Evolving Biotechnology – an adaptive conceptual model of the biotechnology firm

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ABSTRACT

Today's biotechnology company must exhibit expertise across two unrelated fields, science and business. The intricate melding of the necessary skills and navigation through the litigious and venture capital environments has forced expertise specialisation, networking, strategic management and a survival of the fittest mentality. Developing a product through to the market requires planning and a focused effort of all involved parties, and with no proven biotechnology specific models available, this is very difficult. This article offers a revised conceptual model of the biotechnology firm that identifies the gradual melding and the tension between the science and business pathways in relation to the firm's life cycle. The model also highlights the need for communication between science, business, and the public, and discusses opportunities for income through strategic alliances across the value chain and through strategic human resource management.

Keywords: Biotechnology, science, business, networking, strategic management

INTRODUCTION

Biotechnology has been the source of some 4300 companies carrying out research in life sciences – predominantly with the aim of developing drugs for human healthcare (Ernst & Young, 2002: , Williams, 2001: 131). Not only does commercial investment currently sustain biotechnology, but clearly the expectation of financial gain was responsible for the considerable interest during the initial stages of its development (Murphy and Perrella, 1993).

Biotechnology and pharmaceutical companies compete in industries with extensive product and service diversity. Biotechnology companies are said to be more entrepreneurial and nimble than their pharmaceutical counter parts and are ideally designed for exploiting market and value chain niches and adopting new technologies early (Salfeld, 2004: 81-95).

The diversity and inherent complexity of the biotechnology industry has led to a continuing evolution of the technology, markets, playing fields and rules of competition (Altman, 1999: 1-5, Commission of the European Communities, 2002: , Harvard Biotech, 2004: , Strategy Unit, 2003). Business models used by biotechnology firms need to keep pace with this evolution, yet due to such factors as industry concentration, resource access, sophistication of financial markets and quality of science, the two faces of the industry, science and business, have developed at differential rates. As such, defining the optimal business model for a new biotechnology firm has become somewhat of a “holy grail”. This article adds important insight into an evolving field and proposes a new evolutionary model that will help managers coordinate the internal and external growth of their companies.

BACKGROUND CONCEPTS

The road to market – the business imperative

The drug discovery process is drawn out and expensive. The current estimate for product development, from lead identification to a marketable therapeutic is ten years and in excess of US$ 800 million per compound (Hine and Griffiths, 2004: 138-149, Reichert, 2003: 695-702, Powell, 1998: 228-240, Ernst & Young, 2002: , DiMasi et al., 2003: 151-185, Champion, 2001: 109-115). The process begins as problem solving research attempting to answer a scientific phenomenon. Following a discovery and applied research, the scientific team must decide whether to publish or to attempt to commercialise. If commercialisation is chosen, a commercialisation team is required to help guide and protect the scientific development. Scientific development must now be focused on exploiting a niche market opportunity and must follow a well recognised path to market (Davis, 2004: Commercialisation Workshop). The scientific team will often have to out-source or form strategic alliances to achieve many of the later development processes that require very specialised skills.

Business development for a biotechnology company is an extension of the drug discovery process, which alone does not identify the business requirements and opportunities. Business development can and indeed must happen parallel to scientific development and deliver the much-needed money for clinical trials and intellectual property (IP) protection (Evans, 2004: Commercialisation Workshop, Harvey, 2004: Commercialisation Workshop, Devine, 2004: Commercialsiation Workshop, Davis, 2004: Commercialisation Workshop, Siddle, 2004: Commercialisation Workshop). It is important that both pathways are complementary and work concomitantly to one another as the closer the product is to the exit strategy the greater the need is for integration between both.

Strategic Human Resource Management

For the CEO, effectively managing these pathways is fundamental to survival in the biotechnology industry. This falls under Strategic Human Resource Management (SHRM) and is gaining attention in biotechnology as managers are realising that the industry is fuelled by the intellectual capital produced by the employees (Yaroshevsky-Glanville, 2004: 1189). In this regard, managers and leaders are increasingly seen as coaches and or facilitators, providing coordination of efforts and orchestration of worker skills, talents, and motivation towards the facilitation of team performance (Ahearn et al., 2004:

309-327). Instead of ensuring that employees are adhering to rigid, top-down bureaucratic rules, successful leaders are responsible for eliminating barriers, which includes the removal of structural impediments and the implementation of team based work structures (Cascio, 1995: 928-939). This management driven bureaucratic dilution helps with the liquidity of role structure, responsibilities and assignments common in bipartisan work groups (science and business) and to align the different drivers in a biotechnology firm and the industry, given that group and individual trust and autonomy levels are actively monitored.

Trust and autonomy, commonly accepted as having a variety of positive effects (Kramer and Tyler, 1996) has been shown to at times have a negative impact on members in self managing work teams. Self managing teams (such as scientific research groups composed of students, research assistants and post-doctoral fellows) with high levels of individual autonomy will perform better when trust is lower than when trust is high as high levels of trust can make members of self managing work teams reluctant to monitor one another. (Langfred, 2004: 385-399). Trust also has important implications in the effectiveness of communication between the biotechnology firm and the public. Biotechnology firms can take steps to ensure trust by realistically addressing issues of concern and potential risk, be non-technical and must acknowledge the limitations of science (Clarke, 2001: 51-58). Reputational and leadership management and star scientists are key for effectively managing public perception of the biotechnology organization.

Charismatic leadership is a management style that is able to influence external and internal support for the organization, particularly in making the company more attractive to outside investors (Flynn and Staw, 2004: 309-330). Charismatic leaders are able to communicate their vision to their followers, and by the force of their own excitement and enthusiasm, induce their followers to support their vision. In an industry fuelled by external investment, charismatic leadership can act as a competitive advantage.

Success in the biotechnology industry is also very dependent upon good science as defined by its Intellectual Property (IP), usually patents, publications and citations (Murray, 2004: 643-659, Romijn and Albaladejo, 2002: 1053-1067, Crépon and Dugent, 1997: 243-264). However, recognition of a new biotechnology firm can be achieved not only through its leadership and good science, but also through good scientists. It is widely known that the eminence of the scientist gives a linear eminence to the quality of work reported. In today's modern biotechnology industry, as scientists become more productive, their eminence grows and more colleagues seek to collaborate with them, increasing the sourcing of ideas. Furthermore, greater eminence through academic and commercial success attracts more funding, allowing for increased publication output and subsequently more recognition (Oliver, 2004: 583-597). These effects reinforce each other and snowball, resulting in a "compounded" Mathew Effect (Van Looy et al., 2004: 425-441). Managing this intangible asset, known as reputational capital, is important for biotechnology firms. It has been suggested that a CEOs reputation accounts for up to 48% of a company's reputation (Burson-Martseller, 2001).

Building Intellectual Assets

Another valuable intangible asset that requires careful management is Intellectual Property (IP). In the 1990s, three-quarters of the Fortune 100's total market capitalisation was represented by intangible assets, such as patents, copyrights, and trademarks (Reitzig, 2004: 35). IP management must be a primary responsibility of the commercialisation team and must involve regular discussions with the scientific members in guiding the development within the boundaries set by the IP.

While generating value out of the IP is what delivers today's returns, creating the potential for employees to innovate in the future ensures long-term survival. The intellectual capital residing with the company is often referred to as intellectual capital (IC) and without it, the gains made with the IP cannot be sustained. IC must be considered central to the competitive advantage of the growing biotechnology organisation. The company cannot rely on IP alone and must generate new IP to achieve sustainable growth. In this regard, IC goes beyond human resources. While SHRM will regard the social capital of the company, IC is a more specific concept; it is the intellectual resources of the company. Not only should the people in the company be nurtured, but also their intellectual capacity must be appreciated and the sharing of their knowledge facilitated through effective communication channels.

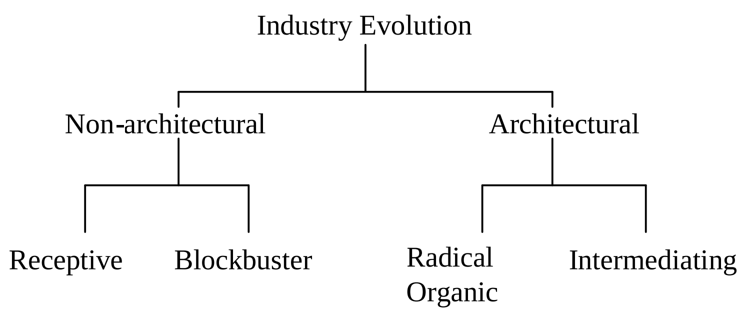
The ability to develop an intangible asset (intellectual capital) into a tangible resource in turn generates both income to develop other products in the pipeline and future investment. This link between the company life cycle and an ability to develop IC is paramount to successful development of the biotechnology company.

Lifecycles of the biotechnology industry and firm

Biotechnology firms must closely watch the life cycle of their firm and of the industry and seek to exploit market niches and opportunities by modifying their life-cycle strategies. Management strategies of biotechnology firms should reflect the position of the firm in its own life cycle. Long term survival and competitiveness critically relies on this, courtesy the enormous costs in taking a product to the market and protecting the product from infringement by competitors (Kowalski et al., 2003: 305-331, Lexchin, 2004: 47-54). Geoffrey Moore's Chasm, Bowling Alley and Tornado models (Moore, 1991: , Moore, 1998) describe the traditional bell-shaped or Gaussian life cycle curve (Foster, 1986: , Abernathy and Utterback, 1978: 40-47), with product moving from early adopter market through a number of specialised niche markets and then into a broad unsegmented market characterised by high sales volumes. Despite its limitations, such as limited relevance to an industry in which there is little revenue to consider, this model also has implications for new biotechnology firms suggesting that product pipelines should be developed to ensure that the company generates the maximum value from all its resources and does not focus too many of these into one endeavour. To avoid becoming a "one trick pony", new biotechnology firms need to consider and enact evolutionary business models which align with their R&D pipelines, thus combining both science and business imperatives.

To this end, four new evolutionary models have been proposed and are illustrated in Figure 1 (McGahan, 2000: 1-16). The major distinction in this framework is between "architectural" and "non-architectural" change. Architectural change is defined as any innovation that disrupts the industry's established relationships with both suppliers and customers (Henderson and Clark, 1990: 9-30), such as an enhancement in the specificity and selectivity in the drug screening process. Non-architectural change involves innovations through established customer or supplier relationships (McGahan, 2000: 1-16) such as the introduction of a new pharmaceutical product.

Figure 1. Pharmaceutical and Biotechnology industry lifecycle models



Non-architectural change can occur between those where the customer and supplier markets provide continuous feedback (receptive) and those where profitability is mainly determined by the outcome of major projects for which feedback is delayed and unpredictable (blockbuster) (McGahan, 2000: 1-16). Architectural industry change is less common but may lead to major shifts in the overall character of the industry. Radical organic evolution encompasses approaches that provide a quantum improvement in customer or supplier value (performance, ease of use, mode of use) big enough to disrupt existing customer and supplier relationships and intermediating change describes architectural innovation that originates within established relationships (McGahan, 2000: 1-16). The pharmaceutical industry is facing a change of having to move from the long-successful strategy of blockbuster, to an industry model similar to that of biotechnology (Service, 2004: 1796-1799). The biotechnology industry, a high technology adaptive and market niche exploiting industry, operates in both non-architectural and architectural environments. While this is a competitive advantage over the pharmaceutical industry, the fluidity is why industry networking is so important and why it is so difficult to create a model that truly reflects this industry.

The evolutionary model, and the inevitable resource limitations for biotechnology firms facing a path to market costing upwards of $800M, requires these firms to avoid operating in isolation. The nature of its R&D cycle also behoves the smaller biotechnology firm, the vast majority of competitors in the industry, to consider the elements of their value chain (relating closely to their R&D pipeline), and where they and their current and potential collaborators fit within that value chain. The value chain is essentially a framework for identifying the discrete but interconnected activities that run a business and how those activities affect both the cost and the value delivered to buyers (Carr, 2001: 27-34, Porter, 1985). It is important that the company be able to shift in its life-cycle curve to be able to adapt to architectural or non-architectural changes in the industry value adding chain. To this end, collaborative efforts have given rise to the intricate web of networks that facilitate the efficiency of biotechnology firms and the elimination of linear supply chains, R&D and relationship business models.

Specialisation and alliances across the value chain help coordinate resources and strategies and thus deliver far greater returns for much lower costs (Mirasol, 2004: FR8-FR9, Accenture, 2004). Strategic alliances offer firms a money saving route through out-sourcing areas beyond the core competencies of the scientific or business team to other specialised groups. Strategic alliances are not exclusive to the commercialisation pathway and are common in academic research groups. In-licensing is a common example of a commercial strategic alliance in the biotechnology industry as product acquisition brings rapid progress to product development, which allows fundraising beyond that possible for most biotechnology startups (Schafer, 2002: BE36-BE38). In turn, excess funds raised can support a more aggressive development of novel technologies in the product pipeline. The ability to create economies of scale and scope means that limited resources are not squandered and that the important critical mass for developing biotechnology companies is achieved faster.

It has been argued that the growth of the biotechnology industry is due to the healthy triple helix relationship – academia, state, and industry (Giesecke, 2000: 205-223), which has created a very strong science base through which commercially viable innovation thrives. Scientific research proved a much more time and financially expensive venture than what was typical in the IT industry (compare US$ 2-3 million in IT to US$ 800 million for a typical drug) (Ernst_&_Young, 2002: , Reichert, 2003: 695-702, DiMasi et al., 2003: 151-185, Powell, 1998: 228-240, Champion, 2001: 109-115) forcing financial networking and a more strategic approach to investment. With the potential high rates of return the VC industry has grown into the dominant financial and management expertise source for developing biotechnology companies.

Through financing, VC firms shape the biotechnology environment. They act as both a “scout”, able to identify future potential, and as a “coach” that can help realise it (Baum and Silverman, 2004: 411-436). In the entrepreneurial setting, financial intermediaries such as VCs have been cited as perhaps the dominant source of selection (Anderson, 1999). They affect selection by providing financial resources to cash-hungry startups and by favouring new firms with, or requiring them to adopt, particular strategies, practices, or other characteristics. VCs may also provide management expertise or access to other capabilities that bolster the competitive advantage of startups that they fund (Hellmann and Puri, 2002: 169-197). In addition, their investment provides a certification benefit that can enable the startup to obtain other resources (Baum and Silverman, 2004: 411-436). Scientists and business managers must carefully choose their technology transfer vehicle, strategies and models, as this may well deicide on the success of the product.

Current biotechnology models

The generic business model is a description of how the company intends to create value in the marketplace and is a tool for predicting environments (Carbone, 2003: 203). It includes that unique combination of products, services, image and distribution that the company carries forward. It also includes the underlying organization of people and the operational infrastructure that the company will use to accomplish its strategic directions (Fisken and Rutherford, 2002: 191-199). For a biotechnology company, the business model should serve to secure value from the company's intellectual assets through describing the scientific and business pathways and the tension between them. The model should also reflect the need for strategic alliances with pharmaceutical or other biotechnology companies as customers, collaborators or even partners.

The four major business models currently in use in the biotechnology industry are the Fully integrated pharmaceutical company model, the product business model, the platform/tool business model and the hybrid business model (Fisken and Rutherford, 2002: 191-199).

1. The *Fully integrated pharmaceutical company model.* This model generates value by controlling the entire value chain and so is only applicable for the largest and mature biotechnology and pharmaceutical companies. This model maximises risk and requires high levels of financing and is geared towards blockbuster evolution. With the rising complexity and segmenting of the biotechnology / pharmaceutical value chain, this model is becoming less useful.
2. The *Product business model.* This models generates value by progressing products along the drug development process and either licensing them out to pharmaceutical and top tier biotechnology companies or, when the company has reached maturity and there is sufficient free cash flow available, taking them through to commercialisation. While this generally takes around 10-20 years to reach, orphan drug legislation offers the opportunity to accelerate free cash flow generation. Companies may partner initial products at an early stage of development to mitigate some of the risk in this model. This is a proven model with 19 of the top 22 pharmaceutical and

biotechnology companies in the world with market capitalisation in excess of US$ 3 billion being classed as product companies (Integration, 2001: A1, Fisken and Rutherford, 2002: 191-199).

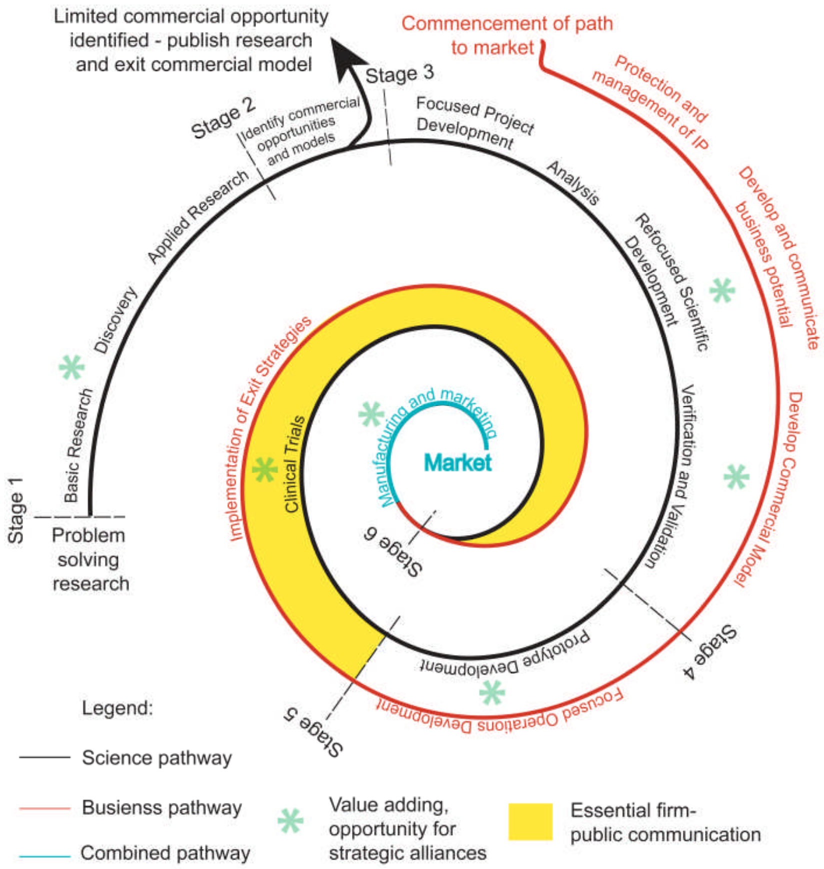
3. The *Platform or tool business model.* This model has existed in other markets for some time and generates value predominantly from the front end of the industry value system through licensing fees, subscriptions and service fees and can include provisions of new research tools, informatics and or services and reagents. The evolution of this model came about by addressing the need to reduce the risk of drug development through applying technological advances to drug discovery. The model is particularly prevalent in countries that cannot access the venture capital markets seen in the US (Scarlett, 1999: E13-E15, Lyles et al., 2004: 351-375, Fisken and Rutherford, 2002: 191-199).
4. The *Hybrid business model*. This is a hybrid of the product and platform business models and generally constitutes a platform technology capable of generating a pipeline of products. Time is critical in this model to ensure the company maintains a healthy balance between the contributions of the platform and product components to the business, ideally maximising revenues from the platform to assist in financing the transition. Management skills to achieve this transition generally need to be specifically recruited and must include a strong track record in the planning and execution of clinical development programmes and the ability to raise the capital to meet the increasing cash burn requirements.

The platform / tool business model, characteristic of other high-technology industries, has enabled companies to commercialise breakthroughs such as the Human Genome Project, and where possible, establish first-mover advantage. With the biotechnology industry characterised by rapid technological change and advancement, the continuing rapid pace of technology development has made platform companies vulnerable to commoditisation of their tools and technology obsolescence or even irrelevance. Biotechnology management teams must continually evolve their business models to reflect the internal and external environments to ensure that this does not happen. The static design in these models is their major weakness and is why they fail to describe the conditions in the biotechnology industry. With evidence from the post-IPO stock performance of biotechnology companies that went public in 2000 indicating that public investors in the more mature US public market differentiate companies on the basis of their business model (Pavlou, 2003: 167-176), it is important that the next logical step be taken in the development of the biotechnology industry; designing an evolving adaptive conceptual model that captures some of the more esoteric characteristics of growing biotechnology companies.

AN EVOLVING ADAPTIVE CONCEPTUAL MODEL

Figure 2 presents a new conceptual model is offered that builds on the operational models above and captures the temporal aspects of the tension between the science and business pathways in a developing biotechnology company. The model helps describe the myriad of forces involved with biotechnology development such as strategic alliances, communication with the public, and the general steps to development, by accounting for the non-linearity of the biotechnology value chain. This non-linearity is important as the relationship between a company's position in the biotechnology value chain and its ability to generate value is non-linear and so a linear model cannot be applied to the system. Because of this, many of the operational models presented above fall short of telling the complete story. This model evolves with the company in its product development and provides an informational framework for managers for identifying what influences they should be aware of in different stages of development.

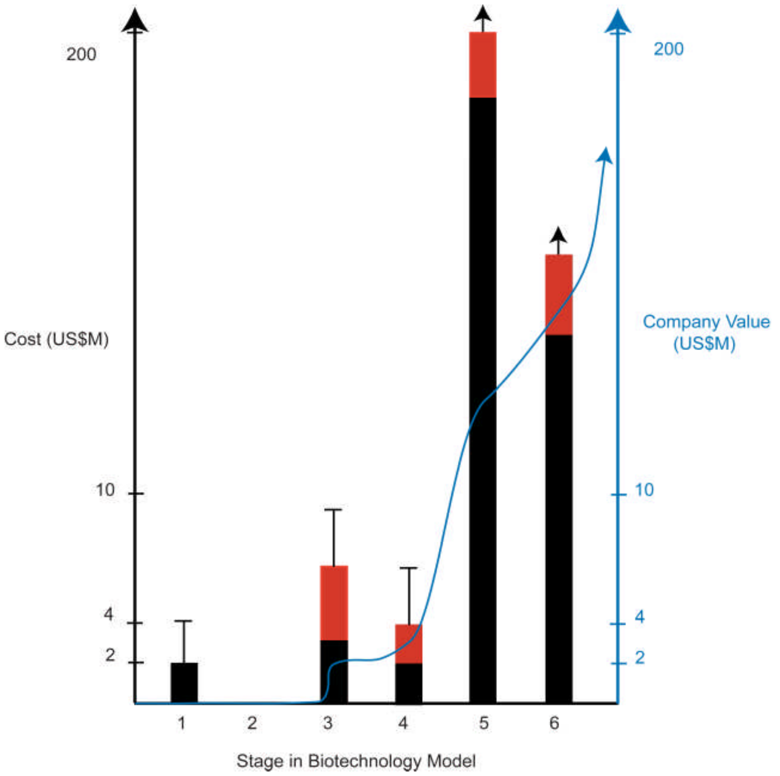
Figure 2. An evolving adaptive conceptual biotechnology organisational model



The model highlights the temporal processes and tension between the science and business pathways and indicates opportune times for seeking strategic alliances. The final path to market is a merging of the science and business processes. The stages are for reference with the cost:value graph.

The model is broken into stages to reflect the company life cycle and to link to the cost:value graph presented in Figure 3. The stages have been given a temporal dimension depicted by their graphical length in the model. Time is not explicit, but a reference to the other stages and the entire process is expected to take approximately 10 years (DiMasi et al., 2003: 151-185). Stage 2 is a conceptual stage and is the cumulative effort of the previous stage. However, where previous life cycle analyses have anthropomorphed the biotechnology organization into a growing/mature/declining company definition, this model focuses on the life cycle of each product development. In conjunction with the cost:value graph below, the model illustrates why it is important for product co-development given the cost:company-value ratio. This allows management to identify more clearly the development pathway and anticipate the expenses. The cost:value graph highlights the non-linearity of the value adding life cycle of a developing biotechnology company. It illustrates why it is so important that the company operates as efficiently as possible in the industry value chain and with a definite strategic plan to minimise unnecessary financial and temporal expenditure.

Figure 3. Cost:Value graph of a developing biotechnology company



The stages are in reference to the conceptual model above. In this graph, the black bars are the approximate costs of scientific development with the red bars indicating business expenses. The blue line illustrates the value of the company. Arrows indicate a propensity for higher costs then indicated and error bars an approximate maximum typical of the stage.

A strategy commonly used for balancing this cost:company-value ratio is forming strategic alliances. Strategic alliances are a ubiquitous phenomenon throughout the cycle from initial problem solving research to manufacturing and marketing. They help to bridge the industry value chain thereby allowing the company to focus its resources on exploiting market niches that align with the company's core competencies. They help to shift the company's position in its life cycle by progressing the product through certain stages more quickly, allowing excess money to fund development of pipeline products. However, while strategic alliances can aid development, they come at a cost and involve payments, royalties or a share in the company. The type of payment often depends on the type of alliance entered into and alliance type is often characteristic of the stage in the cycle. On the model, following the arrival of the commercialisation team, strategic alliances can also be opportune times for selling the company as by this stage the company does have a net value.

A firm's innovativeness and new product development directly impacts continued survival and performance and as such, early biotechnology companies look for opportunities through strategic alliances to enhance their innovativeness (Rothaermel and Deeds, 2004: 201-221). Selecting alliances must be a careful process as the configuration of alliances impacts early performance, and the nature of a firm's cooperative arrangements has a bearing on the firm's level of product innovativeness (Baum et al., 2000: 267-294). Also, recent research has suggested that strategic alliances entered into between small technology ventures and large established firms during periods of limited external equity financing tended to be less successful as the larger ventures can often gain too much leverage for the partnership to be mutually beneficially (Lerner et al., 2003: 125-156).

Developing and maintaining long-term competitiveness in the biotechnology industry, regardless of whether the company is in a strategic alliance, demands the development of the reputational and intellectual capital. Achieving this through management of the organizations communication channels, effective leadership, and exploiting the advantages of star scientists and the resulting compounded Mathew Effect, promotes efficient internal product development and external product acceptance beyond what is otherwise achievable. These require the coordination of the science and business teams and ensuring that they have common goals, drivers and an understanding of the organizations strategic direction and the public and investors.

In the early stages of the biotechnology life cycle, the lead scientist and their field of interest guides any problem-solving research. Development of science and the intellectual capital in an academic institution (where many biotechnology companies are born) may often involve strategic alliances with complementary research groups. In the early stages of development, this helps the team to reach the critical mass necessary for commercialisation. Once a discovery has been made and applied research developed it further, if commercial potential is identified the researchers will need to seek the advice of a commercialisation team for protection of the IP. If the discovery is purely academic then the team may publish the research and exit the model. Once the IP is protected, the research team can then publish but this may take many months or even years before it is safe to bring the discovery to the public. Patenting is gaining acceptance as an estimate of innovation capability in academia and therefore offering an equal justification for academics seeking funding for research in the basic sciences (Romijn and Albaladejo, 2002: 1053-1067, Crépon and Dugent, 1997: 243-264).

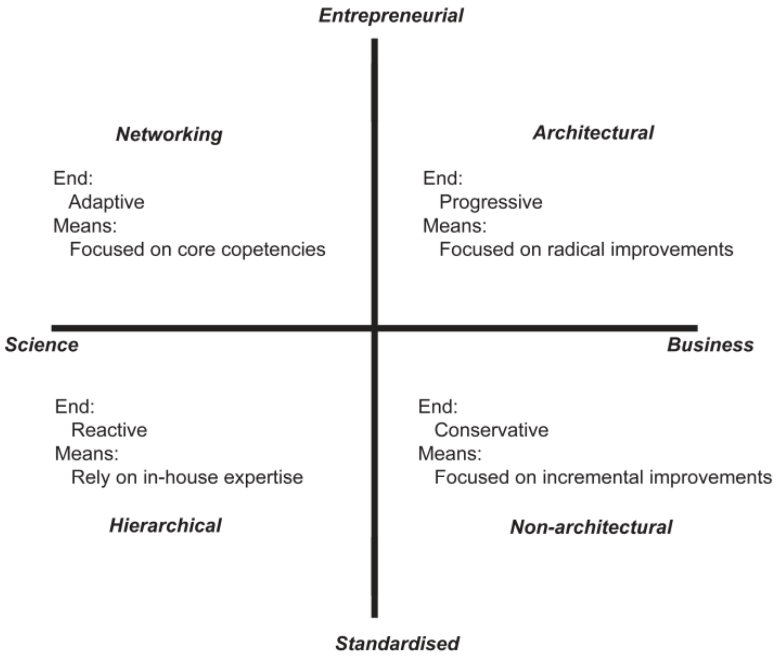
The arrival of the commercialisation team helps to focus the commercial ideas of the scientific researchers, provide the expertise needed for patent filing, help develop the management and scientific reputational and intellectual capital, further develop the strategic human resource management and to elucidate the position of the company in the biotechnology industry value chain. As the process continues, it is important for the teams to work closer together and to ensure efficiency in the research and development of the commercial drivers to minimise unnecessary expenditure. The organizations intellectual capital must be developed and both teams must be understanding of the others limitations and skills; without the business team the necessary industry financing cannot be accessed and without the science team there is no product. The lines of science and business must eventually merge into a marketable product and a merging of science and business pathways in the model represents this. Both fields have to be operating as one streamlined body and need to be communicating effectively between each other and the public to understand and build off the others strengths, knowledge and expectations. Tension between the two fields can often inhibit the development pathway early and is seen when commercialisation teams do not understand the technology or when science teams do not understand the market. Effective communication strategies and channels, developed through effective SHRM, in addition to aiding internal networking also acts like an oil between the companies external networks and helps to eliminate unnecessary development and to maintain awareness of changes in the value chain. To compete in this industry, the firm must use its entire arsenal of competitive advantages, which requires the effective use of both science and business.

The ability of the firm to effectively communicate with the public is also important for its success. The highlighted yellow area indicates a minimum communication time necessary for openly informing the public as to your developments. Communication may begin much earlier in the form of publications and announcements but can come only when the intellectual property is protected. Star scientists and charismatic leaders can not only help promote trust in the public sector thereby increasing future product acceptance. By increasing awareness of the company, the compounding Mathew Effect encourages networking within the triple helix (state, industry, and academia) which drives down operating costs and further promotes the company to the public sector. As the company matures, the Board of Directors and the management teams may need to be replaced to reflect the new skills and responsibilities inherent in that life cycle stage. Communication with the public is vitally important for both the buying of the product and for shares as the biotechnology and pharmaceutical industries are much more impacted by the moral climate set by society than what other industries such as IT have experienced.

FUTURE RESEARCH

To qualify the conceptual model presented in Figure 2, an analytical "Competing Focus Framework" (CFF) has been developed (Figure 4). The framework is modelled off the Competing Values Framework and defines the organisational culture of the biotechnology firm (Goodman et al., 2001: 58-68, Quinn and Rohrbaugh, 1983: 363-377). Measuring the culture of a firm gives a reflection of the internal characteristics of the business that may directly or indirectly influence the quality of work (Goodman et al., 2001: 58-68). As such, the CFF will be used to help guide a multiple-case longitudinal study of a selection of appropriately sized international biotechnology firms for insight into how these firms develop and how management can optimise the relationships between the science and business pathways, as presented in Figure 2.

Figure 4. Competing Focus Framework



The two-dimensional typology yields four cultural orientations and helps to identify the focus of the firm. Architectural entrepreneurial business refers to radical improvements in business methodology, generating similar results as an entrepreneurial scientists who uses extensive networking to access skills and resources outside of their skills and resources scope.

CONCLUSIONS

The biotechnology industry is rapidly evolving and is driven by innovation and creativity. Maintaining pace within it requires careful planning and implementation of timely business strategies, management techniques, and of course, cutting edge scientific research. The company must identify niche market opportunities with complementary strategic alliances to bridge the value chain gaps and must ensure that its science and business pathways are carefully intertwined. Management must seek to develop the organizations unique intellectual property and capital that will enable the company to stand out amongst these enormous global biotechnology and pharmaceutical value chains and must proactively control the product pipeline to regulate the company's position in its life cycle. Firms must also proactively seek opportunities for advancement, such as new market opportunities, partnerships, alliances, or even licencing deals, but must be mindful of securely protecting those valuable intangible intellectual property assets.

Steering the organisation through this is difficult. The long drug development process, the bureaucracy with attaining and maintaining venture capital, the expensive clinical trial procedures, and the numerous and litigious intellectual property fields are but a handful of the prominent characteristics of the biotechnology industry and help to make each market considerably diverse from the next. With the relative infancy of the industry, identifying relevant and proven models to help with the navigation is very difficult and while developing generic biotechnology critical success factors and core competences inherent to long term competitiveness is not possible (due to the diversity of the industry), there is an opportunity to develop guidelines and evolve the business models that will help maximise the opportunity for success. By capturing the time relative tension between the two pathways and by identifying some of the more esoteric development pathways in this industry, we believe that this model provides a framework for better understanding a growing biotechnology firm. Combined with an operational model and cutting edge science and market awareness, we feel that this model can deliver knowledge that will help improve the success of a biotechnology venture in this expensively unforgiving industry.

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