R&D process. These trends threw into question Schumpeter's proposition that the torch of innovation had passed from entrepreneurial to corporate players (Kenney, 1986).

We turn now to scientific endeavour and find, despite more obvious differences, key similarities between innovative scientists and entrepreneurs and contrasts between the practices of scientists (the way they go about their work) and those in large established firms.

#### ***2.4. Science as Enterprise***

We can summarise our findings on the commonalities between innovative science and business enterprise as follows. At first sight, nothing could be further from the experiments of business entrepreneurs than the pursuit of new scientific knowledge. But on further inquiry, there are striking parallels between the outlook and practices of innovative scientists and entrepreneurs, just as there are striking differences between these two and already established firms. Innovative entrepreneurs pursue their business conjectures in ways that resemble the exploratory methods of science. Scientists pursue opportunities to make a breakthrough in the web of knowledge, as business entrepreneurs respond to gaps in the meeting of market needs (Kuhn, 1962; Freeman, 1982). Scientists, like entrepreneurs, are resource constrained and find all manner of ways to economise on and gain leverage from the resources at their disposal. They attempt to plan and control their experiments, but in the face of uncertainty and resource shortage, they improvise, explore and probe. In contrast, corporations place less emphasis on experimentation, focusing on preserving their already established resource base.

Corporations prioritise the capture of returns from value, sometimes created elsewhere. Scientists create value in the form of new knowledge and obtain returns – the students, grants and resources needed to advance their knowledge-building project further. Science and business enterprise alike are subject to evolutionary selection pressures. Major breakthroughs are rare (Kuhn, 1962; Dougherty and Heller, 1994). Just as a few entrepreneurs have

disproportionate impact on the economy, rare scientists make significant discoveries (Kuhn, 1962; Koestler, 1964; Zucker *et al.* 1998). Innovative scientists and entrepreneurs alike have an unconventional outlook but it is essential for them to enlist others if they are to have influence.

These parallels between innovative scientists and entrepreneurs are not coincidence but result from the extent to which both are creative thinkers, networkers and disturbers of the peace. Both scientists and entrepreneurs creatively combine different matrices of thought to resolve problems they encounter. The common characteristic of these forms of creativity is not simply the pursuit of opportunity, but the attempt to engage in some new activity to create value.

There is an obvious contrast in the rewards that drive the efforts of those in science and those in business enterprise. Unlike scientists, businesses seek profits as reward in itself and for the recognition it affords. Nevertheless, for many entrepreneurs, experimenting, organising a worthwhile new activity, achieving independence or “power, prestige, public approval, or the mere love of the game”, are no less important than amassing wealth (Penrose, 1995, p. 30)<sup>7</sup>. While entrepreneurs and scientists resemble each other, their priorities differ from those of established firms, where there is pressure to exploit rather than to explore, to appropriate value rather than to create value in new ways.

The creative cycle in science involves building resources that make it possible to engage in experimental activity, the scientists’ version of productivity activity (figure 2). It can be seen that the value creation cycle has much in common with that of the entrepreneurial firm (figure 1).

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<sup>7</sup> Many forms enterprise are motivated by returns other than market rewards. Social and civic entrepreneurs initiate innovations in social and community life. Providing value to others is their primary aim, rather than a means to secure economic returns. But these pioneers also need to capture returns of some sort if they are to sustain their innovation. In a survey of about 400 British high tech entrepreneurs, while a third were motivated by the prospect of financial reward, over half were motivated by the prospect of independence and of doing something worthwhile. This sample includes relatively large numbers of older, larger companies and two thirds of the 2000 approached did not respond. But it shows the variety of incentives motivating entrepreneurs (Whittaker, 1999, p. 73.)

**[Insert Figure 2 about here]**

The creation and propagation of knowledge is an iterative process analogous to the entrepreneurial cycle of value creation and capture. To obtain the necessary resources for innovative science requires that innovators overcome obstacles along the course of the scientific career and the grant proposal process. Scientific research creates value in the form of new knowledge. But to gain authoritative endorsement is no less difficult than the entrepreneur's task of reaching customers, and as often requires collaboration and partnerships. Scientists who secure returns from knowledge creation can use these returns to strengthen their position, gain further resources and extend their base for further research aimed at the creation of new knowledge – the underlying driver of innovative scientists.

In the following case study we trace the activities of scientists who sought to move their discoveries into use as innovations. We propose that the difficulties they had working with large corporate partners were not simply the result of commercial as opposed to scientific culture and priorities, though these existed. We explore the contrasts between their experience of working with teams from entrepreneurial business and with large pharmaceutical companies.

### **3. Methodology**

Our purpose is not to test existing theory but to provide a conceptual framework to elucidate translational processes from science to industry. Organisational phenomena unfold as complex and dynamic processes which can best be conveyed in a case history which provide rich and revealing accounts of a phenomenon (Scott, 1974; Katz and Kahn, 1978; Yin, 1989; Eisenhardt and Graebner, 2007; Siggelkow, 2007). Single cases are not designed to be representative but to be of theoretical interest. They can provide exploratory information or insights into constructs and relationships (Yin, 1994; Siggelkow, 2007). Siggelkow notes

that “getting closer to constructs and being able to illustrate causal relationships more directly are among the key advantages of case research vis-à-vis large sample empirical work” (2007, p. 22). While statistical generalizability is a central concern for theory testing, single-case designs have been fruitfully employed for exploratory analysis and analytical generalisations (e.g. Weick, 1995; Penrose 1960; Plowman et al., 2007). In this context, Eisenhardt noted that: “with fewer than 4 cases, it is often difficult to generate theory with much complexity, and its empirical grounding is likely to be unconvincing unless the case has several mini-cases within it” (1989, p. 545). Ours is such a case – consisting essentially of five mini-cases, bound together by the journey of the underlying technology. Conceptual constructs obtained through single cases can subsequently be explored through multiple case studies and larger-scale quantitative analysis (Eisenhardt, 1989; Van de Ven and Poole, 1989).

When theory building rather than theory testing is the aim “it is often desirable to choose a particular organization precisely because it is very special in the sense of allowing one to gain certain insights that other organizations would not be able to provide” (Siggelkow, 2007, p. 20)<sup>8</sup>. A single case study of an innovative project from the pharmaceutical industry is used here to explore and enrich our proposition that science and enterprise represent common creative processes. Our focus is on the interactions in which scientists engage and the innovative companies with which they work to commercialize their research findings. Accordingly, our unit of analysis for the case study is the innovative scientific project, “the new unit of analysis”, that transcends organizational and ownership boundaries and can help explicate the impact of dynamics at these levels on the overall commercialization process (Edvinsson, et al., 2001, p. 40).

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<sup>8</sup> One interviewee noted: “if you look into the antibody [CAMPATH] and understand the history [of it], you sort of understand the history of monoclonal antibody technology at large.”... It was also pointed out that “probably more products are developed like CAMPATH than the one’s where from day one you take exactly where you want to take it, it is being developed by one sponsor that is taking it all over the goal line, whereas CAMPATH I think is a great example of an antibody which is early technology, you really have to try to understand the different uses, you really have to keep going to do a clinical trial of different approaches and as a result – the results are there...”

We investigate evidence from this project using the lens of the two constructs central to our conceptual framework – entrepreneurial orientation and practices. To align the conceptual model with evidence, these constructs were operationalised by indicators from case evidence. When priority was accorded to the pursuit of opportunities, this was identified and coded from the case evidence, as was resource flexibility and resource creation.

**[Insert Table 3 about here]**

The pharmaceutical industry offers a rich context for this type of inquiry, as specific technologies are vital for the economic performance of a pharmaceutical company. Since the end of the Second World War, knowledge in the life sciences has been expanding apace and corporate have been struggling to keep up with scientific advances (Nichols-Nixon and Woo, 2003; Changsu *et al.*, 2007). Earlier outcomes from scientific research had lowered barriers to entry. Rapid advances in the pharmaceutical industry had been underpinned by extensive government spending on both universities and corporate labs (Mowery and Rosenberg, 1998; Gilsing and Noteboom, 2006). From the 1970s important innovations based on genetics and advances in biotechnology were emanating from small university spin out companies, not from well resourced corporate labs (Gilsing and Noteboom, 2006). These new technologies constituted a technological shock to the industry, challenging incumbent pharmaceutical corporations to reconfigure their capabilities and/or to integrate new technology resources (Nichols-Nixon and Woo, 2003; Gilsing and Noteboom, 2006; Hopkins *et al.*, 2007; Rothaermel, and Thursby, 2007).

The case of monoclonal antibodies for therapeutic use provides a dramatic illustration of these developments. While monoclonal antibodies are nowadays an established technology with some 21 FDA-approved antibodies and several hundred in clinical trials, the fate of this technology was much less certain at the outset of the 1980s, the entry point of our study

(Waldmann, 2003; Reichert and Pavlou, 2004). The FDA approved its first monoclonal antibody (Muromonab-CD3) for clinical use only in 1986, more than a decade after Köhler and Milstein's breakthrough discovery. Major pharmaceutical corporations showed a reluctance to engage with this innovation (cf. Abernathy and Utterback, 1988; Bower and Christensen, 1995). Moreover, the case of monoclonal antibodies, advances in scientific knowledge had applications developed by new companies far from the research lab in which they originated. This brought to the fore new issues for the transfer of knowledge to practice, including the regulation of intellectual property originating in university research. We describe the developments and issues occurring in the case of CAMPATH-1, the world's first fully humanised monoclonal antibody.

Qualitative research such as case studies operates within the inductive and interpretative tradition (van Maanen, 1998). Walsham argues that the most appropriate method for interpretative research are face to face interviews (1995), which provide an important source of evidence here. Patton (1990) and Greenhalgh (1997) note that for interviewee selection researchers should deliberately seek out individuals "who fit the bill" to obtain an in-depth understanding of participants' experience. Ideally, multiple interviews with knowledgeable actors who are able to view the phenomenon from a variety of perspectives can provide triangulation of insight (Eisenhardt and Graebner, 2007).

Evidence for our case study of CAMPATH was obtained through 15 interviews (4 with the key medical scientists, 11 with industry participants), documents and archival records. Initially, extensive archival records and documents (e.g. press releases, photographs, contemporary statements of actors) were obtained from multiple sources, including contemporary press databases, scientific journals and regulatory announcements. This public domain material was subsequently combined into an initial case study based on secondary sources, to inform our interviews. We conducted twelve semi-structured interviews with participants who had been centrally involved in the development and commercialisation of

CAMPATH, which elaborated on the developments from their perspective and provided access to additional documents from their private archives. Several interview partners had taken on new roles, as venture capitalists, academic founders of start-ups or full-time entrepreneurs, accordingly their involvement with CAMPATH provided multiple perspectives on their part. These interviews, which occurred in the participants' natural settings, sought to elicit interview partners' experience of events, while the contemporary records provided a cross-check on retrospective sense-making by interviewees (Eisenhardt and Graebner, 2007). Our detailed case history was reviewed by key informants and by peers to check (Geertz, 1973). We present a summary of this evidence in the subsequent section.

#### **4. The Case of CAMPATH-1**

In 1975, Köhler and Milstein made their breakthrough discovery of a technique for the production of monoclonal antibodies that would form the basis for modern biotechnology and earn them the Nobel Prize (Köhler and Milstein, 1975). While many contemporary observers hailed Köhler and Milstein's discovery as an important scientific advance that opened up new opportunities for medical research, a visiting researcher in Milstein's lab at the University of Cambridge – Herman Waldmann – recognized the potential of the technology for developing treatments for some of the most pressing diseases and proposed to realise it. Building on the discoveries of the Milstein group, Waldmann established a research group with funding by the Medical Research Council (MRC). Scientific creativity of a high order was shown by individuals among the group, as well as in collaborations with other research groups, enabling Waldmann and his newly formed group to identify a cell line producing a monoclonal antibody showing strong effects in the patients suffering from graft-versus-host diseases. Since the origin of this work lay in the Cambridge Pathology department, the researchers named the cell line CAMPATH-1.

*“Early on we wanted to see what the opportunities were. We decided on bone-marrow transplantation as a first step, because clearly there were ways of doing things in the test-tube with cells from a person that didn’t necessitate putting the antibody into the person.”*

Though they did not believe they were legally obliged to do so, the researchers felt that it was appropriate for them to offer intellectual property rights to CAMPATH-1 to the (then government-owned) British Technology Group (BTG). Initially limited by the absence of any formal technology transfer practices and revenue arrangement at the University of Cambridge, the researchers worked with an experienced colleague, and an office that was later to take on the university’s technology transfer function, to develop new practices. The scientists felt that official technology transfer arrangements might help them in reaching patients with a new medical entity:

*“We, on the basis of our MRC funding, wanted to do the right thing to satisfy the MRC and to help what we found develop. And it seemed making contact with [...] BTG was the right way to satisfy perhaps the unspoken need perhaps, no one quite told us, but it meant we might have a technology partner who might help us interact with industry.”*

The rights to CAMPATH-1 were licensed in 1985 to Wellcome Biotechnology, a small, relatively autonomous subsidiary of Wellcome, a major pharmaceutical corporation (nowadays part of GlaxoSmithKline), charged with exploiting opportunities in the still emerging biotechnology industry. Wellcome Biotechnology was well received as a partner by the researchers – the company was well resourced and had developed a strong reputation in the area of biotechnology.

The cooperation with Wellcome began promisingly. Upon licensing CAMPATH-1 (later renamed CAMPATH-1M) from BTG, Wellcome Biotechnology initiated an extensive clinical

development programme to exploit CAMPATH in different target markets. The researchers and management of Wellcome Biotechnology had established good working relations amongst themselves. The effectiveness of the ties between Wellcome Biotechnology and the Waldmann group was evidenced when the researchers achieved an important improvement in CAMPATH-1M. Recognising the potential for improved value creation, Wellcome Biotechnology obtained the license for the improved antibody, CAMPATH-1G, from BTG, halted its studies on CAMPATH-1M and began clinical studies anew, viewing previous expenditures as an investment in learning.

*“We didn’t know how much it cost. [...] By the time they had worked up the IgM for bone-marrow transplantation as a commercial idea we had already swapped to the Ig2b antibody. And so they then made the decision to swap to the rat Ig2b so [...] their programme of development was put back to begin again. And before they had a chance to essentially get the commercial test production and testing of the rat Ig2b completed, we had humanized it, so they had to go back to square one again and to start work on the humanized version. So to some extent it was quite a difficult situation to try and manage because I think there were some people within the company and also some people within [...] [BTG] who seemed to resent the fact that academics were going off and making improvements to a product. It was [...] like we were moving too fast.”*

The asynchronies between the rate of advance of the science in the Cambridge labs and development work at Wellcome became a source of tension when Wellcome took the decision to reintegrate Wellcome Biotechnology into the larger organisation. Part of this reintegration was a new emphasis on realising the value potential of the new clinical studies.

*“We hadn’t entertained in our own minds what development meant. [...] [A]t some point [...] our pharmaceutical partners had [...] entered into a program that they called “development”. And that meant the original antibody they had from us was the one they wanted to work with, whereas our motivation was to always stay ahead of the game and improve.”*

Researchers at the Waldmann group were still eager to support the further development of the antibody but found it increasingly difficult to cooperate with the larger organisation.

*“You couldn’t get transfers across at a scientist level, you actually had to go through a higher managerial level in order to get communication of ideas, which to us as academics was really a difficult one to grasp. Because we would be solving purification problems, passing the information over and then a few month later discovering that the company was still having a purification problem - which we had already solved and had already told them the solution of. But we told the wrong people in the organization and the message hadn’t got through to the right people in the organization.”*

Problems over development at Wellcome arose from the continuous efforts of the Waldmann group to improve the antibody for patients. From clinical studies with volunteer, terminally-ill patients, it had emerged that patients were developing an immune response to the antibody in use, which had been derived from rats. This response significantly limited the antibody’s application in clinical treatments.

*“Effectively it gave you a very short window of therapy. And so if your therapy didn’t work in that natural window it was nullified. So you just had like a one-shot therapy. [...] You*

*couldn't even swap to a different antibody. [...] A rejection of one antibody would be a rejection of all antibodies effectively.”*

Seeking to broaden the applicability of the treatment and thus value to patients, the researchers adopted multiple search strategies to obtain a humanised version of the CAMPATH antibody. Eventually, the Waldmann group collaborated with the research group of Professor Gregory Winter at the MRC Laboratory for Molecular Biology, which had made pioneering developments in the area of antibody engineering. Collectively, the groups developed a humanised form of CAMPATH-1, named CAMPATH-1H, the world's first humanised monoclonal antibody. This improved antibody not only opened up new areas of research but also outperformed previous versions of CAMPATH. However this created new problems of asynchronous development paths:

*“Their development programmes were much slower than our research programmes and so by the time they had completed the development our research had moved several levels further on and we had actually identified a far superior product.”*

As with previous versions of CAMPATH, the Waldmann group made the humanised form of the antibody available to Wellcome. Their initiatives met with criticism. Wellcome recognised the significant improvement of CAMPATH-1H over CAMPATH-1G yet was concerned that the product eliminated most of the progress towards value capture that they had made in their studies with CAMPATH-1G. Wellcome lawyers threatened legal consequence if the results of the studies on the humanisation of CAMPATH were to be published. The scientists resisted these pressures, publishing the results in *Nature* in 1988.

Indeed, Wellcome managers eventually took on the new technology, initiating clinical trials for CAMPATH-1H, focusing predominantly on applications in the area of rheumatoid

arthritis. These tests produced poor results in the area of rheumatoid arthritis but promising results in untargeted diseases such as chronic lymphatic lymphoma. The initial aim at Wellcome to capture the rheumatoid arthritis market had thus become less feasible. At the same time, the growing prominence of AIDS made managers at Wellcome very wary of therapies that suppressed patients' immune responses even though these could reduce rejection responses to interventions such as to bone marrow transplants. It was believed that the immuno-suppressant features of CAMPATH might damage Wellcome's reputation. This risk was felt to be greater than any benefit Wellcome might achieve by taking the development programme further. The decision was taken to abandon CAMPATH and return the license to BTG in 1994.

Wellcome's decision to abandon the product because of its immuno-suppressant effects was understandable at a time when there was much publicity around the way the AIDS HIV virus infected its host by suppressing the patient's immune system.

*“There was a fairly extensive commercialisation search and we had a lot responses of the basis of ‘CAMPATH kills people’-type of response.”*

The scientists working on CAMPATH believed, however, that the HIV analogy was not pertinent. Some of the terminally ill patients would not have survived regardless of CAMPATH. Although it was “a major blow” that Wellcome had pulled out, the Waldmann group decided to continue what they were convinced was promising development work without them. The Waldmann group had seen the opportunity for enhancing the value of the medication for patients in areas such a chronic lymphatic leukaemia or multiple sclerosis. Beyond the initial mandate, Wellcome had adopted for the trials, there had been promising results from use of CAMPATH-based therapy in preliminary studies.

*“I always seemed to me that in the end if a drug was going to work, then the drug would dictate how you market it. [...] You’d have to find a way.”*

The group turned to their network of relationships with doctors and regulators to overcome doubts about the antibody.

*“A key thing in keeping CAMPATH alive through that difficult period, when it was not going well with Wellcome, was the long-term commitments, I describe it as faithfulness, of the doctors we were working with. They were faithful, they were consistent, they didn’t really have a particular axe to grind, from their own point of view – they weren’t going to make money out of this. They were just committed to it and stuck with it even when other people were [...], pulling clinical trials.”*

This was the result of long term relationships:

*“The good thing we did was to always surround ourselves by young registrars, clinicians who came to train, to do their Ph.D.s and so [...] in training these people up, we were sending ambassadors to the different parts of the hospital<sup>9</sup>. And that was the beginning of all the clinical collaborations. So what we developed was a way of working with the clinicians as equal partners, where their people were trained by us.”*

To reinvigorate the commercialisation process of CAMPATH, Waldmann introduced BTG to U.S. biotechnology Leukosite, a two-year old biopharmaceutical spinout from Harvard Medical School. The Waldmann research group had moved the CAMPATH work to the University of Oxford in 1995 because there were better bio-processing facilities there than at

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<sup>9</sup> Many of the clinical studies of CAMPATH were conducted at or originated at Addenbrookes Hospital, Cambridge.

Cambridge. They had worked well with Leukosite on these facilities. Licensing negotiations with BTG were successful and Leukosite began developing the product towards new target, where the potential for creating value for patients seemed clearest.

*“What made this [development of CAMPATH] easy was the fact that the data from a small trial that Wellcome had done suggested that it [CAMPATH] was really quite active in a form of chronic lymphocytic leukemia that was refractory to the only drug that was really approved to treat it [...] So the idea was to do a trial in that group of patients to ensure that we could have a statistically significant and meaningful increase in life expectancy in those patients.”*

Leukosite managers recognised that they lacked the ability to develop CAMPATH on their own and consequently enlisted the support of ILEX Oncology, a three-year old contract research organization (CRO) which was moving into drug discovery. While development work in the resulting alliance was promising and the collaboration with the Waldmann group was mutually beneficial, Leukosite soon encountered challenges in funding further clinical development of CAMPATH. As a result, Leukosite (which then had only 54 employees and \$12.1 million in sales) merged in 1999 with Millennium Pharmaceuticals, a significantly larger and better resourced biotechnology company (7 years old, 1330 employees, \$196 million sales). While securing funding for the subsequent development of CAMPATH, the merger created new collaboration difficulties. Millennium was strongly focused on capturing value from CAMPATH.

*“We had the really very fruitful relationship with a small company again that we had with Wellcome Biotechnology. We had a really good working relationship between our scientists and their scientists: We were doing work that was complementary to their work, we used to*

*visit them, they used to visit us, and we exchanged information and helped one another. So working with a small company again was a good thing.”*

But the merger changed the relationship of CAMPATH scientists with the development labs. Integration of Leukosite’s resource-based with that of Millennium resulted, once again, in the departure of staff with whom the scientists had developed close relationships. Similarly, Millennium’s strategic approach to value creation was foreign to the scientists. While development work thus continued, relationships began to resemble those held with Wellcome.

Millennium continued the development of CAMPATH, obtaining product approval as a third line product for chronic lymphatic leukaemia patients. In its first year of commercialization, CAMPATH generated sales of \$27.1 million. Nevertheless, Millennium sold its share in CAMPATH to ILEX because their ownership stake was judged to be insufficient, stating in a press release that:

*“Millennium considers pipeline ownership to be a key element to building value in our company. The sale [...] will allow us to invest our resources in product candidates for which we have greater control and ownership over downstream development and commercialization activities, while providing a considerable revenue stream to build our company. ” – (Business Wire, 2001)*

ILEX subsequently continued the further development of CAMPATH in alternative application of greater patient and commercial value, most importantly multiple sclerosis, but, like Leukosite, this smaller company had insufficient resources to carry out clinical trials. The firm subsequently merged with Genzyme, a large biotechnology firm that had specialised in the commercialisation of “orphan drugs” such as CAMPATH, which took on the further development of the product.

Reflecting on the development process, the developers of CAMPATH remarked:

*“At the end of the day we know that only the pharmaceutical industry has the resources and expertise to bring a product to market. We need to work closely with them to transfer the technology and know-how in an effective way and to ensure that a fair (not extravagant) reward flows back to the academic institution when a potential product is marketed. In our experience, it has been much easier to interact with small biotech companies where the ethos is more akin to our academic culture and the management is closer to our level. To us, the big pharmas like Glaxo/Wellcome seem daunting and impersonal; our main point of contact was with lawyers who appear obsessed with details we find trivial”* – Hale and Waldmann (2000)

## **5. Discussion**

The events occurring during the translation of CAMPATH into health products illustrate the themes of our discussion – similarities between academic and scientific creativity, the different practices and priorities of scientists, entrepreneurs and corporations respectively and the impact that these differences have on collaboration between industry and academic research.

The researchers in our case study were continuously focused on the creation of new knowledge. To this end, they were active in mobilising resources in ways not unlike the attempts made by founders of a start up to mobilise resources.. They applied for grants from the MRC, encouraged pro-bono funding efforts by former patients and gained access to complementary knowledge in neighbouring research departments. When resources ran short and supplies were unavailable, they traded services and new antibodies with other scientists. Like entrepreneurs exploiting under-used resources, they relied on Ph.D. students and post-docs for low-cost talent. These resources were combined in the intellectual effort of

knowledge production and the physical production of antibodies (e.g. an initial production facility for CAMPATH).

The discovery and filling of gaps in the web of knowledge gave rise to new questions. For instance, initial difficulties with CAMPATH-1M spurred the development of CAMPATH-1G. Combining resources gave rise to new value creation, most strikingly in the humanisation of CAMPATH-1G, which was conducted in collaboration with a neighbouring research group. Gaining leverage from resources was done through the broad network of contacts with regulators and physicians (many of whom had trained with the Waldmann group). Proximity to clinical departments in Cambridge University permitted the group to find economical ways to trial CAMPATH-1 on volunteer patients. Exploiting this value in order to achieve returns played a less central role in their early efforts. Commercial exploitation was driven by the medical researchers' desire to see the product used by patients and available on the market, rather than to maximise financial returns for participants. But rewards were forthcoming; publications and grants based on the research provided recognition and further resources for scientific advance.

A focus on value creation similar to that espoused by the academic scientists was apparent in each of the entrepreneurial organisations with whom the Waldmann group worked, a focus lost in larger, corporate settings. Wellcome Biotechnology was an innovative unit, run independently of its pharmaceutical parent firm, which, like Leukosite and ILEX focused on creating value from the new technology - Wellcome Biotechnology as a prospecting unit, Leukosite as a start-up and ILEX as a contract research organisation seeking to move into drug development. Each showed flexibility in its scale-up efforts and in developing the technology with a focus on value creation. At Wellcome Biotechnology new opportunities were recognised in more potent versions of CAMPATH and there was willingness to disinvest in previous versions on a flexible basis and restart the development programme. When Wellcome Biotechnology was integrated into the larger organisation, communication

channels became too complex and hierarchical for the ready exchange of knowledge needed for effective collaboration. A U.S. university spin-out, Leukosite showed the kind of flexibility originally demonstrated at Wellcome Biotechnology. The managers decided to pursue a promising technology although it was outside the initial mission of the firm, adopting a new direction for clinical studies based on early clinical evidence on CAMPATH. ILEX, another entrepreneurial business, showed initiative in seeking to broaden CAMPATH beyond its initial niche positioning and investigated new application in such areas as multiple sclerosis.

‘Culture’ as a factor lacks the precision needed to explain the cooperation between CAMPATH scientists and a culturally diverse set of entrepreneurial companies. Wellcome Biotechnology, while relatively independent, was embedded in a large British corporation. Leukosite was a nascent university-spinout from a New-England University. ILEX Oncology was a young CRO from Texas. Yet the CAMPATH scientists were able to develop close relationships with managers in all three organisations with whom they shared a focus on opportunities to create value. Together they pursued the further development of technology in the face of significant challenges. Both Leukosite and ILEX invested time and effort in CAMPATH in spite of having very limited financial resources – a constraint they initially addressed through an Initial Public Offering and subsequently resolved through merger with larger, more established firms. These developments, however, transformed their orientation from entrepreneurial to corporate.

The focus of the large established pharmaceutical firms differed from that of the researchers and entrepreneurial ventures. The literature on corporate expansion helps to explain these differences. In a large company, standardisation is required for coordination. Processes become established so that participants in a large organisation where communication is not easy, know how things are to be done. Budgets are allocated to prevent misuse of funds by branch or line managers, whose interests may not align with the founders

or owners. Career incentives penalise failure to adhere to conventions and precedents, making corporate managers risk averse. Organisational inertia is a common feature of established organisations (Mintzberg, 1979; Dougherty and Heller, 1994; Garnsey, Heffernan and Ford, 2006). To some extent this is required to secure the assets of an established organisation which can be put at risk by radical change in strategy and practice. But resistance to organisational change may be so strong as to extend beyond what is needed for the preservation of the organisation. The managers of the pharmaceutical corporations which took on CAMPATH were charged above all with preserving the companies' assets and ensuring that value was forthcoming in the form of profits from the projects they managed. The search for value capture led them to impose predetermined milestones in the hopes of ensuring value appropriation.

An important consideration for corporate managers was to establish and retain control over the intellectual property rights to CAMPATH. This is why IP was such a thorny issue for CAMPATH. The collaboration of the Waldmann group with the MRC for the humanisation threatened Wellcome's IP position, as the MRC was not bound by their original licensing agreement, leading Wellcome to pursue legal means to protect its IP resources. Equally, the transfer of CAMPATH to Leukosite was impeded by concerns of Wellcome over rights to important IP aspects such as manufacturing information. Similarly, Millennium abandoned CAMPATH as it felt it had insufficient control over this resource.

Wellcome's decision to abandon CAMPATH reflected corporate risk aversion in the light of litigation issues and concern that the project would not capture sufficient value in the market places that had been targeted by the company. Millennium, in turn, passed the CAMPATH project on to ILEX because managers believed that not owning the IP could impair their ability to capture value from CAMPATH, a priority for a listed company. The corporate focus on preserving the value of their existing resources is illustrated by Wellcome's threat of legal proceedings against the Waldmann group. This occurred when

Wellcome's lawyers learned of a further innovation, CAMPATH-1H. They believed this to be a threat to the viability of their earlier development programmes for the earlier CAMPATH-1G. In contrast, the scientists were focussed on improving the medication for patients and thus on creating new social value rather than on the capture of economic value from earlier work. The corporate response is understandable but is in contrast with the rapid pace of change both among entrepreneurial young firms and among innovative scientists.

In examining the story of CAMPATH we found disconnected strands of evidence in literature on science and enterprise reviewed in the first part of this paper. Together these revealed the basis for strong communalities between innovations by scientists and entrepreneurial businesses. The strands combine to offer an explanation of how and where breaks tend to arise in industry-university collaborations. These breaks become apparent in the case of a highly innovative technology such as CAMPATH-1.

## **6. Conclusion**

The evidence presented here suggests that while the combination of science and enterprise may help produce important innovations, fault lines between participants may significantly impair value creation from this interaction. We find that the literatures on scientific and entrepreneurial innovation help to provide a fuller explanation of this phenomenon than that provided by notions of cultural clash between science and business, because it addresses differences in creative practices and innovative orientation. CAMPATH evidence shows how the focus on the creation of value in both scientific and entrepreneurial teams contrast with the priority accorded in large pharmaceutical corporations to the appropriation of returns. This is particularly so under current systems of corporate governance which prioritise short term gains for shareholders. Recognition of the nature of such fault lines can help explain what otherwise appears to be unpredictable outcomes in collaborative developments in biopharmaceuticals (cf. de Rond, 2003).

Replication of our exploratory findings through larger scale studies is desirable. The part played by current corporate governance arrangements should be examined, given the distinguished past of corporate R&D (Florida and Kenney, 1991)<sup>10</sup>. Further insights might be obtained by more closely examining the fault lines between academia, biotechnology and corporations and the processes and pressures that affect them. Do these fault lines make it possible to predict where collaboration difficulties will arise, even though we do not know precisely how or when or what precise form they will take? Can preventative measures be effective? Further work should examine how individuals who know, and are known, in both spheres can cross these fault lines and how bridging mechanisms can be set up to promote collaboration. Our evidence suggests that rifts reopen when the agents or mechanisms that facilitate interaction between the corporate world and innovative science and enterprise are ineffective, or are removed. These findings are consistent with evidence from other such collaborations (de Rond 2003).

It has been remarked that the university-industry links could be at “the heart of innovation and development” (Dzisah and Etzkowitz, 2008, p. 101). Achieving this goal requires bridging mechanisms and continuity among interacting agents. Bridging could be provided by semi-autonomous entrepreneurial subsidiaries of large pharmaceutical companies charged with such collaborations.

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<sup>10</sup> Whether measures such as those introduced at GSK by J.P. Garnier would bridge the fault lines we have identified seems unlikely, since they would promote a lack of communication between research teams of the kind that inhibited work relations with the CAMPATH team.

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<b>Category</b>	<b>Contributions Include:</b>
University industry-interaction policies and impact	Steenhuis and De Bruijn, 2002; Murray and Stern, 2007; Buenstorf, 2009; Rosell and Agrawal, 2009
Spin-out formation and mechanisms	Shane and Stuart, 2002; Nicolaou and Birley, 2003; Lockett, Wright and Franklin, 2003; Lockett and Wright, 2005; Djokovic and Soutaris, 2007
Firm-side management of collaborations	Perkman and Walsh, 2007; Harryson, Kliknaite and Dudkowski, 2007; Burnside and Witkin, 2008
Technology transfer policies	Dzisah and Etzkowitz, 2008

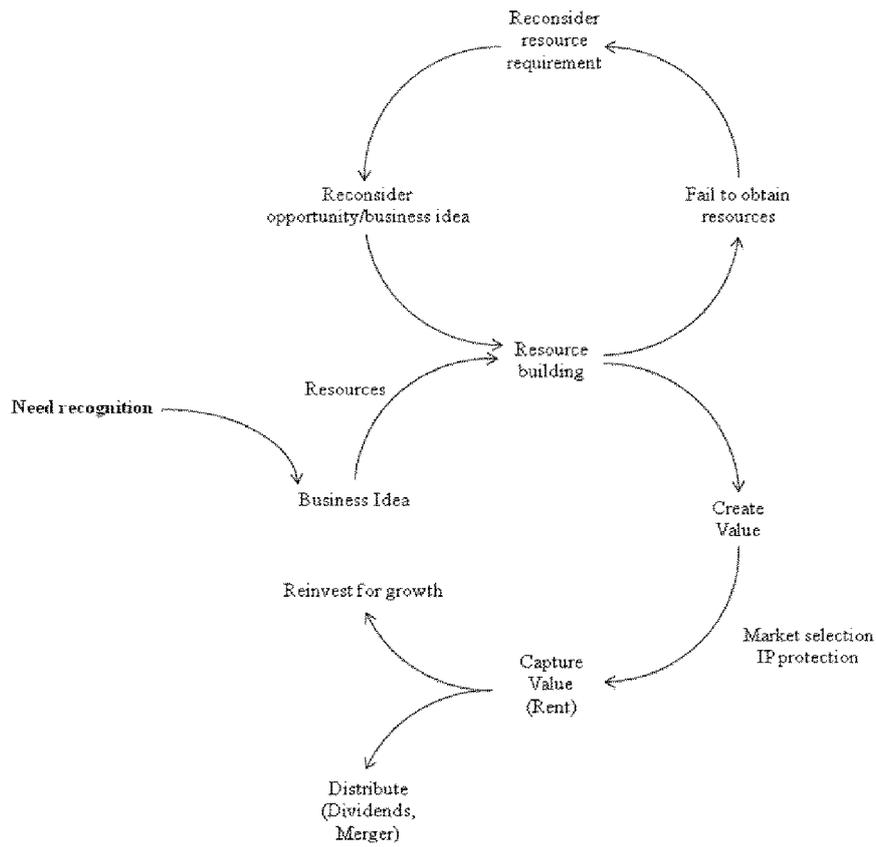
**Table 1 – Summary of Prior Research**

<b>Category</b>	<b>Entrepreneurial Ventures</b>	<b>Established Corporations</b>
Priority to	Value Creation	Value Capture
Opportunity	Experiment, explore opportunity	Scale-up, cut costs, exploit returns
Control over Resources	May be foregone temporarily	Control, plan, budget, monitor
Resource access	Requires enlistment of others	Established asset base available
Resource base	Under construction, malleable	Managers charged with preserving asset base; risk averse

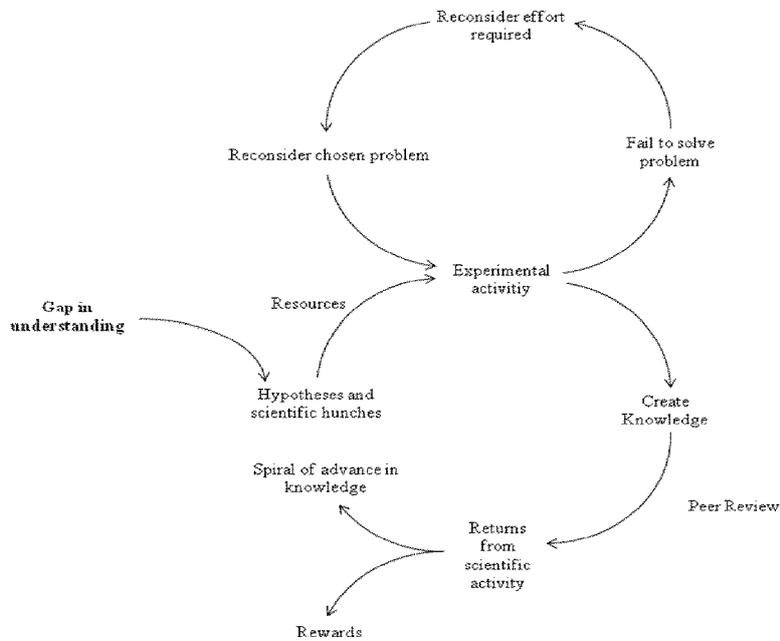
**Table 2 – Indicators of Orientation of Entrepreneurial Ventures and Established Firms**

<b>Construct</b>	<b>Indicators from Case Evidence</b>
Entrepreneurial orientation	Pursuit of opportunity a priority; flexible deployment of resources to this end
Entrepreneurial practices	Resource creation through: <ul style="list-style-type: none"> <li>- Resource economy</li> <li>- Resource combination</li> <li>- Resource leverage</li> <li>- Enlisting others</li> </ul>

**Table 3 – Construct and Indicators for Case Analysis**



**Figure 1 –Value Creation in Enterprise**



**Figure 2 –Value Creation in Science**