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Building Innovation Networks in Biotechnology Industries

Abstract

This paper aims at developing a tentative guideline for managers of biotech firms on how to form and design network ties in biotechnology industries[1] by integrating the findings from the analysis of the networking characteristics of the five leading biotechnology firms (Amgen, Biogen, Chiron, Genentech, Genzyme) with extant scholarly research on biotech networks. We derive a set of recommendations on salient process issues such as the timing, duration and design characteristics of both vertical (upstream, downstream) and horizontal network ties. Further, we generate insights into how biotech firms may develop their own organizational networking capability ("networkability") by making networking part of their business strategy, by creating networking-enhancing organizational structures and processes and by instilling network values in the organizational DNA. In doing so, we extend prior contributions on biotech networks and hope to create actionable knowledge for managers on how to build innovation networks.

Despite the rapid growth of inter-firm networks in biotechnology beginning in the 1980s, many thought the upsurge of innovation networks in biotechnology industries to be a transient phenomenon of adaptation to the diffusion of a set of new generic technologies (*Freeman*, 1991: 510).[2] It was predicted that firms would internalize most of the networking arrangements as they become more fa-

1 Modern biotechnology is today understood as a set of technologies (rDNA, monoclonal antibody, protein engineering technology) relevant to a wide range of disciplines and industries rather than being a discipline or industry per se (*Powell* 1996: 123). The expression "biotech industries" thus comprises various industries in which biotechnology is applied.

2 In this papers innovation networks are understood to be loosely coupled organisations having a core of both strong and weak ties among constituent members (compare *Freeman*, 1998). They include joint firms, licensing arrangements, management contracts, sub-contracting, production sharing and R&D collaboration. This definition is applied since these different modes of networking are not mutually exclusive. Consequently, most biotech firms are involved in several of these modes of networking.

miliar with these technologies (*Greis, Dibner, & Bean*, 1995). But so far, merger and acquisition activity, both vertically and horizontally, has not exceeded a moderate level. Most M&A transactions have been undertaken by larger firms which attempted to shift strategically sensitive areas under their direct and immediate control or by firms which benefited from firms that failed miserably in their pursuit of a "going alone strategy". A prominent case in this respect is Somatix which was able to develop two products up to Phase II but was then unable to finance the expensive Phase III of the regulatory process. Eventually the firm was taken over by Cell Genesys, another gene therapy company.

The surge of partnerships has thus only slowly commenced to stabilize as the industry matures (*Greis et al.*, 1995; *Jain*, 1997; *Pfirrmann*, 1999; *Powell*, 1998). As the most recent biotech study by *Ernst & Young* (2005) shows, biotech companies continue to partner with each other as well as with big pharmaceutical companies. Therefore, networking can still be regarded as one of the biggest strategic issues for biotech firms today (*Burrill & Lee*, 1990; *Jain*, 1997; *Zucker, Darby, & Armstrong*, 2002).

However, the academic discussion of innovation networks in biotech has so far mainly focused on two issues: a.) the motives for biotech firms to join networks (e. g., *DeCarolis & Deeds*, 1999; *Powell, Koput, & Smith-Doerr*, 1996; *Steentsma & Fairbank*, 1999) and b.) the implications of networking activity for the individual biotech firm (*Deeds & Hill*, 1996; *George, Zahra, & Wood*, 2002; *Liebeskind, Oliver, Zucker, & Brewer*, 1996; *Zahra*, 1996).

The drivers behind collaboration, however, have been repetitively shown to have remained unchanged over the years. Biotech firms mostly collaborate due to financial resource constraints and the resulting need to accelerate their paths to products. Pharmaceutical firms embrace collaboration in the face of patent expirations and diminished R&D productivity (compare e. g., *Ernst & Young*, 2005). Similarly, the recent, steadily increasing body of literature that continues to evaluate the importance of network arrangements for firm profitability, new product development, growth and survival has failed to generate novel insights. Collaboration is found to positively affect R&D productivity and firm survival while the effect of collaboration on financial performance remains equivocal (*Baum, Calabrese, & Silverman*, 2000; *George, Zahra, Wheatley, & Khan*, 2001; *George et al.*, 2002; *Powell et al.*, 1996; *Riccaboni & Pammoli*, 2002).

In contrast, it has remained largely unaddressed how biotech firms should build and design innovation networks (see *Greis et al.* 1995 for an exception). This shortcoming seems critical for a number of reasons. First, while the motives for building a network are likely to be self-evident to the biotech firm, biotech firms seem to lack an understanding of how their motives for collaboration may predetermine their network design as well as how their motives may affect its bargaining position in the different phases (e. g., network partner selection, negotiation, formation and design) of the network building process. Second, the desired outcomes (e. g., increased R&D productivity, faster time-to-market) are only likely to materialize if the biotech firms generate knowledge on how to get the design of the network structure right. Today, roughly 50 percent of the network ties that have been build are severed without result. These

bleak outcome of networking activity is proof for the lack of knowledge firms currently hold on how to successfully build and design successful network relationships.

It thus seems essential to find answers to several unresolved sets of questions regarding the timing, duration, essential capabilities, prerequisites and crucial parameters in the network building process. This papers thus aims to shed light on key process questions such as: When should network ties be build? What factors determine when and for how long network ties are struck up? How should networking be institutionalized in the organization? What organizational structures and processes should be laid out to facilitate network building? What are desirable characteristics of the "portfolio" of network ties?

In an attempt to explore the capabilities necessary for creating a successful innovation network as well as the actual process of building such a network, we draw on five case studies of the most successful (in terms of revenues) biotech companies today. We further reflect upon our empirical findings in the light of existing literature on biotech networks to generate actionable knowledge for biotech managers on how to successfully construct an innovation network.

1. Tentative Guidelines for Building Innovation Networks in Practice

Amgen, Biogen, Chiron, Genentech and Genzyme have become the most successful biotech companies constantly ranking among the top ten biotech firms in terms of revenue generation. Amgen and Genentech in fact epitomize the "founding fathers" of biotechnology and were among the first public biotech companies. Against the backdrop of their history and overall track record, these firms seemed the ideal subjects to study (for further details see Methods Box below).

Our analysis of these companies unraveled a set of striking commonalities among them both in regard to their understanding and design of network ties.

Just like skilled investors, these firms are found to define a clear network "investment" strategy and its returns (network objective function), to pick network partners according to their individual preferences at different stages (timing of tie-building; nature of ties), to have a long-term horizon (duration of ties), to hedge and spread the risk through (partner) diversity and a balance in their portfolio (balance of vertical and horizontal ties). Most importantly, we find that these networking skills go back to a distinct networking capability of these firms. The firms' networkability – their ability to create network ties in a fast and cost effective manner (*Fleisch*, 2001) – serves as the foundation of the entire network construction and design process. This networkability is found to be institutionalized in the firm's strategy, culture (people) as well as their organizational structure and processes. In doing so, networkability seems to have been infused into the organizational DNA of these firms.

The tentative guidelines that may be derived from the cases on how to build networks as well as the essential underlying organizational networkability are outlined in Table 2 (see below) together with the measures and benefits that accrue from them.

Research Design and Methodology

We selected the five most successful biotech firms (in terms of revenue) – Amgen, Biogen, Chiron, Genentech, Genzyme – to conduct our study on how to build innovation networks in biotech industries (see Table 1 below). The selection of these cases was driven by the ambition to learn from the "best in class" on how to design innovation networks.

Tab. 1: Overview of Case Study Companies

Company	Short Company Profile
AMGEN	Founded: 1980 Location: Los Angeles, CA # of Employees: 14,000 Revenues: 10,550 million USD
BIOGEN	Founded: 1978 Location: Cambridge, MA # of Employees: 4,266 Revenues: 2,211.56 million USD
CHIRON	Founded: 1981 Location: Emeryville, CA # of Employees: 5,400 Revenues: 1,605.11 million USD
Genentech In Business for Life	Founded: 1976 Location: San Francisco, CA # of Employees: 7,646 Revenues: 4,621.16 million USD
genzyme	Founded: 1981 Location: Cambridge, CA # of Employees: 7,100 Revenues: 2,201.15 million USD

Obviously, these established biotech firms cannot be directly compared to what has been called the new biotech firms (NBFs) which are much smaller in size and younger in age than the selected case study firms. The applicability of the network structures of the case study firms thus needs to be reflected against the backdrop of the additional constraints faced by NBFs (e. g., resource scarcity, low degree of routinization). Notwithstanding, an analysis of these case study firms' current network structures seems of major interest also to NBFs because at the outset these case study firms faced the same constraints and followed traditional development paths. As a matter of fact, the firms' current network structure emerged from a lengthy trial and error process – as the drawn out and immensely costly litigation processes between Genentech and Eli Lilly as well as the litigation between Amgen and Johnson and Johnson highlight. By gaining knowledge on the current design characteristics of the networks of these established players, NBFs may be able to take a short cut and prevent costly flaws. For the analysis of the firm's network structures, extensive secondary information was collected. Both firm internal and external information were gathered for this purpose. In-

dustry reports, analyst reports and comments, case studies, IPO prospectus, 10K statements, annual reports, roadshow presentations, company websites and CEO interviews served as the primary sources of information for this analysis.

Tab. 2: Tentative Guidelines on Network Construction

Tentative Guidelines	Measures	Benefits
#1 Start Network Construction at the Founding Stage	Mobilize social networks and former work-related ties Recruitment and "lock-in" of scientists embedded in strong social networks	Enhances long-term performance Incorporates social networks Provides signaling gains Reduces opportunistic behavior and establishes trust
#2 "Market-time" tie-building at later stages of the corporate life cycle	Tie-building in times of strong financial position Tie-building in times of strong public market conditions	Lends greater bargaining power Increases collaboration success chances through correct allocation of control rights
#3 Create Enduring Relationships	Long-term partnership contracts	Signals mutual benefits Reduces likelihood of opportunistic behavior
#4 Make Networking Part of Your Business Strategy	Make networking part of the firm's strategic intent Alignment of networking objectives and strategic objectives Operationalization of networking objectives	Emphasizes strategic and not only operational benefits of networking Provides shared understanding of network objectives Facilitates partner selection process
#5 Support Networkability Through Organizational Structures and Processes	Appointment of network managers ("honest brokers" and "marriage counselors") Establishment of Alliance management function Post-doctoral Programs for Scientists	Clear accountability Ensures smooth transition from contracting to actual partnered activities Embeds scientists in organizations (retention)
#6 Make Networkability Part of the Organizational DNA	Instilling network values	Increases chances for collaboration success Prevents hazards through cultural clashes (e.g., delays)
#7 Balance Horizontal and Vertical Network Ties in Network Construction	Simultaneous engagement in both horizontal as well as vertical upstream and downstream ties	Improves bargaining position Functions as entry barrier Creates Learning Opportunities
#8 Continuously (Re-)Shuffle your portfolio of network ties	Link explorative and exploitive network ties in product development	Improves chances for timely and successful product discovery and commercialization
#9 Ensure Partner Diversity	Sufficient level of partner diversity (while avoiding redundant network ties)	Limits intra-alliance rivalry (learning races) Avoids "conglomerate network discount" Increases absorptive capacity

#1 Start Network Construction at the Founding Stage

One of the foremost process questions is "when to start building network ties". The case study firms all started networking right from their inception. This fact itself may be somehow self-evident given the usual constraints young biotech firms face at the founding stage. Both liability of smallness (*Baum*, 1996) and newness (*Stinchcombe*, 1965) seem to make networking particularly salient at this early stage.

But less obviously, the timing of the start to build network is found to have major implications both on the nature and the development of the firms' networks. These imprinting effects on network evolution seem to be due to the special origin of these early ties. In keeping with former studies (*Hite & Hesterley*, 1999), we find that the networks created by the five case study firms at the time of founding originated from the social and work-related ties of the founders (e. g., Chiron, Genentech). Long-standing personal ties among scientists and university professors, sometimes forged decades earlier at universities, were often the starting point for network ties in the case study firms. Distinguished scientists often became either co-founders or/and were appointed to corporate officer positions which led to an attachment of the academics' strong social networks to the firms. For example, the founding of Genentech was based on the idea of commercializing scientific innovations at the University of California and Stanford University. Consequently, Genentech Inc. appointed Dr. Herbert Boyer, one of the star bioscientists at the University of California to the position of vice president and director of Genentech. Similarly, Genzyme Corporation fostered extensive long-term contractual relationships with BioInformation Associates (BIA), a firm owned by a group of eight scientists from both Harvard (George Whitesides) and seven MIT professors (among them Charles Cooney who was also appointed as a Genzyme director). Edward Penhoet, former faculty member of the Biochemistry Department at UC-Berkeley became the co-founder of Chiron and later served as the CEO and director of Chiron. Walter Gilbert, a Harvard professor and 1980 noble prize winner, together with other professors of MIT served on the scientific board of Biogen. Equally, Amgen "installed" respected university professors from Caltech, Stanford and UCLA on its scientific board.

Interestingly, these star bio-scientists and academics have not only been leveraged by the firms in respect to research and development. In addition, the star scientists have also been clearly used as a signalling instrument. The companies listed the star bio-scientists in their IPO prospectus as an executive, director, or member of the company's scientific advisory board (e. g., Amgen, Biogen, Chiron) and continue to present them prominently in their annual reports.

Benefits. Through the "lock-in" of star-bioscientists by making them part of the founding team, biotech firms achieve multiple objectives. First, a "lock-in" of star scientists at such an early stage has been found to strongly enhance long-term performance since they tend to deliver first-rate science but also because positive spillovers only arise through active participation of academic scientists in co-evolution and technical progress (*George et al.*, 2002; *Murray*, 2002; *Powell*, 1998; *Powell et al.*, 1996; *Zucker, Darby, & Armstrong*, 1998). Second, the scientists' inclusion ensures an incorporation of their dense social networks. These social

network ties can be turned into and leveraged as part of the firm's "professional" network relations. Third, the inclusion of scientists at the founding stage is a clever strategic ploy of biotech firms since it signals to competitors and resource providers the quality of the firm's activities and products (*Powell* 1998). Fourth, these early network ties can be extremely valuable for limiting opportunistic behavior and for establishing trust among the network partners since ties to these scientist may engender the diffusion of norms of open science and concomitant cooperation from which the biotech firm can benefit in the future (*Zucker et al.*, 2002).

Building the firm's network on the social network of scientists, however, also creates a certain degree of path-dependency in network evolution. In general, firms tend to turn first to their existing network relationships for potential partners to seek referrals from them on potential extensions to the network (*Gulati*, 1998). Such, the initial social network ties not only influence the creation of the network but also affect the design, the evolutionary path and the ultimate success of the network constellation (*Gulati*, 1998). The construction of a network should thus be undertaken with great care right from the start as the early network ties in particular are exhibiting a strong imprinting effect on the network's overall development. In fact, performance differences arising from compositional differences in biotech firm's network building at founding are likely to be immutable (*Baum et al.*, 2000). Firms that fail to configure an effective network at their founding stage are thus likely to be inferior competitors at any age.

#2 "Market-time" tie-building at later stages of the corporate life cycle

While networking at the founding stage is likely to come natural to biotech firms, the cases show that later on in the life cycle network building needs to be carefully timed. Most importantly, the timing of building network ties should be attuned with the firm's bargaining position.

The relative bargaining power of a biotech firm is to a great extent determined by two factors: the firm's relative financial position and the public market conditions for biotech firms at the time of network-building.

The relative financial position of the firm may be assessed by looking at the industry-adjusted performance measures of the firm. The "healthier" the biotech firm the stronger its bargaining position toward pharmaceutical firms. The biotech firm should thus be aware of efforts by pharmaceutical firms to protract network negotiations until the biotech firm comes into a weaker financial position which allows the pharmaceutical firm to extract key control right concessions.[3] *Aghion* and *Tirole* (1994) predict that a cash constraint of the biotech firm at the time of network building causes an inefficient outcome of the collaborative arrangement

3 The five most important control rights that have been identified in prior studies are the right to manage clinical trials, to undertake process development, to manufacture the final product, the right to market the product universally and the right to market the product alone (*Lerner & Merges*, 1998).

due to the tendency of pharmaceutical companies, that function as financiers, to misuse their bargaining power to retain suboptimal high levels of ownership.

The other factor determining a biotech firm's bargaining position, the public market conditions, can be estimated based on the volume of public equity issues by all biotech firms in a given quarter or year as well as the level of an inflation-adjusted index of publicly traded biotechnology equities in a given quarter or year.[4] The availability of equity from public investors has been greatly variable in the time from 1978–2004. During periods with little financing activity, especially young biotech firms suffer from critical financial distress and the bargaining power in network negotiations is likely to shift in favor of their potential network partners. In such "buyers' markets" biotech networks should disdain from entering too many network ties since they are likely to cede too many control rights in these instances (consult *Lerner & Merges*, 1998 for further discussion). In total, studies on the performance outcome of biotech-pharmaceutical partnerships underscore that partnerships that are entered between small technology ventures and large established firms during periods of limited equity financing tend to be less successful (*Lerner, Shane, & Tsai*, 2003).

Benefits. The correct market-timing in tie building ensures a strong bargaining position of the biotech firm. Consequently, it prevents a misallocation of control rights in the bargaining process.

#3 Create Enduring Relationships

The analysis of the five firms also lend several insights into the duration of network ties. As is custom for most biotechnology network ties, the firms manage a number of long-lasting ties. The question if the companies can create an enduring, committed relationship is a major selection criterion in Biogen's network strategy. Such a commitment to enduring relationships is typical for biotech industries and motivated by the long product development paths and regulation processes that can take up to 15 years.

In comparison, the literature offers contradictory advice concerning the duration of network ties. From a game theory perspective biotech firms should forge long-term ties with pharmaceutical firms as to reduce the likelihood of opportunistic behavior. Long-term ties also allow the participating firms to lower transaction costs since the drivers of transaction costs such as uncertainty and the frequency of interaction can be positively influenced. In addition, long-term relationships allow the partner firms to develop a common language and mutual understanding which may lead to positive reciprocity. *Jain* (1998), however, advises biotech firms to strike up temporary network ties during their growing period. This undoubtedly allows the networked firm greater flexibility and provides the firm with a larger opportunity set. But Jain's (1997) standpoint on this issue

4 Such statistics are, for example, provided by Recombinant Capital's database of biotechnology financing activity – a comprehensive database on biotechnology firm network recommended by the Biotechnology Industry Organization (BIO).

is somehow contradictory to his advice that biotech firms should at the same time seek financial security via network ties from a big pharmaceutical company. Due to the protracted development process these financial involvements are long-term investments by nature and generally involve an upfront payment followed by milestone payments and royalties of profit sharing. In addition, the drawn-out regulatory process proves to be another burden for biotech firms to gain greater independence since it slows the progress of products down thus hampering their commercialization pipeline. Therefore, it seems rather inevitable for biotech firms to enter long-term network relationships.

Benefits. Networks relations in biotechnology are characterized by longevity. Generally, follow-on collaborations are desirable since they are usually an indication for the mutual benefits of a collaboration. Biogen's network structure highlights that second and third collaborations with the same partner are not unusual. However, before prolonging the network partnership, biotech firms should critically assess these existing ties as well as alternative networking options. As has been cautioned above, prior network ties may severely limit the opportunity set of the firm both consciously and unconsciously. Determining a "use-by-date" for individual network ties at which the outside opportunities are evaluated may thus enhance the firm's networking performance.

#4 Make Networking Part of Your Business Strategy

In respect to the firms' wider understanding of and perception on networking, it is interesting to see that their networking abilities are constantly reckoned among the reasons explaining the companies' past and current success.[5] The sample firms describe their networking capabilities as being key in their ongoing search for innovative products and technologies and as a critical aspect of their business strategy. For example, Biogen Inc. proclaims that "partnering is an essential strategic component to Biogen's future success". Consequently, the five firms are found to have formulated a clear objective function for their networking activities. The firms' network objective function clarifies what to seek and what to achieve.

Biogen, Genzyme and Genentech specify the areas in which collaboration is desired (e. g., oncology, immunology and angiogenesis) as well as have well-defined sets of skills that are regarded as complementary (e. g., expertise in biologics capabilities in small molecules, proteins and antibodies). In addition to the definition of what is sought through networking, the selected biotech firms have set clear objectives. As part of its 5x5 project, Genentech, for example, explicitly formulated its goal to generate 500 million USD in new revenues from networking. Similarly, Biogen announced that it aims to in-license half of its pipeline by 2010

5 "Developing alliances has been one of Genentech's key strategies for success from its inception" (Genentech Inc.). "Successful alliances have the potential to create significant value for Biogen Idec and our partners. The ability to enhance our pipeline through partnerships will be an important driver in the future growth of our company" (Biogen Inc.).

and has budgeted $200 million a year for business development and external research opportunities starting in 2006.
Benefits. The definition of the network objective function provides a shared understanding about what is sought and what needs to be achieved. Moreover, the clear outline of the objective function helps to direct the selection process both for the firms as well as potential network partners.

#5 Support Networkability Through Organizational Structures and Processes

Complementary to the social ties star scientists have carried into their organizations, the firms are found to have established appropriate organizational structures which assist the social network construction with the scientific community as well as other potential network partners. These structural measures comprise a.) the appointment of an individual or an entire organizational unit exclusively dedicated to network construction and b.) the creation of special career development tracks for scientists.
a.) A major structural measure to facilitate network construction is that these firms have appointed key individuals who function similar to what *Powell* (1998: 237) describes as network managers, "marriage counselors", or honest brokers. These individuals provide the glue that sustains the relationships between parties. Biogen has even established a professional alliance management function that consists of a department of program and alliance management as well as alliance review committees to establish a routinized networking process. The alliance review committees are therapeutically focused panels that provide an evaluation of individual networking opportunities from a clinical, scientific, legal and commercial perspective. The Department of Program and Alliance Management at Biogen provides mostly leadership and management expertise in building collaborations. The department gets involved early in the deal process, takes an operational role during due diligence and structures the collaboration deal. Most importantly, the network task forces not only take part in the identification, selection and negotiation phases but also in the actual "integration period". Within this integration period, their task is to identify, align, and leverage the capabilities of both network partners as well as to map and align the work processes as well as to constantly monitor the quality of the relationship between the partners. In addition, joint program teams that are led by program directors from Biogen and the partner firm are set up that report to a joint steering committee, composed of senior executives from Biogen Idec and the partner firm. This steering committee typically meets on a quarterly basis to review the product development strategy and program progress. Another important process parameter which can be noticed when analyzing the formation and design process at Biogen is that in addition to the alliance management department, Biogen ensures the active involvement of its top-management team (TMT).[6]

Similarly to Biogen, Amgen created Alliance Management, a group dedicated to streamlining the business and contractual aspects of Amgen's partnerships. The

group of network experts works with team members across all functions from both Amgen and its network partner to establish project objectives and decision-making procedures before research work begins on the program. The Alliance Management groups is also meant to manage the collaboration process after the deal through ensuring that questions are channeled quickly through the company's law, licensing, corporate communications, finance and information services departments. The Alliance Management group also holds a monitoring function meant to identify and resolve issues that might otherwise strain the relationship. As part of the continuous guidance of the relationship, the Alliance Management team also helps identify strategic opportunities for the program which includes suggestions for an extension of the network.

b.) Another structural measure to increase the firms' networkability is the design of special career tracks for scientists. The firms have launched career advancement programs that are conducive to embed scientists in the organization and thus tie their social network to the firms' professional network. At the lowest level, Biogen, for example, has initiated a post-doc program. These post-doctoral programs are generally meant to attract top scientists and to embed the companies in strong and lasting ties with the scientific community. Further, career tracks for scientists have been designed that allow them to play a decisive role in the company's overall development instead of being just heads of laboratories. In most of the cases, star scientists have been promoted to serve on the actual corporate board. In addition to the corporate board, scientific boards or scientific advisory committees have been established to link scientists to the firms.

Benefits. The creation of an organizational function ensures a professional management of the portfolio of network ties. Moreover, it ensures that the relationship is not disrupted by continuously changing responsibilities and project management changes. The management of the relationship by one task force from beginning to end also clarifies accountability and ensures a smooth transition between the final contract signing and the beginning of partnered activities. It also enhances the integration of the program and helps to build stronger relationships. Moreover, networking has clear advocates in the organization with both a formal department and the TMT being involved. As for many other strategic initiatives, the involvement and support of the TMT seems particularly crucial for collaborative success. For potential new network partners, the alliance departments make it easy to approach the firms since they offer a clear "point of entry". The establishment of career tracks and career development functions helps to embed scientists and their social networks in the professional network structure of the firm.

#6 Make Networkability Part of the Organizational DNA

The analysis of the case study firms further unravels that each firm claims networkability to be one its major assets or values which has been incorporated in

6 "Our senior management team will play an active role in forging productive, long-lasting partnerships" (www.biogen.com).

their firm-specific culture. Biogen, for example, states collaboration as one of its five core values in the firm. Collaboration is thus virtually infused into the companies genetic code. Moreover, the firms not only try to instill a network culture but also take close attention to the cultural fit of the network partner. The alliance management teams at Amgen and Biogen also have the task to assess the cultural fit of the network partners. The complementarity not only of products and skills but also of strategic intent or vision are stated as being of major importance when setting up network ties. Biogen for example explicitly states that it aims at becoming the partner of choice for companies with not only complementary products but also complementary vision.

Benefits. By embedding networking as a value in the firm's culture and assessing the network partners' culture, the firms seem to take a decisive step to networking success. After all, culture clashes have been found to one of the main reasons alliances fail (*Lerner et al.*, 1998). A cultural adversity to networking may also cause delays that can multiply within the network. In fact, a major reason for delays is the "not invented here" syndrome in pharmaceutical companies in which the technical staff is unwilling to accept the "imposed" innovation (*Lawton-Smith, Dickson, & Smith*, 1991). A lack of trust and ensuing difficulties in relinquishing control are further barriers to effective collaboration that may result from cultural differences (*Powell et al.* 1996).

#7 Balance Horizontal and Vertical Network Ties in Network Construction

A key challenge for the network architect is to construct a portfolio of collaborators that provides access to both the emerging science and technology as well as the necessary resources. On average, the firms show a well-balanced portfolio of network ties in respect to their number of horizontal and vertical (downstream and upstream) ties.

Horizontal ties refer to network ties to other biotechnology firms. Vertical downstream ties refer to cooperative arrangements with pharmaceutical, chemical and marketing firms. Vertical upstream ties refer to collaboration with universities, research institutes, government labs, hospitals and industry associations. Genentech, for example, has numerous "upstream" collaborations with academic institutions such as the United Medical School and the University of South California which focus on the discovery and development of new products. Its "downstream" collaborations with pharmaceutical firms differ in focus and are mostly focused on the commercialization of its products. "Horizontally", Genentech offers a "Windows on Technology Program", in which Genentech makes equity investments in companies with promising, novel technologies and builds ongoing relationships that may lead to greater future collaborations.

Similarly, Genzyme has numerous agreements with research institutions such as the University of Pittsburgh, the John Hopkins Medical Institutes and the New England Medical Center in place as well as several marketing agreements with pharmaceutical firms concerning the distribution of its products. Genzyme

has also considerably extended its outreach to the academic sector by participating in the Network T2 Program of LARTA, a private non-profit organization, that initiated a program to foster collaborations with companies by providing technology opportunities from its academic affiliates (17 universities and institutions in California). Also, Biogen holds licensing agreements for initial discoveries with Abbott, Lilly, Merck while collaborating with research organizations in the field of analyzing clinical trial data on medicines in development and numerous ties to start-up gene therapy companies (i. e. *Genovo*). Amgen also has numerous ties to small, early-stage biotech companies (e. g., ARRIS, Envirogen, Zynaxis) which have been welded through Amgen's corporate venture fund. The small biotech firms develop technology which is marketed with Amgen's financial and scientific assistance and through close affiliation with established pharmaceutical companies. Amgen also holds key licensing agreements with Sloan Kettering Hospital, the Ontario Cancer Institute and Rockefeller University.

Benefits. The balance of horizontal and vertical ties generates a number of benefits for these firms. In this context, not only the operational (e. g., exchange of complementary technologies, reduced time to market) but also strategic benefits should be recognized by the network architect. Horizontal ties strengthen the biotech firms' bargaining power towards pharmaceutical firms and avert resource constraints that may be exploited by pharmaceutical companies in the subsequent partnering for the commercialization of the product by demanding excessively high levels of control rights. Especially, the ability to attract top scientists from the relevant academic fields helps to gain bargaining power towards the pharmaceutical companies which have for the most part been unable to offer the combination of equity-based financial incentives and research environment sought by most scientists (*Pisano*, 1990: 240). Obviously, compared to vertical ties, horizontal ties are certainly more fraught with difficulty due to a fear of proprietary information leakage and the propensity for learning races. However, horizontal ties succeed in discouraging potential entrants through blocking access to uncodified, tacit knowledge about strategy, technology and operations critical to success for new entrants (*Baum et al.* 2000: 515; *Liebeskind et al.* 1996; *Powell* 1990). Further, as Edward Penhoet, president and chief executive of Chiron points out (quoted in *Fisher*, 1996), collaborating with competitors gives the focal network firm an opportunity for peer review that is hard to come by in the corporate world. Moreover, scholarly studies proposed that a balance of horizontal and vertical ties positively affects a firm's absorptive capacity (*George et al.*, 2001).

#8 Continuously (Re-)Shuffle your portfolio of network ties

In addition to the firm's overall balance in their portfolio of vertical and horizontal ties, we noticed that there are subtle variations in both the extent and nature of these ties. In contrast to smaller biotech firms facing severe resource constraints, pharmaceutical firms function far less predominantly as financing partners ("sugar daddies"), present to write checks, for the case study companies. While the pharmaceutical companies are also seen as vehicles to fund product develop-

ment and commercialization, they are additionally recognized as sources for valuable expertise in manufacturing, clinical trials, regulatory affairs, and marketing. A similar distinctiveness can be made out in respect to the firms' horizontal ties. Due to their privileged resource endowment, the case study firms not only engage in research and development ties with other biotech firms but have obtained also the position of a financing partner for other biotech firms – a role which has mostly been reserved for pharmaceutical firms. Amgen and Genentech (GenenFUND) have even set up corporate venture capital funds that identify and invest in companies with compelling technologies and/or drug candidates that are too early for licensing.

Also, closely connected to the balance of vertical and horizontal ties, the five biotech firms are found to reshuffle their portfolio of horizontal and vertical up- and downstream ties over the product life cycle. At the initial stage of product discovery, horizontal ties with fellow-biotech firms and vertical upstream ties are prevalent. These ties are explorative in nature. Exploration network ties are built with the motivation to discover something new. At later stages, when the product reaches a marketable stage, exploitative ties gain in importance. Exploitation network ties are built with the goal to join existing competencies across organizational boundaries in order to generate economies of scope. Biogen, for example, struck up a collaboration with the University of Zurich which led to the discovery of Intron A, the first product to enter clinical trials for the treatment of certain types of leukemia and hepatitis C. Subsequently, Biogen decided to commercialize Intron A through an exploitation alliance with the pharmaceutical company Schering. The exploitation alliance included a licensing agreement with Schering, which took on the clinical trials and regulatory activities of the product as well as its marketing, distribution, and sales. Product discovery and development were thus achieved through an explorative network tie with a research institution while the subsequent commercialization of the product was realized through an exploitative network relationship. While biotech firms should foster both exploration and exploitation network ties, they should weigh them according to the product development stages in different areas of expertise. Multiple types of network ties with different objectives thus need to be coupled in the process of product development.

Benefits. The firm's ability to offer both complementary research and development resources as well as essential financial resources to other biotech firms increases their attractiveness for potential network partners. By attuning network relations with the individual product life cycle stage, the firms ensure a timely and successful development and commercialization of their products.

#9 Ensure Partner Diversity

The firms' network ties seem also well-balanced in respect to the diversity of the network partners as can be judged by the network partners' individual backgrounds and special foci. Balancing partner diversity seems another critical issue in building an efficient network. Biotech firms that increase their number of net-

work ties without considering partner diversity are likely to end up with inefficient configurations. Too much diversity in partners may delude the objectives of the networking efforts and the costs of handling the diverse relations may in fact exceed the benefits due to too much redundancy in information. Chiron, in fact, seems to have fallen into this "diversity trap". Over the years, Chiron has become something what may be called a "biotech-conglomerate". The firm has established a highly diverse and complex network of equal-partner alliances. This has generated harsh criticism on part of analysts, investors and capital markets. On the one hand, the construction of such a network of multiple, duplicate partners may thus not only have internal implications on the productivity of network ties but may also have wider external implications leading to a "conglomerate network discount" for the firm. On the other hand, a too narrow focus in partner selection and by limiting the number of links with other firms, the focal firm may fail to obtain novel information about emerging technologies critical to its adaptation. Learning races – constellations in which partner firms attempt to extract as much knowledge as possible from its partners while divulging as little as possible – and intra-network rivalry, more generally, are imminent threats faced by a too narrow configuration of networks that predominantly consist of potential rival biotech firms that operate in common market sectors. Biotech managers should thus be very thoughtful about the number and configuration of ties they cultivate. The utility assessment of a new relationship becomes more difficult to assess with a larger number of ties. The network architect needs to contemplate the trade-offs when pursuing multiple partnerships. It is hard to balance flexibility and embeddedness in the network. Network architects need to be aware of the fact that the network might eventually, similar to any technical system, face the problem of rigidities causing diminishing returns.

Benefits. Partner diversity is an important element in network construction. Partner diversity avoids excessive intra-network rivalry and learning races among network partners. Further, partner diversity lends firms flexibility with respect to financial constraints and risks since it diversifies financing (*Staropoli*, 1998). A too extensive degree of partner diversity, as in the case of Chiron, however, may lead to costly redundancies and a potential "conglomerate network discount" for the firm.

2. Conclusion

A new market opportunity often initiates the creation of an innovation network (*Powell* 1998). The identification of a new market or technological opportunity which the firm is unable to access, survey, and exploit, activates the firm's cooperation potential. However, it should not be taken for granted that such a cooperation potential is an asset which is automatically inherent in firms. Instead, the first major step in building a network is the creation of a cooperation potential which is a function of the firm's networkability. The firm's networkability is needed to lay a foundation for networking activities to allow the firm to profit from its network ties. It is important for a firm not to rely on an individual's networ-

king ability since these key employees are often hard to retain in highly competitive industries such as biotechnology. As the cases illustrate, networkability has to become an organizational capability which means that this capability has to be developed throughout the organization and should be institutionalized in the firm's strategy, culture, structures and processes. Succinctly, networkability needs to be build into the organizational DNA of biotech firms.

The guidelines we suggested cannot be more than tentative suggestions since the construction of a network is likely to be influenced by many other idiosyncratic firm and context factors that could not be possibly be covered by our discussion. Also, the guidelines and measures, we derived, should by no means be viewed as independent of each other nor should they be misinterpreted as dictating one, single logical sequence of measures to be taken – as may be wrongfully implied by their numbering. Nonetheless, we hope to have raised biotech managers' awareness for the multiple individual as well as integrative effects of the contingencies biotech managers should consider when building an innovation network. Further, by carving out potential 'ground rules' for building innovation networks, we hope to have given biotech managers a better idea of the desired network building process and the final network structure which may assist them in developing networkability and in defining a suitable network building strategy.

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