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**Interaction between  
Researchers, Firm managers  
and Venture capitalists  
—  
the Essence of  
Biotechnology business**

Anna S Nilsson



Stockholm 2001

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## ABSTRACT

The knowledge gained from the advances in biotechnology-related research is the basis from which a number of opportunities are derived. The potential of these opportunities have raised high expectations with actors, regions and entire nations. There are, however, difficulties in pursuing opportunities, which calls for increased understanding of the logics of such processes. One aim of this thesis is therefore to gain further insight into processes of opportunity-pursuits in biotechnology business.

Four studies contribute to an increased understanding of pursuits of opportunities in the areas of knowledge production, firm creation and business development. Study I, using the method of bibliometry, contributes with data on the development of knowledge production regarding publications in Sweden over a 10-year period. It shows, for example, that the area of Stockholm-Uppsala is the most active region both in terms of production of publications and collaboration. Studies II and III contribute with frames of reference with respect to firm creation and business development. Study II points out that the personal networks of founders of firms are vital for establishing contacts with venture capitalists, and that there are substantial differences in the type of added value provided by specialized venture capitalists. A possible predictor of the ways in which an early-stage venture capitalist will add value in a biotechnology venture, is the initial existence of a chief executive officer and his or her experience. Study III establishes that biotechnology firms apply network strategies that enable them to keep a flexible organization and that facilitate access to front-line research through collaboration with academia. Their strategies are divided into the concepts of intermediary and integrating firms. Study IV contributes by exploring risk issues in business development and ways in which managers in biotechnology firms may respond to these issues. The result implies that the nature of decision-processes may be opportunity-driven.

The findings from the studies, in conjunction with previous research, imply that interaction is essential to pursuits of opportunities in biotechnology business. Another aim of this thesis is therefore to create a conceptual framework clarifying the role of interaction in such processes. An analysis of interactions between researchers, firm managers and venture capitalists was performed by using the empirical data from the studies collectively. The analysis is the foundation for the development of a new conceptual framework and for a general discussion on opportunity-pursuits in biotechnology business. One insight gained from the analysis is that entrepreneurship can be understood as a relational concept. The conceptual framework shows that social capital is of utmost importance in the pursuit of opportunities. Interaction enables social capital to increase and without interaction it will die out. Interaction is thus necessary for the existence of social capital and social capital is necessary for pursuing opportunities, which leads to the proposal that interaction is essential in biotechnology business.

The logic of processes of opportunity-pursuits in biotechnology business introduced in this thesis speaks specifically for the groups from which it was derived and, hence, is applicable to them. The descriptions and explanations are therefore likely to be valuable to practitioners and policy makers who want to increase their understanding of opportunity-pursuits in the areas of knowledge production, firm creation and business development. The conceptual framework, including a model of processes of opportunity-pursuits, clarifies the role of interaction and is of value as a base for future research.

*Key words: biotechnology, opportunity-pursuit, interaction, knowledge production, firm creation, business development, financial – human – social capital, researcher, firm manager, venture capitalist*

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## LIST OF PUBLICATIONS

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- II. Nilsson, A. and Skår, J. Differences in provision of added value: The case of specialized venture capitalists and early-stage biotechnology ventures. Manuscript
- III. Nilsson, A. (2001) Biotechnology Firms in Sweden, *Small Business Economics*, vol. 17, no. 1-2, pp 93-103
- IV. Nilsson, A. and Skår, J. Where risk meets risk – risk understanding in biotechnology research firms and in the financial market. Manuscript

*To my parents Maj-Britt and Sven-Ola*

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## LIST OF KEY WORDS

|                        |  |
|------------------------|--|
| Actor                  | The types of actors focused on in this thesis are researchers, firm managers and venture capitalists active in biotechnology-related areas   |
| Biotechnology          | Technologies that make use of living organisms, or parts of living organisms, in order to create new products or processes   |
| Biotechnology firm     | Firm that, as main activity, develops, produces, analyzes, or uses living organisms, or parts of living organisms, in order to create new products or processes  |
| Biotechnology business | A broad concept including all activities that aim at improving quality of life by enhancing the value of knowledge of living organisms   |
| Business development   | Strategic activities in existing firms: increasing the pipe-line of research and development and/or bringing selected projects closer to commercialization   |
| Capital                | Financial, human and social capital  |
| CEO                    | Chief Executive Officer  |
| Financial capital      | Indirect or direct access to money   |
| Firm creation          | Pre-firm and start-up stages: establishing proof of commercial potential in research   |
| Firm manager           | Individuals that manage biotechnology firms  |
| Human capital          | Natural abilities combined with skills acquired through schooling and working experience   |
| Intellectual property  | Patents, copyrights, trademarks, trade secrets and similar rights in ideas, concepts etc.  |
| Interaction            | Reciprocal action between two or more persons  |
| Knowledge production   | Activities that add to the science base. The outcome of such activities may include, for example, publications or patents.   |
| Living organisms       | Organisms that can reproduce themselves  |
| Opportunity-pursuits   | Refers to opportunities that are derived from the knowledge gained from the advances in biotechnology-related research (opportunity-areas addressed in this thesis: knowledge production, firm creation, business development) |
| Researcher             | Individuals that work as scientists in biotechnology-related areas in the academic world   |
| Social capital         | Relationships through which actors get to use financial and human capital  |
| VC                     | Venture Capitalist (Individuals that are general partners or associates in a firm that specializes in providing venture capital financing)   |

## 1 BIOTECHNOLOGY BUSINESS - SETTING THE SCENE

*“As we stand at the dawn of a new century, we recognize the enormous potential that biotechnology holds for improving the quality of life here in the United States and around the world.”*

President Clinton, January 20, 2000

The potential for improving the quality of life through biotechnology has created an entire industry. New business opportunities are continuously recognized along with the advancements of biotechnology-related research. Biotechnology stands for technologies that make use of living organisms, or parts of living organisms, in order to create new products or processes. Although the industry is new, biotechnology is not. Our constant search for a better life gave rise to discoveries long ago that made it possible for beer, wine, cheese and more to be produced by the use of living organisms and fermentation processes. Likewise, crops and livestock have been improved through biotechnology for centuries.

Watson and Crick’s discovery in 1953 at the University of Cambridge of the structure of the genetic code for all organisms (DNA) laid the foundation for modern biotechnology. Another major step was the development of a technology allowing genetic material that runs the production of proteins to be taken from one organism and put into another. The organism with the added genetic material can then produce the proteins that the new material codes. This technology - recombinant DNA – was developed in the 1970s by Cohen and Boyer at the University of California, San Francisco. Discoveries about the importance of proteins had already been made and researchers were eager to grasp the new opportunity to produce large amounts of proteins by inserting genes in fast growing bacteria. The use of the technology would allow researchers to increase the research on the functions of different proteins and, further on, improve diagnostics and medical treatment. Noting the large demand for the technology and envisioning its importance for future improvement of quality of life, the venture capitalist Swanson recognized a business opportunity. In 1976, Swanson and Boyer commercialized the recombinant DNA technology by creating the biotechnology firm Genentech. Thus, the first step toward an entirely new industry was taken.

The development of this industry was influenced by several factors. One was the successful introduction of Genentech on the public market in the USA in 1980. It signaled that investors could be interested in firms even though they did not yet have products, sales or income, as long as they had potential. It thereby became possible, from a business perspective, to develop biotechnology firms. Venture capitalists and researchers, who joined forces to commercialize scientific discoveries, recognized this opportunity. Their efforts were facilitated by the Bayh-Dole Act<sup>1</sup> (1980) that gave universities in the USA ownership to discoveries generated by public financing. This new law, created to increase the competitiveness of the USA, further encouraged increased collaboration between universities and industry, which is of utmost importance to biotechnology firms. The progress of these firms is closely related to the amount, quality and new directions of research produced at universities. Biotechnology firms focus on commercialization of research, which makes access and control of intellectual property and collaboration with front-line researchers key in their business. Regulations regarding intellectual property rights pioneered the opportunity to patent substances that might be developed into “block-buster” drugs<sup>2</sup>. These regulations were essential for the industry as it motivated the creation of firms focusing not only on new processes, but also on the development of new products. At an early age, the pharmaceutical companies lacked competence within biotechnology, which motivated them to collaborate with biotechnology firms to benefit from the new technology.

*“We realize that no single organization has all the expertise required to produce the innovative solutions for the numerous unmet medical needs still present.”*

P. Gwyne, Eli Lilly, April, 2000<sup>3</sup>

These collaborations have become a major source of income for biotechnology firms and motivate many to position themselves as intermediary firms<sup>4</sup>. As such, they perform early research and development of discoveries until a stage where clear commercial potential is established and where pending high development costs motivate collaboration with pharmaceutical companies. Almost all pharmaceutical companies use biotechnology

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<sup>1</sup> The University and Small Business Patent Procedures Act. The act stated that the universities should strive to collaborate with commercial actors to increase the usage of innovations that are publicly financed, the universities are expected to apply for patents on the discoveries they own and grant licenses primarily to small firms. (see, e.g., Barfield & Smith, 1997).

<sup>2</sup> Cockburn et al. (1999) present a thorough description of the development of pharmaceuticals and biotechnology including the issue of intellectual property.

<sup>3</sup> Official statement at an investment conference in New York

today as a comprehensive research tool in the development of drugs. There is also an increasing amount of biopharmaceuticals being developed (drugs based on proteins or other natural or modified biological molecules)<sup>5</sup>. The global market for biotechnology products is expected to increase from 20 billion dollars in 1998 to 75 billion dollars in 2009<sup>6</sup>.

*“The U.S. biotechnology industry, long on promise and short on delivery for the entire two decades of its history, is finally selling real medicine to real people for actual money.”*

The Washington Post, Aug. 22, 1999

The use of biotechnology is not limited to pharmaceuticals, vaccines, diagnostics and research tools. It has also improved processes and provided new products within other areas, including agriculture and environment. Concerning firms, the industry has grown in both the USA and Europe. The number of firms has increased with 56% in the USA and with 100 % in EU between 1996 and 1999, leading to approximately 1,500 firms (USA) and 1,400 firms (EU) in 1999<sup>7</sup>. The industry continues to grow because of the increased use of biotechnology in various areas, the recognition of new business opportunities and the interest from investors.

Investors' attitudes toward the biotechnology industry have fluctuated. Because of long development times<sup>8</sup> and high risks related to research that is hard for most to grasp, investing in biotechnology firms has proven difficult. A lack of competence and unrealistic expectations caused many investors in the 1980s to make investments that proved to be disappointments. One major difficulty for investors is that the main value of biotechnology firms is in the form of intellectual property. The products exchanged are primarily in the form of research and development projects, including patents, that are necessary to develop new products and processes and thereby potentially very valuable. These intellectual properties need to be complemented, verified and further developed

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<sup>4</sup> Another alternative being integrating firms. For definitions, see Chapter 2, Study III.

<sup>5</sup> See Walsh (2000) regarding the emergence of biopharmaceuticals.

<sup>6</sup> Med Ad News, July 1999

<sup>7</sup> US statistics based on the database at the Institute of Biotechnology Information. Source for EU statistics are the Ernst & Young Annual Life Science reports.

<sup>8</sup> It is estimated to take 10-12 years to develop and launch a new drug. The cost is estimated to 250 million US dollars. (Senker & Sharp, 1997)

before products, that can be sold on the market, actually exists. During the development, results may prove unsatisfactory and hence the intellectual property becomes less valuable. The value of biotechnology firms is, in short, hard to measure. The overall picture, however, shows that the investment community finds it worthwhile to continue to invest in biotechnology<sup>10</sup>.

*"When a drug hits, it's like a gusher. With the potential for such huge revenues, venture capitalists will continue to invest in biotech start-ups of all kinds."*

B. Byers of Kleiner Perkins Caufield & Byers<sup>11</sup>

The knowledge gained from the advances in biotechnology-related research is the basis from which a number of opportunities are derived. The project of mapping the human genome (in which the two main actors are the public HUGO-constellation and the private firm Celera) has, for example, produced results considered to have large commercial potential. Actors pursue opportunities in an outcome space in which improving quality of life through increased knowledge of living organisms can be said to be some ultimate objective and outcome. In reality, all types of actor are subjected to a number of constraints with respect to information, available resources, time, etc., forcing them to focus on intermediate outcomes. Such intermediate outcomes are reached through the pursuit of opportunities in areas such as:

- knowledge production: adding to the science base through, for example, publications
- firm creation: establishing proof of commercial potential in research
- business development: increasing the pipe-line of research and development and/or bringing selected projects closer to commercialization

### **Research area**

The advances in biotechnology-related research have raised high expectations with actors, regions and entire nations that hope to realize the potential of opportunities. Apart from

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<sup>10</sup> The investments by venture capitalists in biotechnology firms increased with 14.8% between 1998-1999 in the USA (National Venture Capital Association). During the two first months in 2000, 8.5 billion dollars were invested in the sector, which is more than for the whole of 1999 ([www.mercurycenter.com](http://www.mercurycenter.com)). There was a dip in the later part of 2000, but the interest picked up again in 2001 (National Venture Capital Association).

<sup>11</sup> The Red Herring Magazine, May 1998 (Kleiner Perkins Caufield & Byers is a well established American venture capitalist firm)

actions taken by individual actors, governments have launched various projects designed to strengthen the commercialization of knowledge of living organisms (Fuchs, 2001, Prevezer, 2001, Oakey et al., 1990, Cookburn et al., 1999). Previous research show, however, that many pursuits of opportunities fail to realize. Orsenigo (2001)<sup>12</sup> highlights the following factors as obstacles for the development of biotechnology firms: lack of strong scientific base, weak links between academy and industry, difficulties in attracting venture capital and the relatively narrow scope in which patents can be claimed. This points to the need for research on pursuits of opportunities in order to understand the logics of such processes in biotechnology business. Within mainstream research, however, there is a scarcity of research in the field. Three areas have been perceived as key within biotechnology business through previous research and my interpretation of the conditions in biotechnology business. Hence, these areas are made focal to this thesis. The following section provides a brief presentation of previous research in each of the three areas that, together, contribute to a picture regarding opportunity-pursuits in biotechnology business.

### Knowledge production<sup>13</sup>

Knowledge production in the area of biotechnology is transdisciplinary due to the need to bring together disciplines such as biochemists, microbiologists and chemical engineers (Gibbons et al 1994). In relation to the mapping of the human genome, molecular geneticists work together with software experts. Gibbons et al (1994) present a “Mode 2” of knowledge production in order to meet the need for a new way of looking at what kind of knowledge that is produced and how it is produced. This mode is appropriate to transdisciplinary knowledge, where creativity is mainly considered to occur within groups and which links actors together through functioning networks of communication. Zucker et al. (1994, 1996, 1997) show that commercial involvement by academic researchers is not a substitute for, but rather a complement to knowledge production in the form of publications. It is the already very productive researchers in academia that engage in commercialization. Moreover, this engagement does not influence their rate of publishing. In fact, the data indicate that the quality of research results by researchers in academia increases during engagement with firms<sup>14</sup>. Furthermore, they show that star scientists<sup>15</sup> in

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<sup>12</sup> Case-study of Lombardy, Italy

<sup>13</sup> Knowledge production refers to activities that add to the science base. The outcome of such activities may include, for example, publications or patents.

<sup>14</sup> Quality measured in number of citations.

the academic world influence where and when firms commercialize biomedical discoveries. Zucker et al. found that the increase of biotechnology firms in a region is significantly related to higher numbers of publishing star scientists, prominent universities, researchers with public financial support and higher average wages. Research on the collaborations between academic researchers and firms in the production of knowledge within biotechnology-related research has also been carried out by, for example, Blumenthal et al. (1996), Anderson et al. (1996) and Audretsch and Stephan (1996).

#### **Firm creation<sup>16</sup>**

The creation of biotechnology firms is contingent on venture capitalists (Fildes, 1990). Bygrave and Timmons (1992) and Gompers and Lerner (1998, 1999a, 1999b) are considered to be among the leading researchers on the behavior of venture capitalists and how it influences the creation of firms. They highlight that venture capitalists are increasingly specializing in order to develop expertise that makes them valuable members of networks. A strong position in networks is necessary to access the information they need to recognize investment opportunities and locate co-investors, managers for their portfolio firms, etc. The researchers do not focus on creation of biotechnology firms, but include it as one of many areas where the venture capitalists in their research are active. Research on the activities and characteristics of venture capitalists in general have been performed by many others, including Sapienza and Gupta (1994), Barney et al. (1996), Cable and Shane (1997), Gifford (1997) and Manigart and Sapienza (2000).

#### **Business development<sup>17</sup>**

Developing biotechnology firms into more established players provides challenges that differ from those found in many other industries. Powell (1991, 1992, 1996, 1998, 1999) has made this point highly visible in his extensive research on the development of biotechnology firms. Results indicate that biotechnology firms use collaborations to continuously expand all their competencies, rather than as a temporary mechanism when they need to compensate some inefficiency. The actions of the firms are shaped by the position they hold in the overall network. Powell noted that a strong and central position within a network is directly linked to increases in biotechnology firms' volumes of

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<sup>15</sup> Zucker et al. (1994) termed scientists as "stars" on the bases of the number of genetic sequence discoveries for which they were an author and the number of such articles.

<sup>16</sup> Firm creation refers to pre-firm and start-up stages.

<sup>17</sup> Business development refers to strategic activities in existing firms.

patenting, non-operating income<sup>18</sup> and sales. It also stimulates growth in the firms' internally funded research and development, the use of alliances within research and development and the size of the firms. The development and behavior of biotechnology firms have also been researched by, for example, Orsenigo (1989), Greis et al. (1995), McKelvey (1996) and Swann et al. (1998).

### **Research problem**

Difficulties in realizing opportunities in biotechnology business, recognized in previous research, point to the question of how processes of pursuits of opportunities in the area can be more effective. There is thus a need for increased understanding of the logic of such processes, which motivates further studies on different opportunities. The purpose of Studies I-III, in this thesis, is therefore to explore pursuits of opportunities in the key areas of knowledge production, firm creation and business development. The purpose of Study IV is to explore the issue of possible obstacles in pursuits of business development.

The findings from the studies, in conjunction with previous research, imply that interaction is essential to pursuits of opportunities in biotechnology business. Whereas previous research increases the understanding of the value of interaction in opportunity-areas, it does not show the dynamics of interaction between actors in processes of pursuits. There is thus a need for further insight into the role of interaction in the processes and theory-building related to such processes. It is therefore an important research task to explore why actors interact in pursuits of opportunities derived from advances in biotechnology-related research and how their roles may change because of interactions. This task can be performed by analyzing interactions between different types of actor within different areas of opportunities on a micro-level. The purpose of the general discussion is to perform such an analysis and thereby lay a base for a conceptual framework and a description of the role of interaction in opportunity-pursuits.

### **General aim**

The general aim of this thesis is to gain further insight into processes of opportunity-pursuits in biotechnology business and create a conceptual framework clarifying the role of interaction in such processes.

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<sup>18</sup> In their study, Powell et al. (1999) included the following in non-operating income: any income resulting from secondary business-related activities, such as grants, licensing or other royalties, investment income, externally sponsored research, and any other source of income not classified as sales.

### **Specific purposes**

The specific purposes of the four studies are:

- I. To analyze the Swedish knowledge production and knowledge flow within biotechnology-related areas and to identify active actors, scientific profiles and collaboration patterns.
- II. To create conceptual frames of reference of (a) how initial contacts are made between founders and venture capitalists and (b) ways in which specialized venture capitalists provide added value in the creation of biotechnology firms in the USA.
- III. To create conceptual frames of reference of the strategies of biotechnology firms in Sweden, how they manage to maintain a competitive edge and how they finance their activities.
- IV. To describe risk issues and how firm managers may respond to these issues in the pursuit of business development.

The specific purpose of the general discussion is to analyze interactions between researchers, firm managers and venture capitalists, within the opportunity-areas of knowledge production, firm creation and business development.

### **Limitations of scope**

There are numerous areas of opportunities within the outcome space in which improving the quality of life through increased knowledge of living organisms can be said to be some ultimate objective and outcome. The concept of quality of life is limited to the issue of health in this thesis. I focus on the three opportunity areas that were mentioned earlier, as the intermediate outcomes that these pursuits can lead to are fundamental for the prospects of improving quality of life through biotechnology. Such a focus permits increased understanding of processes in the development toward some intermediary outcomes. However, it limits the ability to make assumptions regarding their long-term development and ultimate outcomes. Moreover, the opportunities pursued in the chosen areas constitute pieces of a much bigger puzzle.

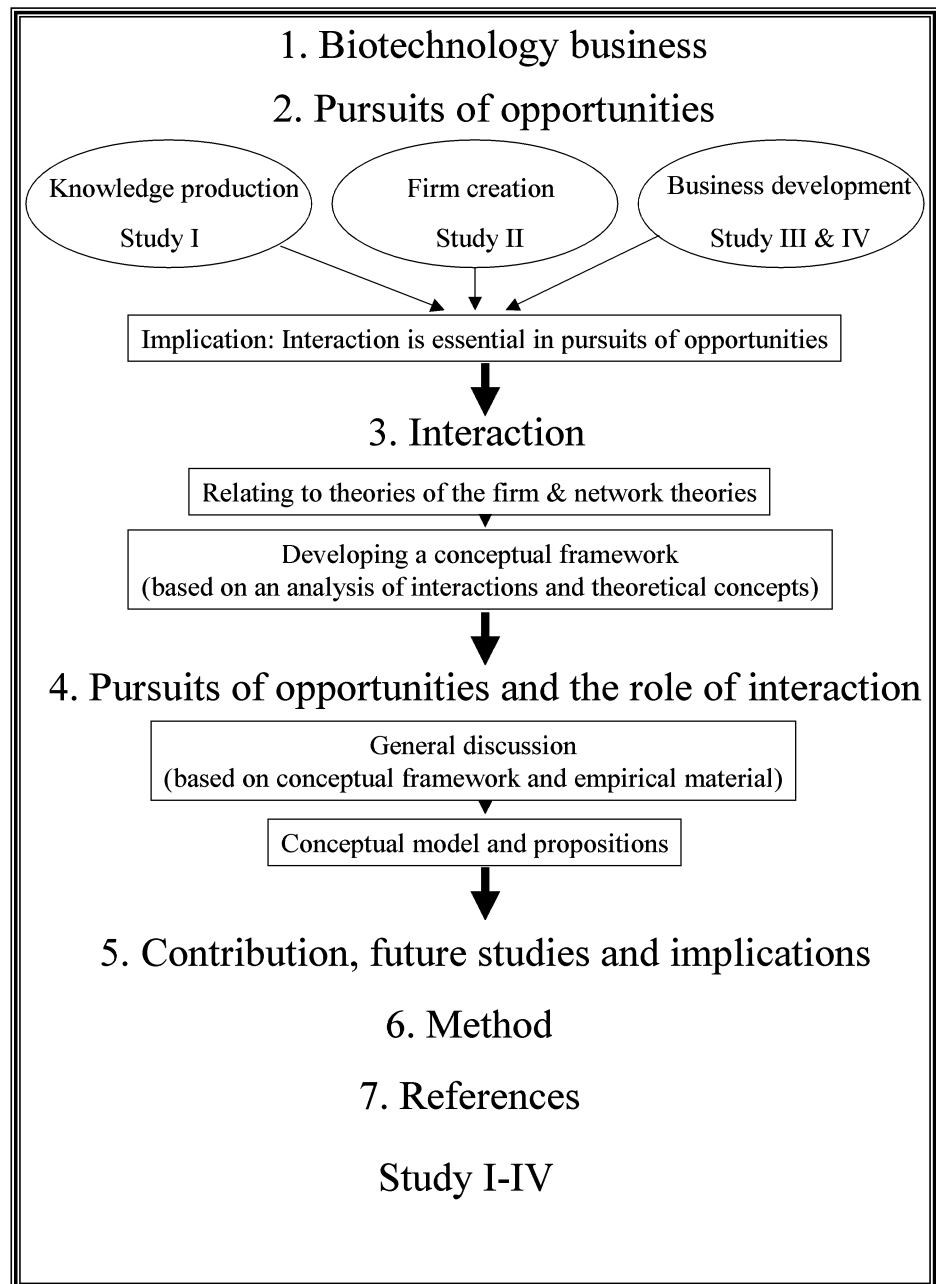
There are many issues related to pursuits of opportunities in biotechnology business that would be of value to study, including the process of innovation from a scientific aspect, intellectual property rights and ethics. My studies do not cover all aspects in this complex field, but serve to highlight selected ones and explore one more in depth (response to risk issues in business development), taking a step closer to a fuller understanding of processes of opportunity-pursuits. There is also a limitation of scope regarding geography and the results of the studies relate to the groups investigated. Two of the studies are based on empirical material from Sweden, one on studies in the USA and the fourth draws on data from both countries. My studies may appear sequential, but are not because it is not the same object that is followed over time.

There are several kinds of actors involved in the three opportunity areas chosen, all of which are of interest to the process of pursuits. Researchers, firm managers and venture capitalists were front actors in the aspects I have investigated. In the interest of providing a clear picture of the role of interaction, I chose to focus on these three types of actors. Through analyses of interactions between the three actors in the three areas of opportunities studied certain patterns emerged. The patterns influence the use of theoretical concepts and the focus on certain components in the development of a conceptual framework. The importance of other components, either accounted for briefly or not at all, cannot be excluded.

## **Outline**

Following this introduction, an overview of the research questions, methods and results from the four studies performed is presented in Chapter 2. Insights gained from the results of the studies culminated in focusing on interaction. Thus, in Chapter 3, a theoretical framework regarding this phenomenon is introduced. In this chapter a conceptual framework, based on some theoretical concepts and on patterns identified from analyses of empirical data, is also presented. The following chapter, 4, provides a descriptive and explanatory discussion based on the conceptual framework and empirical data from the four studies. Chapter 4 is concluded with the introduction of a conceptual model and a set of propositions. Contributions, ideas for future studies and implications are presented in Chapter 5. The final – Chapter 6 – is an overall assessment on the methodology used for the studies on which this thesis is based. The outline is illustrated in Figure 1:

Figure 1. Outline of thesis



## 2 PURSUITS OF OPPORTUNITIES - THE STUDIES

This chapter is a presentation of the four studies. The purpose of the studies is to explore the following areas of opportunities:

- knowledge production: Study I provides data regarding the amount and scientific profile of biotechnology-related publications that are produced by researchers in different organizations in Sweden, along with data on collaborations,
- firm creation: Study II renders frames of reference of how initial contacts are made between founders of biotechnology firms and specialized venture capitalists and ways in which these venture capitalists provide added value in the creation of biotechnology firms in Silicon Valley, USA,
- business development: Study III renders frames of reference of the strategies of biotechnology firms in Sweden, how they maintain a competitive edge and finance their activities, Study IV provides a description of risk issues and decision-making in biotechnology business development.

The presentation of each study consists of an overview of the research questions, methods and results and the chapter is concluded with a summary of the results and contributions. The complete studies are found after the final chapter.

### **Study I**

As described in the introduction, research performed in academia adds to the science base, which is of outmost importance for firms that focus on enhancing the value of research by bringing it closer to commercialization. This link between academic research and biotechnology business motivates studying knowledge production regarding publications. Bibliometric data is used in this study in order to show trends of knowledge production and knowledge flow.

Title: *Knowledge production and knowledge flows in the Swedish biotechnology innovation system*<sup>19</sup>

Data collected in: Stockholm, Sweden, 1998

Method: quantitative (bibliometry)

### Research questions

- Which actors in Sweden are active producers of scientific publications in biotechnology-related areas?
- What is the scientific profile of these actors?
- What do the collaboration patterns look like?

### Method

Bibliometry is a method that allows analysis of publication patterns, giving information about the most productive actors within chosen scientific areas and about relations between actors at a macro or meso level. The geographical and organizational pattern of the authors is mapped and it is possible to follow how production and collaboration develop over time. Apart from providing data, with which patterns of collaboration can be constructed, bibliometry also allows analyses on the variations in research performance of the actors over time (regarding publications and impact factors). This quantitative data on the development, together with expert interviews, allow the formulation of implications regarding knowledge production in terms of scientific publications. The total number of publications analyzed in this study was 25,045. These were articles in journal categories selected as biotechnology-related, with an impact factor of at least five<sup>20</sup> and published in journals covered by Science Citation Index <sup>TM</sup>, 1986-1997, by Swedish authors (see Table 3, Study I, for journal categories).

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<sup>19</sup> Definition of biotechnology innovation system: "The players that develop, produce, analyze or use biological systems on a micro, cellular, or molecular level, and the public and private institutions that affect their behavior" Sandström et al. (2001). The study included in this thesis focuses on producers of publications, which, according to the definition, constitute a part of the biotechnology innovation system in Sweden. Sandström et al. (2001) present a fuller picture of the Swedish biotechnology innovation system. For a broader discussion on the Swedish national innovation system, see Backlund et al. (1998).

<sup>20</sup> Impact factors are based on the mean number of citations a journal has received to its articles 1981-1996. The impact factors were taken from Journal Performance Indicators Diskette (JPID) produced by SCI.

## **Results**

*Which actors in Sweden are active producers of scientific publications in biotechnology-related areas?*

The actors in Sweden that engage in publishing articles within biotechnology-related areas are researchers within academia, other public organizations and firms. Authors from firms are found in 7% of the articles. Although biotechnology firms make use of publishing articles, as a means of creating awareness of their business, exhibit quality of their research and sometimes as a way to prevent competitors from patenting, it is not always prioritized. The firm's own patenting process and the strategy of hindering competitors from sharing the latest discoveries are reasons not to engage in the act of publication. This means that the amount of published articles is not likely to reflect the amount of research that goes on in firms. For academic researchers, publishing research results is the prioritized way to work because of the academic reward system. It is therefore not surprising that at least one academic researcher is an author or co-author of 95% of the articles.

Researchers at a few organizations in Sweden produce the major part of the publications within biotechnology-related areas. Researchers at the Karolinska Institutet, the only university focusing entirely on medicine, are responsible for 36% of all articles. The other major actors are the universities of Lund, Uppsala and Göteborg. Each of these universities contributes from 13% to 18% of the articles. Eleven organizations have produced more than 500 articles, see Table 6, Study I. All of these organizations collaborate with each other. Of the 11 most productive organizations in Sweden, those ranked 9 and 10 are Astra and Pharmacia, respectively (presently AstraZeneca and Pharmacia Corporation). These companies produced 75% of all the published articles from firms.

*What is the scientific profile of these actors?*

The scientific focus of the firms is highly comparable with the production pattern in academia, where about 70% of published articles in the selected biotechnology-related research areas are within the journal categories of "Biochemistry & Molecular biology," "Immunology" and "Neuroscience." The similar focus is a reflection of the close interaction between academia and firms.

### *What do the collaboration patterns look like?*

The most active area regarding knowledge flow is Stockholm-Uppsala (see Figure 1 in Study I). This is mainly due to the dominance of the Karolinska Institutet and the natural effect of many co-authorships with other organizations. There are also co-authorships between researchers in academia and firms. In 65% of the articles with authors from firms, there is at least one author from academia. Co-authorship between firms is very limited (6% of the total amount of articles produced by firms).

The amount of collaboration with firms differs between the universities. Karolinska Institutet has the highest amount of co-authorships with firms in absolute terms. Relatively seen, however, several other universities collaborate to a greater extent with firms regarding co-producing articles (see Table 7 in Study I). In relative terms, the university with most co-authorship with firms and industrial research institutes in biotechnology-related areas is the Royal Institute of Technology. This may be related to the fact that the university has a number of science areas through which it has established collaborations with industry, which would create a culture that encourages the researchers into thinking more toward applications. This tradition may not be as strong at universities that focus more on basic research. According to experts, researchers at Karolinska Institutet have a more positive attitude toward collaborating with industry today than they did before. One reason for academic researchers being inclined to collaborate with industry is a need to find alternative sources of funding.

The number of firms collaborating with academia within biotechnology-related areas is continuously increasing (see Table 7 in Study I). The likely explanation for this trend is the emergence of new biotechnology firms. These firms are often university spin-offs with already established links with researchers in the academic world. On the other hand, the amount of co-authored articles has not increased. This is due to the decrease of Astra and Pharmacia's co-authorships with academia. The new firms apparently do not have a large enough publication volume yet to compensate the reduction caused by the two large companies.

## **Study II**

Identification of commercial potential within academic research may lay the foundation for a new venture. Discoveries made within biotechnology firms may also be spun-off into new ventures. Processes of interaction between researchers, firm managers and

venture capitalists are vital in both forms of firm creation, but the actions behind the ventures are rarely made public. This makes it difficult for outsiders to gain insight to the process of firm creation within biotechnology. To create frames of reference to why and how founders and VCs (venture capitalists) interact to create firms, cross-case analyses at the micro level (Eisenhardt, 1989) of six early-stage biotechnology ventures were performed.

Title: *Differences in Provision of Added Value: The Case of Specialized VCs and Early-Stage Biotechnology Ventures*

Data collected in: Silicon Valley, CA, USA, 2000

Method: qualitative (6 case-studies)

### **Research questions**

- How are initial contacts established between founders and venture capitalists?
- How do specialized venture capitalists add value in the early stages of biotechnology ventures?

### **Method**

Because of the explorative nature of the study, the case study method was chosen. The objective is to build proposals that will fit each of the individual cases, without eliminating variations in details among the cases (Yin, 1984). The focus of the study was mainly motivated by the fact that the field of biotechnology is very knowledge intensive and it has been shown that higher levels of intangible assets within a firm increase interactions between VCs and entrepreneurs (Gompers, 1995). The empirical material was collected in the Silicon Valley, an area well known for providing a climate that is advantageous for new ventures. The key features for this climate, as described by Saxenian (1999), are the informal and formal gatherings where actors freely discuss problems and possibilities, which shape a shared identity that transcends the interest of independent firms.

The VCs were asked to describe their involvement in a specific biotechnology firm in which they had been the lead investor and which was located in the Bay Area. Focused, yet open-ended (Yin, 1984), interviews of 1-2 hours were performed, first with the lead investor and then with the founder of the biotechnology firm. The interviews took place at

the respondents' respective firms. Both parties were asked to recount the story of their initial meeting and describe the early-stage investment of the venture, focusing on certain issues according to a case study protocol. For the complete case studies, see Study II.

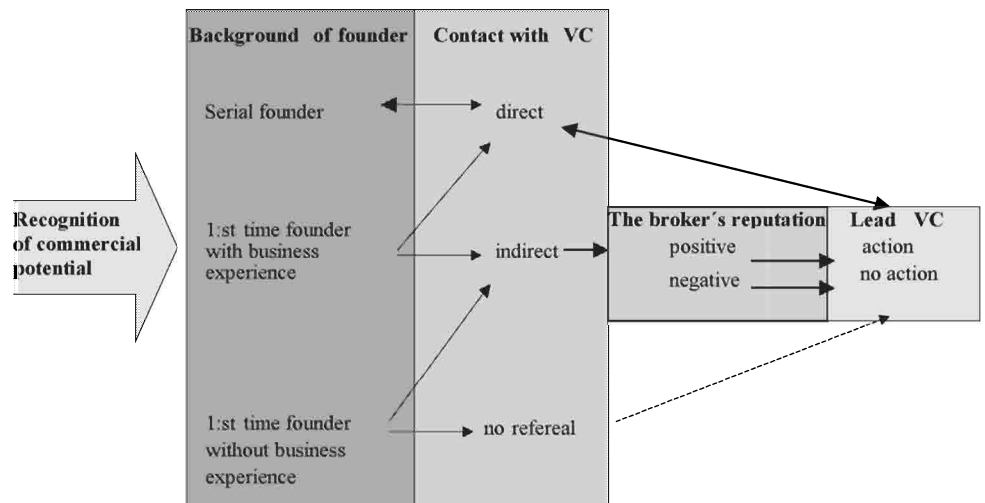
## Results

### *How are initial contacts established between founders and venture capitalists?*

The cases show that the founders' personal networks are a vital resource for establishing the initial contact with VCs, either directly or through brokers. That network, in turn, is directly related to the founders' background. As illustrated in Figure 2, founders without business experience did not have a reference at all or used a broker to access the VC.

Founders with business experience had a broker or a direct contact with the VC. Finally, founders with prior experience of creating a biotechnology firm had direct contact with the VC or were contacted by the VC.

Figure 2. Initial contact between founder and lead venture capitalist



New ventures initiated by academic researchers will at first most probably be limited to their own research, which often is a discovery at an early stage of development in terms of establishing commercial potential. Their personal network within academia is often substantial, but it is not likely to be as well developed in the business area, if they have not had operational experience from related industry. A limited diversity of contacts makes it difficult to obtain a reference from the right people in order to capture the VCs' attention and trust and thus be able to get initial funding.

Individuals already active in biotechnology firms have some advantages over academic researchers when initiating a new venture. Although lacking prior experience of creating a firm of their own, they have a more diverse personal network through which they can access needed resources. Moreover, they are involved in, or have information about, projects within firms and thus can more readily recognize opportunities to spin off projects that may not suit the current strategy of the firm in which it was developed. Furthermore, they may not perceive such a venture to be as big a risk as founding a firm solely on an academic discovery. This is because the projects have already been under development for some time and are closer to market, which also makes it easier to recruit personnel and get access to VCs. Another advantage of individuals active in biotechnology firms is that they already have established links to experienced personnel from the biotechnology firm where they were active, which can facilitate attracting some of them to the new firm.

Individuals that have already succeeded in creating a firm directly from a discovery in academia have the advantage of having personal networks in academia, industry and the VC community. They have gained experience as how to create a biotechnology firm and have possibly strengthened their personal reputation, which makes it easier to attract the various resources needed in a new venture. Having succeeded before, they are likely to keep an eye open for opportunities to try again.

I thus found the founder's background to be a likely predictor of how the initial contact with the VC is made.

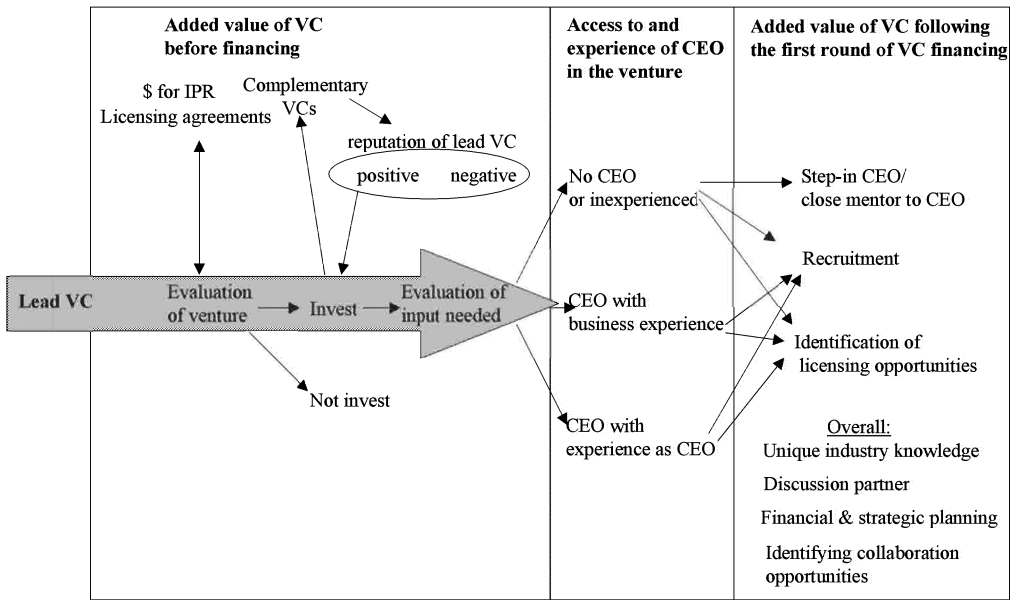
*How do specialized venture capitalists add value in the early stages of biotechnology ventures?*

The actions taken by the lead VC after the first round of financing varied between the six cases. The cases are divided into two groups according to the ways in which the VC provided more than financial capital at this stage, i.e. added value. In the first group, consisting of three cases, the VC actively built up or reconstructed the firms by making new business plans, defining milestones, recruiting personnel, establishing a science advisory board and a board of directors, etc. In one of these cases, the lead investor intervened as a temporary CEO because the founder was not considered suitable to take the position. In the second case, the lead VC became a close mentor to an inexperienced CEO. The nature of the actions could be expected because of the founders' lack of experience and personal networks. In the third of the cases, however, a researcher who had earlier experience in establishing a biotechnology firm founded the firm. The reason for the VC to step in and take an active part in building the firm was that the founder, despite or because of his earlier experience, preferred spending his time performing academic research. The factor that makes the situation in this case similar to the earlier two is thus the lack of an experienced CEO. The most important initial role of the lead VC for the serial founder was described as networking, whereas it was described as strategic in the other two cases.

In the other group, also consisting of three cases, the lead VCs participated in building the firm by providing contacts and knowledge, but did not take as active a part as in the cases described previously. Their engagement mainly resulted in recruitment of key personnel and identification of technologies for in-licensing. In two of the cases, the founders had business experience. In the third case, the founder had experience in both founding and heading a biotechnology firm. In all three cases, the founders became the CEOs of the new venture and made use of their personal networks and operational experience. The most important role played by the lead VC initially was described as supportive by the two founders who lacked prior CEO experience. The founder with prior CEO experience, on the other hand, identified networking as the lead VC's most important way of adding value. Looking at the cases in both groups, it seems likely that even though the activities that the lead VCs perform are similar in some ventures, their role is perceived differently depending on the founder's own experience and needs.

The analyses of the case studies showed differences in types of action taken by the specialized VCs in terms of adding value to their new ventures. The probable reason for the differences is that these specialized VCs are able to adjust their input of resources to the existence of experienced management in the venture initially. This is done as a means of protecting their investment. If the founder does not take the role as the CEO, no matter the experience of the founder, the VC is likely to add most value initially by taking that role until a permanent CEO is recruited. This indicates that the time needed to find a suitable CEO may be a predictor of the extent and form of the lead VCs involvement. That time is, in turn, related to two factors: the access of CEOs with operational experience in the biotechnology industry and the extent and quality of the VC’s personal network and the strength of his or her position within it. The actions taken by the VC and how these relate to the access to an experienced CEO initially, based on the six case studies, is illustrated in Figure 3.

Figure 3. Lead VCs’ engagement in ventures at an early stage



I thus found that a possible predictor of the ways in which the lead VC will add value in the early stages of a biotechnology venture is the existence of CEOs and their experience.

### Study III

Many aspects influence a new venture's development into a biotechnology firm of substance. For instance, internal factors, strengths and weaknesses of the firm integrate with external factors that give rise to opportunities and threats. This exploratory work at the micro level is performed in order to create frames of reference to business development in Swedish biotechnology firms.

Title: *Biotechnology Firms in Sweden*

Data collected in: Stockholm, Sweden, 1998

Method: qualitative (5 case-studies)

### Research questions

- How do biotechnology firms in Sweden position themselves?
- How do biotechnology firms in Sweden build and maintain their competence?
- How do biotechnology firms in Sweden finance their various activities?

### Method

The study provides a reasonable characterization of the situation some firms found themselves in 1998. Together, the case studies create a base for a cross-case analysis (Eisenhardt, 1989) to create frames of reference of business models of Swedish biotechnology firms. The firms differ from each other regarding number of employees (although they are all relatively small), age of the firm, range of activities, whether they are independent or under full ownership of another firm and whether they are on the Swedish stock market.

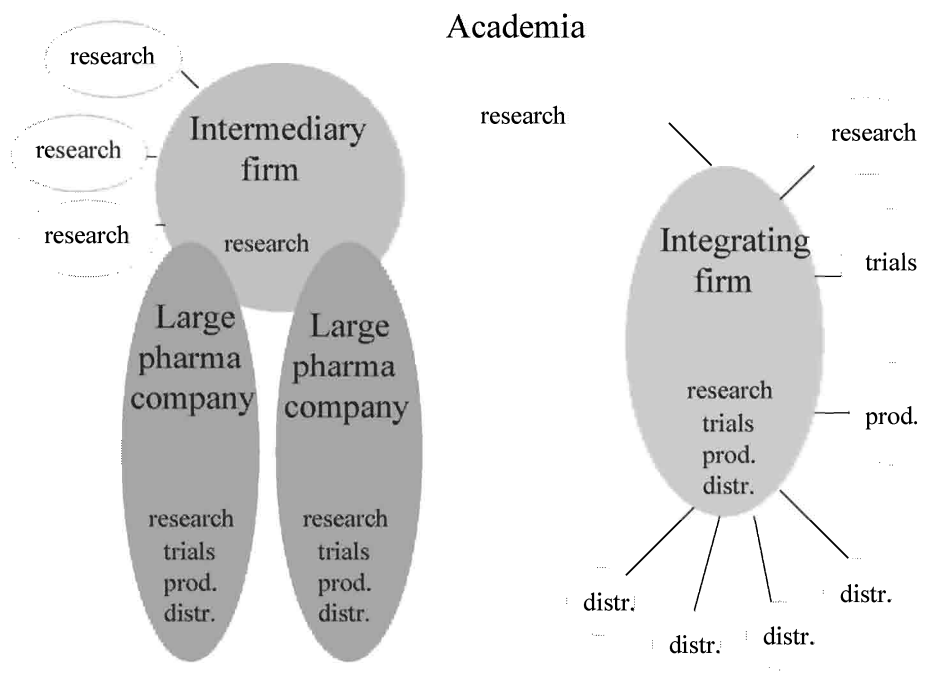
When studying business strategies and positioning, it is of interest to identify factors that influence the choice of a certain strategy. The variables of age, employees and range of activities were used in the search for connections between these variables and business strategies. To identify factors that influence how a firm finances its activities, the variable of being independent was used, as well as the variable of being listed on the stock market. With that information comparisons could be made, leading to a discussion of the reasons why different strategies are employed by biotechnology firms.

## Results

### *How do biotechnology firms in Sweden position themselves?*

The business model of biotechnology firms in Sweden is characterized by outsourcing, which is seen as necessary to maintain flexibility and keep costs down. These firms work with high-risk projects that may fail. Firm managers are therefore careful not to build up and invest in more (human) resources than necessary, as flexibility is constrained by Swedish labour regulations. **Intermediary firms** focus on research activities. They outsource some of the research and sell, or aspire to sell, licenses of their technologies to large companies that will take the project through further phases of development, production and marketing. Regardless of their size, these intermediary firms play an important role as motors of innovation as they bring early discoveries further toward commercialization to a stage where larger companies can become collaborators. The **integrating firms** have a variety of activities. Most of the research is performed in-house and, although maintaining a core competence in production and distribution, they often outsource part of these activities. The characteristics of two ways of positioning a biotechnology firm are illustrated in Figure 4.

Figure 4. Positioning of intermediary and integrating firms



The firms' positioning was not found to be related to either age or size of the firm. The factors that did influence the decision of establishing the firm as an intermediary or integrating firm were expectations of investors, overall access to capital, strategies of large pharmaceutical companies and the application possibilities of the firm's core technology. The latter factor is related to product focus. For instance, firms that develop substances for drugs rarely have the possibility to compete with large pharmaceutical companies<sup>22</sup> because of the high costs of trials<sup>23</sup>, production, distribution and marketing. These biotechnology firms often work with research that can be applied widely and may attract the interest of several external actors. Firms with technologies that are more narrow and/or do not need to pass through costly trials to the same extent (e.g. diagnostics and research tools) may be more inclined and have the economics to allow them to establish themselves as integrating firms.

*How do biotechnology firms in Sweden build and maintain their competence?*

The ability to rapidly identify the latest research findings from academia and transform them into commercially technology is the key to success for all the firms studied. The way to manage this is to hold a front line position within the specific research field, protect the intellectual property with patents and establish and maintain a network of top researchers. Academia is often the birth ground for the discoveries that become platforms for biotechnology firms. Moreover, the interaction with researchers in the academic world plays an important role for the continuation of the firm's research and development. The firms in this study work through extensive networks and have formal collaborations with academic researchers in various countries. Their networks have expanded along with the expansion of the firms' areas of research. Intermediary firms are dependent on a strong network of academic researchers and a core of top researchers within the firm in order to hold a frontline position that makes them attractive as collaboration partners for large companies. They are therefore more dependent on being located in the immediate surroundings of academia than integrating firms. Integrating firms are dependent on a continuous improvement of products and processes, including identifying and picking up new technologies from academia, which motivates a location nearby strong science bases. They are also dependent on the ability to identify market needs and bring an idea, through development and production, to market in order to gain market shares.

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<sup>22</sup> This can also involve collaborations with other types of company (e.g. within alimentation).

*How do biotechnology firms in Sweden finance their activities?*

A firm's strategy is closely related to the access to capital. The financial sources of the cases studied differ, but all use the stock market as a complementary source of capital, except one firm owned by another firm. A well functioning private capital market is also important for the emergence of biotechnology firms as it provides the initial investors with an exit. The greater the access to finance, the further intermediary firms can pursue a research project before licensing out the technology. The aim would be to increase the value of the project and eventually reach a larger profit margin than would be the case if an agreement was established at an earlier stage. Rather than pursue work in later phases of development, which can also be costly, intermediary firms may find it strategic to put available capital into new projects as a means to increase the pipeline. For the integrating firms, the access to capital may influence everything from engaging in more research to improve products, to creating sales organizations to replace some distributors on important markets.

#### **Study IV**

Firm managers in biotechnology businesses need to make decisions in an environment that has characteristics that differ from many traditional industries, see introduction. The specific characteristics make it valuable to describe risk issues and how the attention of firm managers can influence how they respond to these issues. The discussion serves to illustrate the nature of decision making in biotechnology business development.

Title: *Where Risk Meets Risk – Risk Understanding in Biotechnology Research Firms and in the Financial Market*

Data collected in: Stockholm, Sweden, 1998, Boston, MA, USA, 1998

Method: qualitative (applying an existing theory to empirical material from case-studies)

#### **Research question**

- How may decision-makers in biotechnology firms respond to risk issues?

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<sup>23</sup> Trials are performed at various stages and in diverse ways. The trials I refer to in my model are clinical trials.

## Method

The complexity of the biotechnology environment calls for a suitable conceptual framework for understanding processes of decision making. The attention-based approach, developed by Ocasio (1997), is used to address the aspect of decision-making in business development more explicitly in this study. The result of the study is mainly based on typified real life cases. The study is limited to risks in business development. The risks inherent in biotechnology research are not discussed, except from noting that its complexities make it difficult to estimate future value. In the presentation below, risk issues are marked in bold.

### *The attention-based theory*

In the attention-based theory, issues and answers are key constructs. The attention that a decision maker pays to the environment creates a number of issues, which are the decision-maker's interpretation of the environment. The answers available are also a result of how the decision-maker has focused his or her attention. These answers can be translated into action alternatives, leading to an organizational move.

## Results

### *How may decision-makers in biotechnology firms respond to risk issues?*

Within biotechnology, it is a well-accepted fact that projects may fail. Decision-makers therefore focus on keeping a flexible organization and holding down fixed costs to avoid locking up **resources**. They do this by keeping their firms relatively small and outsourcing a large part of the activities. Preserving a small organization is also the response to the risk of endangering the firm's innovativeness through long **decision processes** that lead to poor communication and risk aversion.

The choice of positioning a biotechnology firm as an intermediary or integrating business largely depends on the decision-makers understanding of the internal resources available, as well as their recognition of threats and opportunities in the environment. If an intermediary strategy seems most suitable, the decision-maker needs to assess the width of application of the firm's **core technology** and whether the **quality** is sufficient to attract collaborative partners. To make these assessments the decision-maker needs to maintain continuous up-date on the firm's level of research compared with research performed at other places. If the firm finds that it is in the front-line, the focus is to hold that position. The main risk issue related to this focus is human capital. Measures must be

taken to **keep key researchers** in the firm and, at the same time, attract new researchers. One way of retaining and attracting personnel is by offering shared ownership, which in turn dilutes the initial owners share. Networking with **external researchers** is another, complementary, response to risks related to preserving the front line position.

The decision-maker needs to make sure that there is financial capital to cover the cost of the activities of the firm. For those few biotechnology firms that show profit, it has taken several years before revenue starts to cover expenses. One risk issue related to the need for investors is that the decision-maker in the biotechnology firm may not have prior **experience in managing a firm**. Most venture capitalists prefer to invest in firms in which management has proven to possess the skills necessary to bring a firm forward successfully. A response to this risk issue is to exchange different kinds of capital. The decision-maker can give up more parts of the ownership and control of the firm in return for financial capital and management skills. This can be done by engaging venture capitalists that can invest and help to find suitable managers. Another risk issue is **finding venture capitalists** that match the needs of the firm. If the decision-maker does not have a personal network that includes actors in the financial market, he or she may not be able to identify, nor differentiate between, venture capitalists. One response to this risk issue is to augment the firm's exposure (conferences, media, etc.) and thereby increase the personal network. The number of potential investors may then increase, which would likely strengthen the firm's negotiating position. By increased interaction between the decision-maker in the biotechnology firm and venture capitalists, a process of learning may begin and risks can be reduced.

The most common ways for investors to collect a return on their investment is through selling the firm to another firm or performing an initial public offering of the firm. The **timing** for entering the stock market is critical and it is not always that the former decision-maker and the investors agree on the appropriate time. Because of investors' time plan, some firms may go public even though their position in the market place is not fully established. The firm becomes subject to speculations on the stock market, especially when it does not have those resources that can be evaluated by traditional tools. There is a risk that **market expectations** prompt decision-makers in biotechnology firms to make premature announcements of, for example, likely results of a clinical trial. If the results are not realized, confidence for the firm falls along with the firm's valuations. The

stocks run the risk of **fluctuating** a good deal because the firm is difficult to evaluate and therefore vulnerable to rumors. The response to this risk issue is increased communication (see Figure 4.1 in Study IV for an illustration of the above discussion).

The problems of the fluctuations of biotechnology stocks seem to be related to a lack of understanding and poor communication. Both biotechnology firms and investors search for high rewards through risk taking and both create methods to decrease the potential negative effects of the activities. Investors, on one hand, handle the risk of making poor investment decisions by using tool-kits of financial key ratios that give them a rationale to guide their decisions when comparing investment objects. Biotechnology firms, on the other hand, have developed strategies that maintain a balance between stability and change. Their organizational strategy keeps them from the risks connected with large organizations and their business strategy enables them to strengthen their position and grow without having to compete with large companies. A lack of understanding for this business model on the investors' part constitutes a risk for biotechnology firms. Investors may shy away because of their own rules of handling ambiguity (inability to predict outcomes from research and evaluate intellectual capital), see Figure 4.2 in Study IV.

The nature of the decision processes in biotechnology business development, interpreted by discussing responses to risk issues, appear to be characterized by how firm managers recognize opportunities. The ability they have to pursue the opportunities influences the response to risk issues.

### **Contribution**

The present studies add to research with increased understanding of pursuits of opportunities in the areas of knowledge production, firm creation and business development. Study I contributes with data on the development of knowledge production regarding publications in Sweden over a 10-year period. It shows, for example, that the Stockholm-Uppsala region is the most active regarding production of publications and collaboration activity. Studies II and III contribute with frames of reference with respect to firm creation and business development. Study II points out that the personal network of founders of firms is vital for reaching venture capitalists, and that there are substantial differences in the type of added value provided by specialized venture capitalists. A possible predictor of the ways in which an early-stage venture capitalist will add value in

a biotechnology venture, is the initial existence of a chief executive officer and his or her experience. Study III establishes that biotechnology firms apply network strategies that enable them to keep a flexible organization and facilitate access to front-line research through collaboration with academia. Their strategies are divided into the concepts of intermediary and integrating firms. Study IV contributes by exploring the issue of possible obstacles in pursuits of business development. It highlights risk issues and ways in which managers in biotechnology firms may respond to risks. The description implies that the ability to respond is related to the attention of firm managers, which in turns implies that the nature of decision-processes may be opportunity-driven. Traditional risk management tools may therefore not seem to be the most useful for understanding how biotechnology firm managers deal with risk issues. A future discussion of the usage of the concept of opportunity may provide a more suitable platform for understanding risk dealing in biotechnology business.

Moreover, the present results, in conjunction with previous research, imply that interaction is essential to pursuits of opportunities in biotechnology business. Further exploration of the role of interaction is thereby motivated. By using the empirical data on interactions between three types of actors, within three opportunity-areas collectively, I therefore performed an analysis of interactions. Through this analysis, patterns of processes of pursuits of opportunities and the role of interaction emerged. These patterns are applicable to all three opportunity-areas and lay the foundation for the development of a new conceptual framework and for the general discussion.

In order to bring the empirical evidence from the studies up to a more general level and thereby develop a conceptual framework, there is a need for introducing some theoretical concepts (Robson, 1993, Creswell, 1994, Strauss, 1998). In the following chapter, some theories are presented and related to biotechnology business and interaction. The chapter ends with a presentation of the new conceptual framework.

### 3 INTERACTION – TOWARD A THEORETICAL FRAMEWORK

As stated in the research problem there is a need for theory building related to interaction in pursuit of opportunities. In the development of a conceptual framework it is useful to relate research data and identified patterns with existing theories. To create assumptions regarding the phenomenon of interaction, theories of firms and networks are seen as relevant.

This chapter begins with an overview of some theories of the firm, often applied to research on business. Because of the characteristics of biotechnology business and the fact that part of the pursuits of opportunities examined here are pre-market, I continue with network theories. These theories seem fruitful in research on processes of interaction in opportunity-pursuits that are related to biotechnology business. After a short introduction of network theories, I focus on individual networks, concepts of financial, human and social capital and theories of interaction, exchange and roles. These are used in the development of a conceptual framework, which is introduced in the last section of this chapter.

#### **Biotechnology business and theories of the firm**

Coase (1937) laid the foundation for the logic behind the creation of firms by focusing on transaction costs. His ideas have been further developed by, for example, Williamson (1993), Klein et al. (1978) and Alchian & Demsetz (1986) in transaction cost theory. According to the theory, transactions take place in the marketplace, but are “moved” and become organizationally integrated into a firm when, for instance, asset specificity is present. Under such circumstances, it becomes beneficial to perform transactions within the boundary of a hierarchically organized firm. The existence of bounded rationality and opportunism adds to firm creation. The firm provides a structure that limits the negative effects of these two factors.

Looking at how firms grow, Penrose (1959) developed a theory of the firm that provides a base for studying firms regarding allocation of available resources. Her theory has been the subject of discussion and modification by numerous scholars. During a long period,

there was a consensus concerning the basic notion of the theory stating that it “asserts that the objective of the firm is to maximize net revenue in the face of given prices and a technologically determined production function” (Cyert & March, 1992, p.5).

The above theories are primarily based on the concepts of the economic forms of markets and hierarchy. It is assumed that the items exchanged can be easily measured (prices set) and that there are clear borders between the buyer and seller, which Powell (1991) highlights as a problem when studying biotechnology firms. As described in the introduction, biotechnology firms have close interactions with academia and pharmaceutical companies and hence there are not always clear borders differentiating them from one another. Furthermore, the products exchanged in the biotechnology industry are primarily in the form of intellectual property (research and development projects including patents) and thus hard to measure. Although some biotechnology firms have sales of market products, many firms do not. The type of processes that I attempt to understand more fully are often pre-market and even pre-firm, and the ambiguity of the scene (Black, 2001) adds to the difficulty of applying the above theories to my study.

Resource dependency theory is focused on the firms’ own resources as the fundamental basis for business development (Montgomery, 1995). In this theory it is assumed that social action can be described and explained through actors that act independently and who have independent goals. It does not include interactions with actors not tied to the focal firm. This assumption, which has been criticized (e.g. Coleman, 1988, Kogut et al., 1992), makes the theory less useful in cases such as biotechnology business. This is because the characteristics of the products of biotechnology firms result in complicated sales processes in which close interaction with other actors is necessary. The firms’ strategies and choices are thus dependent on the action of other actors.

One theory implying interaction is the agency theory. Looking at relationships between markets and firms, researchers within this school of thought assume that markets are efficient. The notion of bounded rationality is adopted, similarly to transaction-cost theory. Agency theory identifies one party (the principal) that engages another party (the agent) to take action on their behalf. The process includes delegating some decision-making to the agent, which in turn raises the question of whether the decisions taken are in the full interest of the principal, depending on the interests of the agent. The theory

argues that under conditions of incomplete information and uncertainty, conflicts of interest are likely to arise. To reduce such conflicts contracts and monitoring are implemented. The more uncertain the principal or agent is about a situation and potential outcome of interaction, the more costly will the measures to avoid conflict be. These costs relate to the extent to which variables can be observed (Jensen & Meckling, 1976, Barney & Ouchi, 1986, Hart, 1995). In biotechnology business, variables are hard to pinpoint and observe, making it extremely difficult to write contracts that protect from various conflicts that may arise. This is mainly due to the pre-market situation of large parts of the biotechnology business, which also means that the assumption of an efficient market is difficult to apply. Bringing forth network organizations as an alternative to markets and firms, Casson (1997) focuses on the fact that contractual costs can be reduced when high levels of trust exist between the partners. Such trust develops within networks and Casson (1997) argues that individual owners and managers of firms may benefit from connecting to each other and creating network organizations, especially in complex environments in which contracts are costly and difficult to construct and monitor. Similar thoughts have been presented by, for example, Powell (1991).

Interaction may be seen as a sort of game. Game theory has developed as a response to the need to understand decision problems that involve more than one person (Axelrod, 1985). At the micro level of economic studies, this theory can be used to study bargaining. The basic contention of the theory is that “each player simultaneously chooses a strategy, and the combination of strategies chosen by the players determines a payoff for each player”(Gibbons, 1992, p 2). Evolutionary game theory could be useful in studies of interactions between researchers, firm managers and venture capitalists to understand how payoffs are constructed and strategies chosen (Axelrod, 1985). To apply the theory, however, more knowledge is needed about the processes in which these actors interact within the biotechnology business. One group of theories that invite for studies of processes at the micro level is network theories. They focus on the concept that actors are socialized and that their actions are shaped by other actors, norms and rules in their environment.

### **Biotechnology business and network theories**

Powell and DiMaggio (1991), focusing on the network approach at the institutional level, explain that it becomes evident that the market and hierarchy concepts are not sufficient when studying the world of biotechnology business. They suggest that the network form

of economic organizations, as a concept, enables a more valid interpretation of the complex reality with a variety of organizational forms and relations between these. Networks are the locus of opportunities for learning, innovation and flexible deployment of resources (Baker, 1992, Gibbons et al., 1994, Powell et al., 1999). Therefore, the network approach seems suitable for empirical studies of biotechnology business in which research- and development projects are often the products. The network approach views all organizations as social networks and their environment as a network of other organizations. The networks shape and constrain actions. The actions themselves are best explained by the position of actors in networks of relationships (Nohria, 1992).

A network is a type of relation, where defined persons, objects or events are linked to each other (Mitchell, 1969, Knoke & Kuklinski, 1991, Monge et al., 2001). The relations create the base for network analyses and the persons, objects or events are called actors or nodes in the network. Network analysts focus on the nature of relations, whereas other areas of social sciences tend to focus on the characteristics of individuals (Monge et al., 2001). When analyzing networks, both relations that exist and those that do not exist among the actors must be considered. Furthermore, “the structure of relations among actors and the location of individual actors in the network have important behavioral, perceptual and attitudinal consequences both for the individual units and for the system as a whole” (Knoke & Kuklinski, 1991, p.175).

Networks can be studied at the micro level as the set of links an individual has with other persons, which are referred to as personal or social networks (Ibarra, 1992, Aldrich, 1999, Johannisson, 2000b). The relations an individual has with other actors constitute a kind of capital, social capital<sup>24</sup>, (Coleman, 1988, Burt 1992, Aldrich, 1999), which is one of three kinds of capital described below.

#### Networks at the individual level: financial, human and social capital

Capital can be referred to as “means for taking action on the market” (Johannisson, 2000a, p.1). The elementary idea is that the success with which an actor manages to enhance his or her interest through the interaction with others depends on the kind of capital the actor

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<sup>24</sup> The concept of social capital was discussed by Hanifan (1920) and by several others, but it is Coleman who stressed the importance of defining social capital by its function. Social capital was introduced as a conceptual tool by Coleman (1988), based on components from both economic theory and sociological theory.

brings to the arena. Burt (1992) focuses on three kinds of capital: financial (i.e. direct or indirect access to money), human (i.e. natural abilities combined with skills acquired through schooling and working experience) and social<sup>25</sup> (i.e. relationships through which the actor gets to use the financial and human capital). The three types of capital are closely related. Human capital, for example, produces social capital and the reverse. Through social capital, the actors exchange and combine the human and financial capital that they control with others to reach outcomes through focused actions (Coleman, 1988, Burt 1992, Aldrich, 1999, Johannison, 2000a).

There are two main differences between the concepts of financial and human capital and the concept of social capital: The first difference is that financial and human capital can be controlled by a single person or corporation, whereas social capital is jointly controlled. The second difference is that financial and human capital relate to investments that create ability to be competitive, whereas social capital relates to the opportunity to profit from the investments (Burt, 1992).

At the corporate level, financial and human capital are concepts within accounting. The importance of human capital as to the competence of the personnel is acknowledged as an important asset that influences how the market values the firm. The balance sheet, however, only covers capital accounted for in finance terms: financial assets (e.g. machines, stocks and inventory) have been assigned a value and are financed through debt and equity. The difference in value of total assets and total debts constitutes the equity. Venture capitalists and other investors buy equity in firms that they believe have a good chance of increasing the value of equity. Researchers that cooperate with a firm (but do not own equity) are more related to the asset side as their input is intended to help increase the firm's assets and operations. Firm managers are concerned with both sides of the balance sheet and can exchange their financial capital with respect to firm equity for other kinds of financial or human capital.

Social capital is created and sustained through the exchange of financial and human capital, but the network of relationships also works as a facilitator for reaching outcomes (Nahapiet & Ghoshal, 1998, Coleman, 1988, Burt 1992). Interaction is a

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<sup>25</sup> Nahapiet and Ghoshal (1998) define social capital as follows: "The sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network." Their definition is based on Bourdieu (1986) and Burt (1992).

prerequisite for obtaining and maintaining social capital and thereby increasing the chances of realizing opportunities. Social capital increases with use and dies out, if not maintained (Bourdieu, 1986, Aldrich, 1999, Powell, 1999). It is built and maintained through frequent contacts that enable bonds to develop and tacit knowledge to be transferred, which provides actors with more informal control over each other (Jones et al., 1997). This may imply joint decision-making and sharing and exchanging information. Communication, through which information can be accessed, is part of social capital and “the indispensable tool of interaction” (Kuhn & Beam, 1982, p. 157). The density of interactions facilitates collective learning (Fountain, 1999). Relationships, developed in one interaction, constitute information channels and may be a valuable resource for other interactions (Bourdieu, 1986, Coleman, 1988, Casson, 1997). A network is characterized by different members that trust each other. Accordingly, networks form good forums for finding honest partners to collaborate with, lowering the risk factor of the engagement (Fountain, 1999). The need to avoid incompetent partners is another reason to use existing networks when looking for collaborators because competencies are likely to have become evident through earlier relationships in the network or through reputation (Casson, 1997).

The problem of a lack of social capital can be resolved through the use of brokers. In social network terms, “brokers are people who facilitate links between persons who are not directly connected” (Aldrich, 1999 p. 87). Brokers have networks that allow them to match resources with needs of actors that they have an interest in helping.

Social capital encourages cooperative behavior and is central to understanding innovation and how value is created (Nahapiet & Ghoshal, 1998, Fountain, 1999), which makes the concept fundamental to this thesis. It further motivates looking at theories regarding interaction, roles and exchange at the personal network level, which are found within social science.

### Interaction, exchange and roles in personal networks

There are a number of definitions of interaction.<sup>26</sup> I have been influenced by these definitions in the construction of the definition of interaction used in this thesis and base

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<sup>26</sup> For example, “reciprocal action or influence” (Oxford Dictionary 9<sup>th</sup> edition), “an action between systems” (Kuhn & Beam, 1982), “... when an activity emitted by one man is rewarded (or punished) by an activity emitted by another man... we say that the two have interacted” (Homans, 1961).

my analysis and discussion on the following definition: *reciprocal actions between two or more persons*.

Social order is created through everyday interaction as a practical activity. Two main goals of social interaction is to increase the personal network by acquiring and using social knowledge and to strengthen the network by “getting along” with other actors, which facilitates interaction. Interaction is thus an important but complex process in which actors meet and work hard to merge their interests and beliefs in creating an environment that is beneficial to them. Trust is a key word in the shaping of this environment and the actors apply rules of procedure in a flexible and reflexive manner to ensure that their behavior is acceptable. (Weick, 1995)

Homans (1961) suggests that if a person does another person a service, then the person who performed the favor is found to be more enjoyable or agreeable. He argues that being more likable functions to increase the frequency of interaction. If the interaction is rewarding for both persons, it will tend to persist indefinitely. However, if one person finds the relation unrewarding, he or she will look for alternatives. If alternatives are found, the person will decrease the interaction with the other person. If interaction cannot be discontinued because of, for example, contracts, the interaction may lead to an increase in hostility between the persons.

From a sociological perspective, the most important characteristic of interaction is the content of the relationship. “The links between an individual and the people with whom he interacts come into being for some purpose or because of some interest which either or both of the parties consciously recognize” (Mitchell, 1969, p. 20). The content can vary (friendship, economic assistance, etc.). Homans (1961), laying the groundwork for exchange theories aimed at understanding networks, focused on how individuals create relationships depending on the supply and demand of their resources. He developed a number of propositions to explain findings from a number of studies. Three propositions are listed below.

- *Individuals engage in actions that are rewarding. The level of engagement is dependent on how soon the reward is coming and how big it is.*

- *When an action is followed by a reward, it increases the likelihood for the action to be repeated.*
- *The more an individual values a reward for a certain task, the more likely he or she is to perform it.*

Homan focused on dyads. According to Monge et al. (2001), the view that the larger network in which the dyads were embedded needed to be studied to understand the potential of exchange, has grown among researchers. This view formed the network exchange theory, which “posits that individuals' power to bargain is a function of the extent to which they are vulnerable to exclusion from communication and other exchanges within the network” (Monge et al. 2001, p. 458). This view implies that individuals that are well embedded in networks are likely to have an advantage over other individuals who they disclose or exchange information with. Such advantages are reflected in the distribution of roles in collaboration.

Role theories are focused on the function of social roles and the expectations that persons with certain roles are subject to. A role can be defined as the sum of standards related to a certain position or task. Roles can be of two kinds: ascribed or acquired. A profession is an acquired role while being a woman is an ascribed role. Expectations on roles are of importance in that actors are valued according to how they live up to these expectations. The expectations related to a profession are usually quite specific. If an actor holds more than one position and the expectations on those roles are contradictory, conflicts are likely to arise (Aubert, 1979).

According to Kuhn & Beam (1982), when actors agree to interact in pursuing an opportunity, all necessary tasks should be included in the roles they acquire in the collaboration and excessive overlapping should be avoided. Discussions on characteristics of individuals linked to roles are represented in psychological research (Nord & Fox, 1996). Such discussions are important, but they will not be emphasized here. The reason is that the focus of this thesis is on the nature of the relations, which in turn is closer to the network approach (Monge et al., 2001).

The theoretical framework presented above is used to relate my research findings to theoretical concepts and thereby increase the ability to conduct a discussion on both a

conceptual and empirical level. The general aim to gain further insight into processes of opportunity-pursuits and clarifying the role of interaction in such processes makes theories of interaction, exchange and roles relevant. The concepts of financial, human and social capital in theories of networks at individual levels have helped me to form the basic assumptions of a conceptual framework, presented in the following section.

### **A new conceptual framework**

The need for theory-building related to interaction in pursuits of opportunities motivates the development of a conceptual framework. This framework is based on assumptions formed by using concepts of capital, see previous section, and through analysis of empirical data from performed studies. Patterns of opportunity-pursuits, driving forces for interaction, variations in roles in collaborations and factors that cause unstable interactions emerged through the analysis. The conceptual framework is constructed to reflect these patterns and is divided into the four major components described below:

#### **Opportunity-pursuits**

The biotechnology business is a field in which actors may recognize numerous opportunities to enhance their interests. Their human capital provides them with the knowledge to recognize an opportunity and their social capital furnishes the information channels through which opportunities can be recognized. If an actor is motivated to pursue the opportunity, that actor will assess the capital required to pursue it (for an illustration, see the red field in the model on page 59).

#### **Driving forces for interaction**

When an actor recognizes an opportunity derived from advances in biotechnology and is motivated to pursue it, it is rare that the individual will be able to realize it without interaction with other actors. When assessing the amount of capital required, most actors find that they do not have all the capital that is needed. The first mover will be inclined to attract actors that have complementary capital (driving force 1). This driving force leads the first mover to be active in locating capital and offering exchanges. All actors dispose of capital, but of different kinds and levels. The existence of this capital is the other driving force, for it enables collaboration to take place through the exchange and combination of capital (driving force 2). If the actors that are approached are not aware of the opportunity and how it could serve their individual interests, then the first mover has to communicate pervasively with them. The approached actors, in turn, will evaluate

whether the proposed collaboration will be a rewarding one (for an illustration see the orange field in the model on page 59).

The first move toward interaction can be taken by one or more of the actors:

- One actor may have strong motives to pursue an opportunity and thus initiates a search for other actors to interact with in order to access the complementary capital. The other actors may or may not be already established contacts.
- Two actors, without connection, may simultaneously perform search in the pursuit of a common opportunity and find each other through formal gatherings, brokers or by serendipity. In such an event, both actors are considered first movers.
- Where contacts already exist, the motives to interact in pursuing opportunities may arise through informal discussions among several actors.

In addition to being exchangeable to a certain degree, social capital has a special position in that it facilitates the exchange of other capital. The higher the level of social capital an actor has, the easier it will be to find actors that control the kind of capital needed and persuade them to exchange some of their capital in the pursuit of an opportunity. The two driving forces intertwine because the capital that an actor controls relates to what kind and level of capital the actor needs. The need, however, is also dependent on the opportunity pursued.

### Collaboration

Once the first mover has accomplished the task of locating actors with complementary capital and mutual interest to collaborate in the pursuit of an opportunity is established, the actors will evaluate each other's capital to assess if it seems sufficient to realize the opportunity. If so, agreements are made as to how the exchanges will be performed. The interaction thus takes the form of collaborations. As collaboration is initiated, roles are distributed according to the individual motives of the actors and their control of capital. The actors change their roles from what they were before the collaboration to what is considered needed to pursue a specific opportunity.

Ability to change roles is related to actors' initial existing capital and the capital provided by the other involved actors. The actors may already be aware of the other actors capital and what roles they will play before formalizing the collaboration. However, when this is not the case, they discover the value of the capital the other actors have in due time and the roles are adjusted to correspond to that capital. The first mover, usually the one who recognized the opportunity, may be any of the actors with strong motives to collaborate with the others. The same actor is not, however, necessarily the one who has the strongest influence in determining which actor should play which role in the collaboration. The value of different kinds of capital is related to the opportunity and the capital the other actors control. The actor, whose capital is valued as most vital for the opportunity to be realized, has the strongest influence in what roles they will play in their collaboration.

The sum of the three kinds of capital is difficult to evaluate and it is hard to foresee the full extent of the use of any one actor's capital. The actors strive to complement one another's capital. If there is more than enough of one kind of capital, actors spread their input to other opportunities instead of providing "double input". The collaboration leads to increased social capital, unless serious conflicts arise, in which case social capital may decrease (e.g., bad reputation, lost relationships or difficulty in creating new links). If the actors allow the collaboration to be a learning experience, it will also increase their human capital. An increase in capital broadens the ability of the actors to change their role according to the input needed in future collaborations. For an illustration see the yellow field in the model on page 59.

### Outcome

The purpose of locating complementary capital, offering exchanges and collaborating is to realize opportunities. Reached outcomes influence the environment in which the opportunities initially arose. There are also indirect outcomes that can add to each actor's human, social and financial capital. Reinforced capital stimulates recognition and engagement in new opportunities, which are likely to motivate further interactions and lead to new outcomes. Because attempts to pursue an opportunity may fail, it is of value to discuss reasons for failure. Explanations may be found in institutional factors and factors related to interaction itself. The institutional factors are of many kinds (this point is further discussed in Chapter 5). A set of factors that can create obstacles in pursuits of opportunities are identified through the analysis of interactions between researchers, firm managers and venture capitalists. These factors are listed below:

- under-informed assessment of the capital required to realize an opportunity
- poor ability to localize and attract complementary capital
- a lack of mix or level of capital in the collaboration
- under-informed decisions on the distribution of roles in the collaboration

These factors can all result in unstable interaction, which has a negative influence on outcomes. If expected outcome is not reached, however, it may lead to (primarily financial and possibly social) decreased capital. In either case, human capital increases as the process adds to the actors' experience (for an illustration see the arrows connected to the red star in the model on page 59).

The four components add up to a model of pursuits of opportunities, illustrated in chapter 4. The order in which I present the components is related to how one component is seen as a prerequisite for another. The components are closely integrated. A component is not left behind when another component is introduced, instead all components remain present and continue to affect each other.

This conceptual framework is based on analysis of interaction between researchers, firm managers and venture capitalists. The following definitions of the types of actors are applied in the general discussion on the role of interaction in pursuits of opportunities:

- Researchers: These are individuals that work as scientists in biotechnology-related areas in the academic world.<sup>27</sup>
- Firm managers: Firm managers are individuals that manage biotechnology firms.
- Venture capitalists: These are individuals that are general partners or associates in firms that specialize in providing venture capital financing.

Interaction between these types of actor can take place anywhere and anytime that they are motivated to be active. The conceptual framework presented is based on analysis of the interaction that takes place in relation to pursuits of biotechnology-related

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<sup>27</sup> Many of these scientists are group managers. Their organizations can be viewed as a small business (see Skår & Hollsten-Yamamoto, 1997).

opportunities in the areas of knowledge production, firm creation and business development. In the following chapter the conceptual framework is put to use in order to describe interactions between each of the three types of actors, within each of the three areas of opportunities.

## 4 PURSUITS OF OPPORTUNITIES AND THE ROLE OF INTERACTION - GENERAL DISCUSSION

The general aim of this thesis is to gain further insight into the processes of opportunity-pursuits in biotechnology business and create a conceptual framework clarifying the role of interaction in such processes. A new conceptual framework was presented in the preceding chapter. The framework is applied in this chapter, which serves to describe interactions between researchers, firm managers and venture capitalists, within the opportunity-areas of knowledge production, firm creation and business development. The discussion relies on empirical data from the studies of the three opportunity-areas.<sup>28</sup>

### Research questions

1. Why do researchers, firm managers and venture capitalists interact?
2. How may researchers, firm managers and venture capitalists change their roles because of interactions?
3. How does unstable interaction relate to inability to reach outcomes?

The questions form the base of a descriptive and explanatory discussion, on a micro-level, of the role of interaction in pursuits of opportunities. The chapter is structured according to the four major components of the conceptual framework:

**Opportunity-pursuits** (Addresses question 1)

**Driving forces for interaction** (Addresses question 1)

**Collaboration** (Addresses question 2)

**Outcome** (Addresses question 3)

I conclude the chapter by introducing a conceptual model and a set of related propositions.

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<sup>28</sup> Some empirical data from studies II & III, not included in the articles, was found valuable for the discussion and are referred to as “unpublished data”

## **Opportunity-pursuits**

### Abstract from conceptual framework

*The initial existence of actors' human and social capital allows them to recognize opportunities. If actors have motives they will pursue the opportunity and assess the capital required to do so.*

The biotechnology business, as described in the introduction, is a field in which researchers, firm managers and venture capitalists may recognize numerous opportunities to enhance their interests. It may be that the same actors are involved in several areas of opportunities. Opportunities tend to overlap and outcomes create effects within biotechnology business where new opportunities are recognized. I focus on pursuits in three areas of opportunities.

### Knowledge production<sup>29</sup>

By pursuing knowledge production, the actors involved benefit from gaining increased knowledge. They control the intellectual property they develop and can choose to use it in alternative ways to strengthen their position. Collaboration is a determining parameter in producing and acquiring knowledge (Zucker et al., 1996, Gibbons et al., 1994, Blumenthal et al., 1996, Casson, 1997). The significance of collaboration is demonstrated in the increasing number of jointly published scientific articles between firms and academic researchers in Sweden (Study I). As research advances, new opportunities for both emerging and existing firms are created.

### Firm creation<sup>30</sup>

The motives for pursuing this opportunity are various: financial gain, the satisfaction of bringing a discovery closer to a useful product, a chance to engage in business activities for the first time etc., as seen in unpublished data from Study II. Several interests of the numerous actors involved may be fulfilled by the pursuit of creating a business. When new firms enter the stage of biotechnology business, both existing and potential firms are influenced.

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<sup>29</sup> Knowledge production refers to activities that add to the science base. The outcome of such activities can be publications or patents.

<sup>30</sup> Firm creation refers to pre-firm and start-up stages.

### **Business development**<sup>31</sup>

Recognizing opportunities for business development and pursuing them is a necessity for firm managers that want to continue their business activities. The pursuit also creates opportunities for other actors to enhance their interests. The strategies to develop a biotechnology business include issues such as positioning, competence and finance. These issues relate to activities in which other actors are likely to get involved (see study III). The development will, for example, in most cases demand financial capital, which can create an opportunity for investors. As the opportunity of business development is pursued, various actors and organizations of the biotechnology field are influenced.

### **Driving forces for interaction**

#### **Abstract from conceptual framework**

*If actors assess complementary capital to be needed (driving force 1), then they will be motivated to interact with other actors and engage in locating capital and offering exchanges. These activities, where interaction with other actors take place, are mainly evaluations of the value of the existing capital that different actors have to offer each other (driving force 2).*

Beginning with the researchers, I examine driving forces for interaction in relation to the pursuits of the three types of actors in the three areas of opportunities studied.

### **Knowledge production**

The opportunity to produce knowledge is a given for **researchers**. Using their human capital, they can pursue this on their own, but in biotechnology-related fields, it is common to work in groups to speed up the process and attain results that are more valuable. Because a combination of human capital is often needed, researchers profit from working with other researchers that are specialized in an area that benefits a certain research project. The actors with the sought-after human capital may be found anywhere in the world within academia and industry. Research conferences are a typical forum where researchers with similar interests become acquainted and increase their social capital. It is important for researchers to participate in recognized research in that it increases their human and social capital, which, in turn, enables them to recognize more

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<sup>31</sup> Business development refers to activities in existing firms.

opportunities to produce knowledge. Apart from the need for complementary human capital in the production of knowledge, researchers need financial capital to support their work. In Sweden and the USA, the share of financing from firms is increasing in relation to public funding of academic research<sup>32</sup>. Researchers can also have an interest in collaborating with firms as a means of obtaining access to unique material and research tools, as described in Study III. The researchers' primary capital is human and the higher level of this capital they have, in combination with strong social capital, the easier it is to attract the kind of actors they want to collaborate with so they can pursue knowledge production.

**Managers in biotechnology firms** are stimulated to pursue the opportunity of knowledge production because it provides competitive advantages for their business. Whether firm managers personally engage in research activities depends on their background. Either way, usually other persons within their firm are active in knowledge production (although not necessarily resulting in publications). The continuous struggle to keep a front-line position motivates firm managers to complement the human capital of the personnel in the firm with that of researchers in other organizations. Firm managers accomplish this task by exchanging financial capital and, in some cases, human capital (Study III). The firm managers' social capital is of importance in the sense that researchers, who are sought after can pick who they want to collaborate with. It is likely that a firm manager that has gained the trust and respect through earlier activities with researchers will be able to engage these persons in further collaboration.

**Venture capitalists** view knowledge production as an opportunity in cases where they are involved with their portfolio firms' scientific development, which, in turn, depends on the background of the venture capitalist. This was demonstrated in Study II, which also shows that venture capitalists are active in the interaction to establish collaborations in knowledge production in cases where they support exchanging a portfolio-firm's financial capital for human capital.

### Firm creation

Along with the increase of commercialization of knowledge of living organisms, **researchers** are becoming increasingly involved in pursuits of opportunities to create

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<sup>32</sup> Sources: the National Science Foundation, American Association for the Advancement of Sciences and Årsredovisning 1999, Karolinska Institutet.

firms (Owen-Smith & Powell, 2001). A researcher does not automatically decide to engage in commercial activities when he or she makes scientific discoveries. Samson (1990) argues that the researcher must recognize the opportunities for commercialization first and then consciously decide to engage in business activities. His argument does not hold all the way in the case of biotechnology, however. As shown in Studies II and III, this is because other actors can recognize the commercial potential of a discovery and point it out to the researcher. Either way, the opportunity to create a firm may stimulate the researcher to engage partly or fully in that activity, or not at all. The decision to engage in the creation of a firm is related to the researcher's social capital, as indicated in Study II. When embedded in large personal networks with actors involved in business-creating activities, the likelihood of engaging in business increases. The characteristics of a researcher's personal network influence his or her knowledge concerning opportunities and how to pursue them, which is in line with the findings of Burt (1992), Aldrich (1999) and Casson (1997).

If researchers decide to create a firm, they will have to use their human capital to attract actors that can provide complementary human (business expertise, patenting, technology, etc.) and financial capital needed to create the firm. Social capital is also required because new ventures are, by nature, vulnerable and hence they need to gain institutional support and legitimacy. The road to credibility can become much easier if there is a good mix of partners in the venture from the start with good personal networks (Nohria, 1992). Few researchers are likely to have direct links to the kind of actors needed in the pursuit of creating a firm. However, they may have persons in their personal network who have links to strategically important actors (Aldrich, 1999). As demonstrated in Study II, when researchers' personal networks include people with business experience and contacts, they will have easier access to the different kinds of capital. The usefulness of the contacts is largely dependent on the degree to which the persons know each other and the frequency with which they interact (Hansen, 1995). The people in the network can, for example, be research colleagues, relatives and other friends. When a researcher has started firms before or in other ways been successfully involved in business activities, the person is likely to possess more capital. That control of capital decreases the need for complementary capital and makes the capital still needed easier to attract (also evident in the case studies performed).

If a researcher's motives are not sufficient, he or she will not fully pursue a recognized opportunity, even if equipped with a suitable personal network (case in Study II ). If so, actors that are motivated to create a firm are likely to acquire the intellectual property from the researcher and commercialize it. In the study, the researcher was still motivated to interact with these actors because both parties have an interest in advancing the discovery further. Moreover, the researcher, apart from financial rewards from selling the intellectual property rights or acquiring options in the new firm, can receive financial support for continued research.

A part of **firm managers'** activities is to keep abreast of new discoveries and research projects that can be of use to the firm or possibly create changes in the market and competition. Such activities involve excluding certain projects from the firm's agenda because of changes in strategic direction. These activities can create opportunities for firm creation. If a firm manager finds a project or discovery to be of large enough potential to lay the base for a new firm, then it will increase his or her motives to pursue such an opportunity (unpublished data from Study II). Just like the researcher who decides to create a business, the firm manager will need to complement his or her capital with that of others. In such circumstances, an important ingredient is to have social capital that allows access to suitable actors. There will probably be a need to exchange some of the potential of the new firm for financial capital. The firm manager also needs to ensure that the intellectual property rights are secure and that research collaborations can be established, which may mean exchanging equity of the new firm. The findings of Study II indicate that firm managers are likely to have stronger social and human capital when it comes to business activities as compared with a given researcher. This strength will decrease the need for complementary capital in those areas and facilitate finding suitable actors for interaction. Managing a firm, however, is not the same as creating a new firm. Study II found that unless the firm manager has acquired the experience, there will be a need for complementary human capital when creating a new firm.

The findings of Study II indicate that the opportunity to make a profitable investment through firm creation motivates **venture capitalists** to retain researchers within their personal network. Creating and maintaining personal networks that provide information about and access to, for example, investment opportunities and skilful managers to be recruited to the portfolio firms is a vital activity for venture capitalists (Cable & Shane, 1997, Gompers & Lerner 1999a, Zider 1998, Carvalho, 1996). Besides finding investment

opportunities themselves, they are approached with numerous proposals for investments from researchers, firm managers and others who want to exchange the potential of a new venture for the capital of the venture capitalist. Findings from Study II indicate that proposals for collaboration from actors, who are already a part of the venture capitalists' personal network, receive more attention in that they have passed an "initial filtering process." Actors, unknown to the venture capitalist, will have to work harder to gain attention, unless they use a broker.

Specialized venture capitalists scrutinize research projects that may be of use to their portfolio firms through in-licensing. In this process, they occasionally find projects that are solid enough to form the base of a new firm. This pro-active behavior is primarily a quality of specialized venture capitalists with a scientific background that are interested in investing in the early stages of a firm's development. These venture capitalists (if experienced) have, additional to the financial capital that goes with their profession, the human capital of knowing how to start a firm and the social capital that will facilitate access to complementary capital, which is also emphasized by Greene (1999).

### **Business development**

Within the interaction occurring in the pursuit of the opportunity to develop a business further, **researchers** can use their human capital to access the financial and human capital they need to pursue their research (see Studies I and III). To establish themselves within the industry, firms are in continuous need of human capital in the form of front-line research, which opens the doors for exchange. If mutual interests arise, agreements of different forms of collaboration can be achieved.

For **firm managers**, the opportunity of further developing their business is related to the opportunity of knowledge production in that the need to access research and increase human capital motivates interaction with researchers. Firm managers need other capital as well in developing their business. The need for financial capital is likely to increase along with the development of the firm. The broadening or deepening of the activities creates a need for continuously expanding all competencies (e.g. within management, regulations and scientific areas), which accounts for why various collaborations are sought. These findings in Study III are in accordance with those of Fildes (1990), Liebeskind et al. (1995), Powell et al. (1996) and Autio (2000). Collaboration with venture capitalists that

can provide both financial capital and expertise is motivated. However, such collaboration demands exchanging equity of the firm.

The opportunity of business development is well recognized by **venture capitalists** as they aim to increase the value of the equity they own in firms. The case studies in Study II show that as a firm develops, investment opportunities for venture capitalists that have not been engaged in the firm earlier can take place to finance expansions. Many venture capitalists prefer to invest in firms that have been under development a few years because such firms constitute a less risky investment object. These “later-stage” venture capitalists, often not specialized, are more likely to exchange financial capital without much added-value in return for equity in the firm.

### **Collaboration**

#### *Abstract from conceptual framework*

*When collaboration is agreed upon, action is taken to pursue the opportunity. The actors change their roles and related activities from what they were before the collaboration, to what is considered needed to pursue a specific opportunity. Ability to change roles is related to actors' initial existing capital and the capital provided by the other involved actors. The same types of actors can play multiple roles. As the collaboration takes place, the human and social capital of the actors involved increase providing they learn from each other and increase their networks.*

Beginning with the researchers, I examine the roles and actions of the three actors and how these may change because of the collaboration processes related to the pursuit of the three areas of opportunities studied.

#### **Knowledge production**

The main role of **researchers** is to advance research and spread knowledge. Because substantial education and research experience are needed to perform these activities, researchers can be expected to have control of significant amounts of human capital that is important to the knowledge production in a specific area. If motivated, that researcher will therefore be able to take a leading role in the collaboration. If researchers, without prior business interest, collaborate with firm managers or researchers who have experience in identifying commercial potential in research discoveries, the likelihood that they will engage in the search for commerciality in the research increases. Such

collaboration provides the researcher with information and contacts that strengthen the ability to recognize opportunities to create firms and the motivation to do so (findings from Studies II and III). If a firm already financed part of a research project and has the first right of refusal, then they can make use of the discovery. If managers at that firm decide that it is not of interest or if the project does not receive financial support from a firm, then (depending on the regulations of the country) the researcher who made the discovery or the organisation for which he or she works owns the discovery. The intellectual property rights for the discovery can then be sold to an existing firm or to an individual actor who wants to create a firm based on the discovery. This actor may be the researcher who made the discovery and, possibly, the one that identified the commercial potential.

**Firm managers** can take the initiative to pursue a certain knowledge production; however, if they need to collaborate with external researchers, they may not acquire a leading role. The actions connected with the role of firm managers in the collaboration to pursue knowledge production are to bring finance and/or knowledge and possibly material and tools to advance research (Study III). In addition to seeking research results that add to the firm's existing projects, a firm manager is likely to search for new commerciable discoveries.

A **venture capitalist** is not likely to engage in the actual collaboration in pursuing knowledge production. However, as indicated in Study II, the venture capitalist can take the role of enabling such collaboration by acting as a broker. Venture capitalists have an interest in providing their firms with the best human and social capital possible. When venture capitalists are specialized in biotechnology, they are likely to use their social capital to link firm managers to researchers in academia. The role as a broker demands that venture capitalists have a good reputation and the respect of other parties. As noted earlier, these are usually venture capitalists that engage in early stage investments. When venture capitalists are active in later stages of investment, especially if not specialized in biotechnology firms, they are less likely to be even an indirect actor in knowledge production.

### Firm creation

A person who creates a firm is, in general, referred to as an entrepreneur. In this discussion I apply the following definition of entrepreneurs: *Individuals that recognize unexploited opportunities and who have the ability to make the judgments and coordinate the scarce resources needed to create firms.*<sup>33</sup>

This definition fits in with the findings in Study II in that it allows the term entrepreneur to be looked upon as a role rather than an actor. Furthermore, the definition allows for the possibility that two or more actors, in combination, can take on the role of an entrepreneur. Nohria (1992) points out that the resources needed to create a high technology firm are specialized expertise and tacit knowledge. His argument is that every venture presents a new challenge and the success of the venture is based on the ability of the actors to apply their existing knowledge to a novel situation.

The entrepreneur is the actor(s) who takes the leading role in the collaboration to create a firm. The entrepreneurial role includes several actions such as defining the foundations of the firm, writing business plans, securing intellectual property, attracting personnel and capital and establishing collaborations. An important action in firm creation, which may take some time, is attracting a permanent actor to lead the firm. Study II shows that when the entrepreneur is motivated and has the capital to continue leading the firm after the start-up phase, he or she becomes the CEO. This transition assumes that the others in the collaboration agree or that they do not have enough influence through their capital to refute this decision. When the entrepreneur lacks motivation or capital to continue with the further development of the existing firm, a CEO from outside the firm will be recruited. When this is accomplished, the actor who took the role of an entrepreneur can find a new role in the firm or return to his or her earlier position before the firm creation and retake the entrepreneurial role whenever an opportunity is recognized.

The case studies in Study II show that a **researcher** can take the initiative to create a firm. However, without prior experience and strong personal networks in the area, it is not likely that the researcher will be able to make the judgments or gather the resources

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<sup>33</sup> There are a number of definitions of entrepreneur. Deakins (1999) compares the ideas of several scholars (Kirzner, Schumpeter, Knight, Shackle and Casson) and I have chosen to refer to Kirzner and Casson. I do not adhere to their complete definitions of entrepreneur, but prefer to make use of the overall direction of their definitions and put them together into one that is useful for the aim of this thesis.

needed to pursue the opportunity successfully. If an actor with experience of creating firms can be attracted to the opportunity, then that actor is likely to assume the entrepreneurial role. It is a time-consuming role and in some cases the experienced actor does not prioritize taking that role, but rather act as a mentor for the researcher, sharing both human and social capital to create the firm. In those cases (Study II) an inexperienced researcher may be the principal entrepreneur. If the researcher has prior experience in creating firms along with motives to pursue that opportunity, he or she assumes the entrepreneurial role. If the researcher does not have motives or sufficient capital to assume that role, then he or she can accept a different role (e.g. chief scientific officer) in the start-up. If the researcher anticipates taking a certain role but finds that the other actors in the collaboration with strong influence do not agree, the motives to create a firm are likely to diminish. Poor motivation may result in the researcher rejecting another role in the firm creation and even lead to the researcher leaving the collaboration. This situation occurred in one case in Study II.

The recognition of commercial potential in research can motivate **firm managers** to pursue the opportunity of creating a business. As with researchers, the role taken by the firm manager in the collaboration to create a firm depends on his or her motivation and existing capital. If the firm manager controls enough capital to take the leading role as an entrepreneur he or she may leave the position as a firm manager at another firm (see Study II). The role as an entrepreneur contains activities other than that of a firm manager. When a firm manager has had earlier experience as an entrepreneur, the changing of roles will be facilitated. The results of Study II show the importance of having some actor in the collaboration with the experience of having the top responsibility of a firm, i.e. having worked as a CEO improves the prospects of realizing an opportunity to create a firm. When entrepreneurs, who used to be a firm manager but not a CEO, took on the permanent position as the CEO of the new firm, they needed support for their new role. With or without earlier experience, a firm manager learns from the other actors in the creation of the firm, which strengthens both their social and human capital.

The role of a **venture capitalist** in the collaboration to create a firm can be of various kinds. Study II, which focused on specialized venture capitalists in Silicon Valley, showed that the exchange and input in an interaction from the venture capitalist is dependent on the kind and amount of capital that the other actors provide. When the other actors in the collaboration jointly control a good level of human and social capital, venture capitalists are likely to contribute mainly with financial capital. It is rare, however, that there is sufficient capital of all kinds in a start-up and venture capitalists will probably be active in giving advice and using personal networks to establish contacts for the firm. The amount of activities is restricted to how much time the venture capitalists are motivated to spend on the new firm in relation to other investments. Most start-ups benefit from receiving more attention from specialized venture capitalists, but these actors will prioritize according to their perception of the needs and potential of their portfolio firms.

As suggested in Study II, if venture capitalists contribute the majority of the financial capital in a venture, they are more likely to spend a majority of the time with the start-up and may even take the leading role as the entrepreneur. A venture capitalist's decision to focus on one firm, until the start-up process is completed and a permanent CEO has been recruited, is agreed upon with the partners at the venture capitalist firm. The venture capitalist will have to convince the other members in the venture capitalist firm of his or her potential value as entrepreneur, possibly neglecting some other firms, in order for them to see that it is in the best interest of their firm. It is possible that a venture capitalist that takes on an entrepreneurial role becomes so attached to the firm that he or she will choose to leave the position as a venture capitalist and seek the position of permanent CEO. The likelihood of this happening is lower than for a researcher or firm manager that takes the entrepreneurial role and then becomes the CEO. The reason is that part of the early stage specialized venture capitalist's core competence lies in starting up firms. This is a competitive advantage that they can make most use of by being in the business of starting up several firms and, in the process, adding on to their experience for the benefit of portfolio firms to follow. Although the venture capitalists may also have experience in running biotechnology firms, they often consider their competence to be put to best use by sharing it between several firms (unpublished data from Study II). That argument is also a reflection of a risk balancing strategy that the venture capitalist may have for his or her personal career.

### **Business development**

When **researchers** participate in the collaboration of further developing a business, they do not take a leading role because that belongs to the firm managers. The collaborating role of a researcher in this case can take many forms as seen in Studies I, III and IV. The degree of involvement on the part of the researcher is intimately related to regulations and individual motives. At one extreme, is the researcher who is involved in a project financed in part by a firm in exchange for first right of refusal, but who rarely is in contact with firm managers and does not relate to any extent to their business activities. At the other extreme, is the researcher who shares the time between academia and a role as firm manager. It is not unusual that researchers hold a seat on the scientific advisory board of a firm and receive remuneration or equity in the firm in exchange for their services. The researchers may want to become more knowledgeable about business and the collaboration with the other actors helps the researcher reach that goal. Such collaboration also strengthens the capital needed to pursue other opportunities.

The **firm manager's** development of the business (i.e. the actions taken) is shaped by the position the firm holds in the overall network (Nohria, 1992, Powell et al., 1996, 1999). Firm managers take the leading role in the collaboration of further developing a business. In that role, the firm managers continuously need to assess immediate and future needs of the firm as described in Study IV. The other actors are dependent on firm managers in their leading role, as the collaboration may end as soon as the firm managers decide that certain capital (that the other actors in the collaboration control) is no longer prioritized. The actors involved are not necessarily focused on the same outcome. Researchers that engage in collaborations may have the further development of a specific research project of theirs as their primary goal and not care as much about strategic business questions. Venture capitalists are likely to have the business development as goal, but they may differ with firm managers concerning how to reach that goal.

The **venture capitalist** does not usually have a leading role in the collaboration to further develop a business. However, the venture capitalist does have the power to influence the development of the firm through, for example, his or her equity, seat on the board and personal networks. That power is strongest for initial venture capitalists in the early stages of a firm's development. In later stages, the number of shareholders usually increases through new rounds of financing and the distribution of power changes accordingly. This

point was described in Study IV. The role of the venture capitalist in the collaboration to further develop a business is to support it in various ways. The financial support is a given, without which the venture capitalist would not have been asked to collaborate in the first place. Support through advice regarding such matters as business strategy, financial and legal issues, patenting strategies, collaboration agreements and contacts with future investors, collaboration partners, potential personnel are other activities that can be included in the role of the venture capitalist at this stage (unpublished data from Study II). The amount of activities taken by venture capitalists depends on the level of human and social capital that they control and their motives to spend time to use it on one particular portfolio firm.

## **Outcomes**

### *Abstract from conceptual framework*

*The actors' contributions in collaborative efforts enable actions that lead to outcomes. Unstable interaction lead to poorer prospects of reaching an outcome. Certain factors that cause unstable interaction are identified as:*

- *under-informed assessment of the capital required to realize an opportunity*
- *poor ability to localize and attract complementary capital*
- *a lack of mix or level of capital in the collaboration*
- *under-informed decisions on the distribution of roles in the collaboration*

Examples of factors causing unstable interaction are provided in this section, where each of the three areas of opportunities are discussed, starting with knowledge production.

### **Knowledge production**

The researcher, firm manager or venture capitalist that initiates an interaction process in the pursuit of knowledge production may underestimate the capital required for the endeavor. Even if the estimation is based on solid information, the first mover may not be able to find and attract actors with the necessary capital. In both cases, the result will be that the actors involved in the knowledge production will find that their combined human capital may not be enough to produce research results of value. Alternatively, when they have the required knowledge but lack finance, they cannot carry on with the project long enough to obtain stable and reliable results. Either way, the use of social capital can help the situation by linking other researchers and financiers to the project. That requires

involved actors to have high levels of social capital as well as other capital of interest to potential collaborators, which may not be the case if there was trouble in attracting suitable actors initially. Even if the capital is sufficient for collaboration to take place, the collaboration may suffer simply because the actors do not agree on how to prioritize and move on with a specific project. This can occur if, for example, a firm manager detects commercial potential in one direction, whereas a researcher may find another direction to be of greater research value. The question of leadership and role distribution thus becomes a potential source of conflict that, in a worst-case scenario, can make the collaboration weak or discontinued. Although both researchers and firm managers will have learned from the process, they will have lost the access to each other's capital.

### Firm creation

When actors recognize an opportunity to create a firm but lack the necessary experience, it will be difficult to formulate an assessment of the capital needed to reach the outcome. For example, a researcher may start-up a firm but after some time discover that it is not going anywhere. It may be because the researcher does not have enough experience, financing or networks. It can also be because he or she does not have the ability to assess which resources were needed in the first place. Even with insights about required capital, the researcher may not have networks through which to locate the right actors or be able to persuade them to involve in an exchange of some of their capital in a collaboration.

The access to complementary capital in firm creation is related to how long the biotechnology industry has existed in a region (and how it has developed). This is especially true when it comes to experience of creating and developing firms. In regions with few actors with that kind of human capital, the competition to attract them to a certain venture will be fierce. Many first movers will not be able to access the human capital needed. They risk ending with a collaboration in which there is a lack of capital and hence the chances of survival are poor. One example is the difference in content of the capital provided by venture capitalists, as discussed in study II. When venture capitalists have experience in the area of biotechnology, they are better able to assess the kind and level of capital needed in the collaboration and may provide various kinds of capital required. If venture capitalists lack experience, then they are neither likely to make a well informed assessment of required capital nor of the outcome of the collaboration (Bygrave & Timmons, 1992). When other actors involved are also inexperienced,

conflicts are likely to arise because of scarcity of capital and inability to fulfill expectations. Inexperience makes it difficult to put a value on the capital that the actors contribute in the collaboration, which may make the role distribution unclear. Even if a venture capitalist controls a large part of the firm, it may not be worth very much if key researchers decide to leave the firm because of conflicts between the actors.

### **Business development**

A firm manager's inability to assess the needs for complementary capital can prove fatal for a firm, as described in Study IV. For example, poor awareness of ongoing research and competition will probably lead to levels of human capital in collaborations that do not match the true needs of business development. When firms cannot keep or reach a front-line position within their area of research, they become less attractive as collaboration partners. The firm manager will find it increasingly difficult to establish any kind of collaboration with researchers that are needed to strengthen the human capital. Such a situation will decrease chances of establishing collaborations with pharmaceutical companies, which in turn makes it difficult to attract investments.

Even if firm managers are up-to-date on research and manage to keep their firm in a front-line position, problems may still be encountered regarding attracting complementary capital, also described in Study IV. The development of a research project may take longer than expected. Hence, venture capitalists who invested in firms may prove less patient than the other actors perceived initially. When not enough milestones can be reached, it will be difficult for the firm to receive new financing, resulting in a halt in the expansion of on-going projects. Instead of becoming an established firm, the outcome may be that part (certain projects) or even the whole firm is sold to another company. Although not the outcome expected, such a solution still provides venture capitalists with an exit. Researchers in the collaboration, if willing to work through the acquiring company, may still receive financing for their research. Managers of firms that are acquired receive financial compensations. That, together with their experience and possibly some intellectual property or ideas held on to from the initial firm, often provides the basic framework for starting up new biotechnology firms (see case study of San Diego in Nilsson & Runeberg, 2000). This scenario, however, is only likely in cases in which biotechnology firms possess intellectual property and projects in the front-line of research. If not, there will be few gains for the actors involved in the collaboration, apart

from the learning experience. Their financial capital will decrease (and perhaps even social capital), depending on the reasons for not reaching the outcome. When actors behave unacceptably or demonstrate poor competence in the view of the other actors, it will damage their reputation, which negatively affects the actor's social capital in related networks.

## **Conclusion**

Through the general discussion, based on empirical data from the studies of pursuits in three different areas of opportunities and a new conceptual framework, it becomes clear that interactions are needed to realize opportunities. It thus follows that interaction is an essential property of biotechnology business.<sup>34</sup> This section comprises the introduction of a model of opportunity-pursuits, illustrating the role of interaction, and a set of propositions.

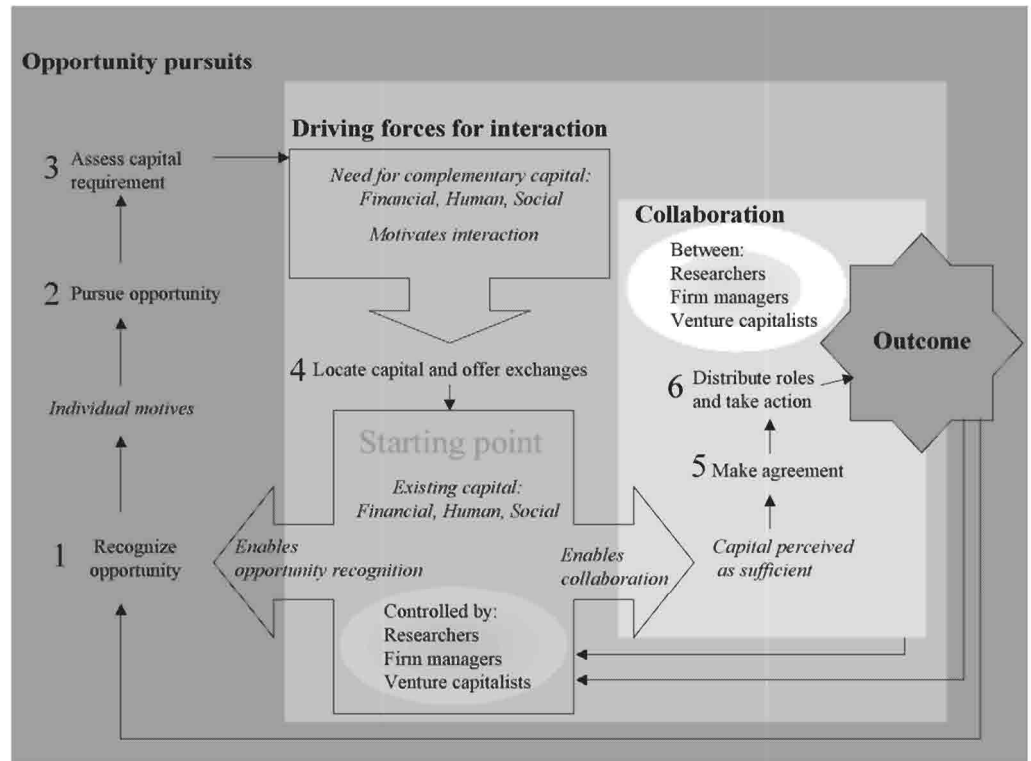
### **A model of opportunity-pursuits**

As an illustration of the conceptual framework, presented in chapter 3, I have developed a model. Through this model, see Figure 5, the research questions in the general discussion are addressed on a conceptual level.

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<sup>34</sup> For a discussion on essence, see O'Neill (2001)

Figure 5. Model of opportunity-pursuits in biotechnology business



#### A guide to the model

The conceptual framework of processes of opportunity-pursuits in biotechnology business is divided into four components (opportunity pursuits, driving forces for interaction, collaboration, outcome). These are represented by fields of different colors. One exception is the component “outcome,” which has the same color as the component “opportunity pursuits” because “outcome” has direct effects on it. The numbers lead through the activities of an actor, pausing at “If – then” – statements marked in italics – along the way. The oval figures, which appear in the orange and yellow components, represent involvement of several actors, which may also occur in the other steps. The starting point is the existence of capital, which is a point that will be returned to and passed through again along the process.

The three research questions of the general discussion are addressed below, through the model. In connection, a set of propositions is introduced.

*1. Why do researchers, firm managers and venture capitalists interact?*

The initial existence of an actor's human and social capital enables him or her to recognize an opportunity (starting point: the box "existing capital" in the orange field which leads to the activity "recognize opportunity" in the red field). If the actor has motives, then he or she will pursue the opportunity and assess the capital required to do so. If complementary capital is not believed to be required, then the actor will take action and pursue the opportunity alone. If the actor assesses complementary capital to be required, he or she will be motivated to interact with other actors (the arrow from the red field into the orange field "driving forces for interaction"). The motive to interact is related to the mix and level of the actor's existing capital initially and how the actor assesses the need for complementary capital, which, in turn, is related to the kind of opportunity that is pursued.

If "need for complementary capital" is established by the researcher, firm manager or venture capitalist (the first driving force of interaction), then that person will engage in the activities of "locate capital and offer exchanges." These activities, in which interaction with other actors takes place, are mainly evaluations of the value of the existing capital that different actors have to offer each other (the second driving force of interaction). The control of existing capital enables the actors to engage in collaboration, as long as it is assessed as valuable by other actors and mutual interest to collaborate arises. The actors will evaluate each other's capital. If the capital is perceived as sufficient to realize the opportunity, then agreements are made as to how the exchanges will be performed. The interaction thus takes the form of collaborations (the arrow from the box "existing capital" in the orange field leads to the yellow field of "collaboration").

Propositions

- If an actor's human capital increases, then there will be an increase in his or her ability to perform an informed assessment of capital needed to pursue an opportunity.
- If an actor's control of a certain capital increases, then there will be a decrease in his or her need for complementary capital of that kind.

- If an actor assesses a need for complementary capital in the pursuit of an opportunity, then he or she will increasingly try to locate such capital and offer exchanges.
- If an actor's social capital increases, then his or her ability to locate needed capital increases.
- If an actor's capital is highly valued by other actors, then those actors' interest in exchanging capital increases.
- If mutual interest to exchange capital increases, then there will be an increase in the chances to reach an agreement to collaborate.

*2. How may researchers, firm managers and venture capitalists change their roles because of interactions?*

When collaboration is agreed upon, action is taken to pursue the opportunity. The actors change their roles and related activities from what they were before the collaboration to what is considered needed to pursue a specific opportunity. Ability to change roles is related to actors' initial existing capital and the capital provided by the other involved actors. Roles are distributed according to the individual motives of the actors and their control of capital. The actors may already be aware of the other actors capital and what roles they will play before agreeing to collaborate. However, when this is not the case, they discover the value of the capital the other actors have in due time and the roles are changed to correspond to that capital.

Actors can take multiple roles and will exercise their influence in an effort to acquire the role they desire in a specific collaboration. The actor, whose capital is valued as most vital for the opportunity to be realized, has the strongest influence in what roles they will play in the collaboration. As the collaboration takes place, the human and social capital of the actors involved increase providing they learn from each other and expand their networks (the arrow from the field of "collaboration" leads back to the box of "existing capital"). An increase in capital broadens the ability of the actors to change their role according to the input needed in future collaborations.

Propositions:

- If the capital of an actor is valued higher as compared with the other actors in the collaboration, then that actor will have the strongest influence in what roles they will play.

- If the assessed value of the existing capital that the actors put into the collaboration matches the needs, then collaboration will increase.
- If the capital of an actor increases, then the actor's ability to change roles according to needs in future collaborations will increase.

*3. How does unstable interaction relate to inability to reach outcomes?*

The actors' contributions in collaborative efforts enable actions that lead to outcomes.

Unstable interaction lead to poorer prospects of reaching an outcome. Certain factors that cause unstable interaction are identified as:

- under-informed assessment of the capital required to realize an opportunity
- poor ability to localize and attract complementary capital
- a lack of mix or level of capital in the collaboration
- under-informed decisions on distribution of roles in the collaboration

The prospect of realizing an opportunity improves along with increased collaboration.

The outcome influences the environment in which new opportunities may arise (the arrow from "outcome" leads back to "recognize opportunity"). Outcome also generates increased capital for the actors involved (the arrow from "outcome" leads back to the box of "existing capital"). It increases the social capital for the actors, unless serious conflicts arise, in which case that capital may decrease. Reaching an outcome will also allow the actors' human capital to grow as they learn from the experience itself and possibly from the knowledge of the other actors. It can also increase financial capital for the actors. An increase in capital strengthens the ability of actors to recognize new opportunities, assess capital requirements, attract complementary capital and be influential in future collaborations.

Propositions:

- If interaction is unstable, then chances of realizing an opportunity decrease.
- If outcomes are reached, then the environment in which the opportunity initially arose will be influenced.
- If outcomes are reached, then the actors' capital will be influenced.
- If human and social capital increase, the actors are further enabled to recognize opportunities.

The last proposition, pertaining to the ability to recognize opportunities, leads back to the box “existing capital”, where the guide of the model started. This serves to demonstrate the dynamics and non-linearity of processes of pursuits in the three opportunity-areas examined in this study.

## 5 CONTRIBUTION, FUTURE STUDIES AND IMPLICATIONS

By analyzing interaction between researchers, firm managers and venture capitalists, I reveal the logic of processes of opportunity-pursuits in biotechnology business. Moreover, I show that interaction is essential in such processes.

The four studies performed contribute to an increased understanding of opportunity-pursuits in the areas of knowledge production, firm creation and business development. Through an analysis of the collective empirical data from the studies I also increase the insights into the role of interaction between researchers, firm managers and venture capitalists in these pursuits. One insight is that entrepreneurship can be understood as a relational concept:

- I found the entrepreneurial role in firm creation to be temporary. Researchers, firm managers and venture capitalists may all take the role of an entrepreneur at certain times in their life. I have also found that entrepreneurship can be shared. It may well be that the firm has more than one person serving as entrepreneur. For instance, if two persons are jointly creating a firm, one person may have recognized the opportunity and the other may have access to capital. Certain characteristics, including ability to recognize opportunities and strong positions in networks through which financial and human capital can be gathered, are the factors determining whether an actor takes an entrepreneurial role. I found these characteristics to be vital, not only in firm creation, but also in the areas of knowledge production and business development. I therefore propose that pursuits of opportunities in biotechnology businesses can be considered as entrepreneurial processes.

Another part of the contribution is a new conceptual framework of pursuits of opportunities in biotechnology business, including a model. The conceptual framework results in a set of propositions and adds to previous research by providing a new base for

research on pursuits of opportunities. Through the conceptual framework, I clarify the role of interaction in such pursuits:

- Interaction is a prerequisite for obtaining and maintaining social capital. Social capital, in turn, encompasses the information channels through which different opportunities are recognized. It is by means of social capital that actors with complementary capital, needed to reach an expected outcome, are located. Social capital facilitates the exchange of human and financial capital and can in itself be valuable in exchange situations. Collaboration with other actors strengthens social capital and thereby the channels through which new opportunities are recognized. The complex environment of biotechnology seems to make the nature of decision-processes in business development opportunity-driven, which in turn also makes social capital important in order to reduce risk. Hence, social capital is of utmost importance in pursuits of opportunities. Interaction enables social capital to increase and without interaction it will die out. Interaction is thus necessary for the existence of social capital and social capital is necessary for pursuing opportunities, which leads me to propose that interaction is essential in biotechnology business.

The logic of processes of opportunity-pursuits in biotechnology business, introduced in this thesis, speaks specifically for the groups from which it was derived and hence is applicable to them (Strauss & Corbin, 1998, Creswell, 1994, Yin, 1984). The descriptions and explanations are therefore likely to be valuable to practitioners and policy makers who want to increase their understanding of opportunity-pursuits in areas of knowledge production, firm creation and business development. The conceptual framework, including a model of processes of opportunity-pursuits, clarifies the role of interaction and is of value as a base for future research, as described in the following section.

### **Implications and future studies**

The proposal that interaction between researchers, firm managers and venture capitalists, is essential to biotechnology business implies that inability to realize opportunities is related to unstable interaction, to a certain extent. The cost of lost opportunities that could have contributed to enhancing the value of knowledge of living organisms is not only high for individual actors, but also for society as a whole as demonstrated through the examples listed below:

- Less knowledge production, than potentially possible, decreases the ability to create a strong scientific foundation, which is fundamental for the biotechnology business.
- Fewer new biotechnology firms, than potentially possible, decreases the amount of research that becomes commercialized and poses a threat to long-term growth of the industry.
- Less business development, than potentially possible, decreases the chances of having strong firms able to bring selected projects into later phases of development.

The common consequence of all three examples is a negative effect on the prospects of turning research discoveries into processes and products that help to improve quality of life through biotechnology. It is therefore important to understand the role of interaction in pursuits of opportunities and it would be worthwhile to perform further studies in the area.

The conceptual framework, introduced in this thesis, is developed from studies of selected areas of investigation, specific groups and is also limited in space and time. Although the data are in accordance with previous research, the assumptions based on the data are not generalizable. The assumptions of the framework would therefore benefit from verification through further studies that serve to broaden the present scope. Such studies could take the form of comparative studies in different geographical regions, studies of other areas of opportunities, studies that focus on other aspects in pursuits of opportunities and studies of other types of actors than those considered in the present study. These kinds of studies would increase the use of the conceptual framework developed in this thesis if it is found to be applicable to larger groups. The assumption that there are two main driving forces for interaction is based on the present empirical results. There are probably other driving forces in this process and a search for such would also be valuable in future revisions of the conceptual framework. The conceptual model is based on research regarding pursuits in three opportunity-areas that are related to biotechnology business. Nonetheless, it may be worthwhile to test the validity of the model on industries with similar characteristics of being relatively new, research intensive and very dependent on human capital. If the assumptions make sense for other industries as well, it would

further increase the applicability of the model for policy makers, firm managers, venture capitalists and decision-makers in academia.

High degrees of uncertainty in the environment of biotechnology business create difficulties in decision-making. Decision processes in business development appear to be of an opportunity-driven nature. Traditional risk management tools may therefore not be the most useful for understanding how biotechnology firm managers deal with risk issues. A future discussion of the usage of concepts related to opportunity may provide a more suitable platform for understanding responses to risk issues in biotechnology business.

Borrowing the concept of social capital has been beneficial in developing the discussion at the micro level and may allow a relatively smooth transition to the macro level in the future. The problem with the concept of social capital is that it is used metaphorically (Hands, 2001). In order to perform quantitative research it would be necessary to operationalize the concepts of financial, human and social capital by identifying factors that can be measured. Together with further adjustments of the conceptual framework, the propositions presented will become useful in formulating a set of hypotheses. If the model of opportunity-pursuits can withstand empirical inquiry, it can be further developed and used as a tool for identifying obstacles in realizing opportunities. Knowledge about those obstacles would provide actors with openings to take action to reduce them. The overall aim of such efforts would be to increase the prospects of improving quality of life through biotechnology.

In future research, it would also be valuable to relate my findings and propositions to the impact of institutional frameworks. This would serve to create a more complete picture of the complexities underlying the processes of realizing the potential of the opportunities derived from the advances in biotechnology-related research.

#### **Beyond the conceptual framework**

The purpose of the following section is to provide examples of how factors related to institutional frameworks that differ from country to country, can be a source of conflict that makes interaction unstable or influences access to capital needed in opportunity-pursuits.

*Knowledge production*

When researchers collaborate with firm managers in their pursuit to enhance knowledge production, the divergent priorities of the actors as how to use the results are a potential problem. To avoid conflicts, the actors need to agree on the issues related to intellectual property. If the actors' organizations are accustomed to these kinds of collaborations, they will most likely have regulations that set the standards for such activities, complementing broader national laws. They may also provide services to facilitate establishing formal agreements, which is also pointed out by Cech and Leonard (2001). Researchers without access to clear guidelines and assistance may find themselves in unexpected situations, especially if inexperienced with firm collaborations. If they feel abused in the collaboration as a result of misunderstandings in agreements, the collaboration is likely to decrease and the potential knowledge production may go unfulfilled. Furthermore, a researcher with negative experience of firm collaboration is less likely to be available for future interactions. Collaboration with researchers is of great importance to firm managers in biotechnology and it is in their interest to keep a good relationship with such actors, which is likely to decrease the risks of conflicts. As collaboration between firm managers and researchers becomes increasingly common, both actors advance on the learning curve in how roles and rights should be distributed in fulfilling the goals of all involved.<sup>35</sup>

Even if collaborations between researchers and firm managers are embedded in clear accord, this may not be the case between researchers within a project. Imagine a pure academic research group whose work results in a discovery with commercial potential. If an existing firm or individual actors who want to create a business become interested in acquiring the discovery, a question of ownership arises<sup>36</sup>. The researcher who is responsible for the most vital work with respect to the discovery, usually has the right to claim to be the main discoverer. The problem is that there are often differing opinions about ownership rights within a group. Ownership can be shared between several researchers, but if someone feels left out a conflict may arise. Such conflicts become an obstacle in the process of transferring a discovery to actors with means to commercialize it. Actors who are interested in acquiring a discovery need to be certain that there are no

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<sup>35</sup> The issue of patenting versus publishing is very complex and beyond the scope of this discussion. The following are examples of references that focus on the issue: Powell, W.W. & Owen-Smith, J. (1998), Barfield, C. & Smith, B. (1997), Blumenthal D. et al. (1996).

conflicts or other problems regarding intellectual property rights. Uncertainties create a risk that would make most actors abstain from investing in the discovery. As a consequence, the potential of bringing new discoveries into commercialization may also go unfulfilled. It is therefore crucial that researchers have full documentation of how the rights are distributed and are able to prove beyond a doubt that the documentation is based on mutual agreement of all the individuals involved in the project.

Public financing of research in the biotechnology area has a major influence on the production of knowledge. Continuous increases in public financing, as in the USA<sup>37</sup>, provide access to financial capital, which increases the amount and, one can assume, the quality of research projects. The importance of public funding has been highlighted elsewhere (e.g. Barfield and Smith, 1997, Cockburn et al., 1999).

#### *Firm creation*

The creation of new firms also requires financial capital. Both public and private seed financing exist in most nations, but the supply is dependent on several factors, which is also discussed by e.g. Oahey et al., (1990), Lee and Keen (1999), Darnbrough (2000), Hellberg et al. (2000). The amount of public seed financing available is related to current political priorities of governments. These priorities are, apart from the general state of a nation, likely to be influenced by how other countries act and which trends their behavior creates. One purpose of the public seed financing is to cover the gap that exists in the early stages when the commerciability of the research still needs to be developed (e.g. to establish proof of principle) before there is adequate substance to attract private financing<sup>38</sup>. The availability of private financing for early stages of development varies between countries, which is related to national regulations and structures. If private investors are rewarded financially (related to taxation laws and other regulations) and if the investors' investment strategies are effective, private financing is likely to become available to a greater extent. Economic cycles carry a natural influence on investments

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<sup>36</sup> In Sweden, the researcher would have full ownership of the discovery, whereas in the USA ownership belongs to the university. The acceptance of being the discoverer is still important in the US-system because many universities share profits made from discoveries with the discoverer and his or her department.

<sup>37</sup> Sources: National Science Foundation, American Association for the Advancement of Sciences.

<sup>38</sup> The Small Business Innovation Research Program in the USA is an example of public seed financing for firms that focus on research and development activities. It is managed by the National Institute of Health (NIH).

and the attraction of investments in other industries also have a significant influence on the supply of private financing for biotechnology firms<sup>39</sup>.

The success of creating a new biotechnology firm is dependent on, among other things, the ownership of intellectual property regarding patents and access to research. Consequently, the attitudes and regulations in the public research organizations are important. The general view of a researcher in academia is shifting from the traditional view to one person who engages both in academic and business activities (Owen-Smith & Powell, 2001). Owen-Smith and Powell (2001) argue that the integration of engagements leads to a situation in which actors in the field of biotechnology will have to compete in both academic and industrial settings to be successful. The interlinked roles give rise to questions such as a researcher's (full-time academic) right to use his or her time to engage in business activities or the threats that commercial collaborations pose on academic freedom and the spread of knowledge (Cech & Leonard, 2001). Public research organizations with a positive attitude toward collaboration with firms increase the access to discoveries with commercial potential and encourage interaction. The behavior of public research organizations will be consistent with what their governments prescribe. Governments also influence the climate for creating new firms in other ways, such as through tax systems and start-up services.

#### *Business development*

Similar to the opportunity of creating firms, the opportunity of business development is dependent on access to research. Therefore, the public research organizations constitute an important factor in this case as well, which is also pointed out by e.g. Powell et al. (1999), and Gambardella et al. (2000).

The process of creating intellectual property in the form of patents is fundamental to most biotechnology firms (Taylor, 2000). National offices of patent and trade have large impacts on the results of this process. Likewise, national offices of drug regulations influence if, how and when a firm is permitted to perform clinical tests and place a product on the market. These offices can cause delays in firms' milestones by not approving patents, trials or products, which is in order to ensure qualitative products.

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<sup>39</sup> As an example, the Internet boom led to an increase in private investments in Internet firms with 57% between 1997 and 1998, whereas the investments in biotechnology firms increased with only 5%. Source: National Venture Capitalists Association, USA ([www.nvca.org](http://www.nvca.org)).

Delays may, however, also occur when things are in order, if the offices have a shortage of personnel to handle requests.

Business development implies that biotechnology firms, although to a large extent applying outsourcing, need to recruit personnel. The access to personnel with a certain competence is related to the educational system. With a flexible system and educational programs that meet the needs of, for example, the biotechnology industry, an increased supply of competence can be expected. This would increase the chances for biotechnology firms to strengthen their competence and become more attractive in the eyes of other actors. One kind of actor that biotechnology firms often are dependent on for their future development is large pharmaceutical companies. It is common for biotechnology firms to act as intermediaries, developing research from academia into commerciable projects and then collaborating with pharmaceutical firms in the phases of clinical trials, exchanging intellectual property for financial capital. The pharmaceutical companies then bring the product closer to market. These agreements can take various forms, but the biotechnology firms usually get an initial payment and subsequent milestone payments for continued work on the project that is now partly the property of the pharmaceutical companies. If and when a product is launched as a result of the project, the biotechnology firms usually receive royalties from the sales. These are the main incomes for many biotechnology firms, making the demands for such collaborations high. The benefits of the collaborations are contingent on the biotechnology firm's ability to value and structure the deals (Moscho et al., 2000). The supply of collaborations is influenced by the strategies applied by the pharmaceutical companies. Over the years, the number of strategic alliances between biotechnology firms and pharmaceutical companies has increased<sup>40</sup>. The main reason is that the pharmaceutical companies need to increase the number of projects and potential drugs to replace the drug patents that run out within the near future<sup>41</sup>. Biotechnology firms become valuable partners for them as scanners of valuable research discoveries, research developers and sources of new competence, which is also brought forth by e.g. Faulkner (1989), Orsenigo (1989) and Oakey (1990).

Biotechnology firms need financial capital to develop their business. Sources regarding income through collaborations or products and/or support from a mother company rarely

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<sup>40</sup> The number of strategic alliances between biotechnology firms and pharmaceutical companies increased from 121 in 1986 to 627 in 1998 in the USA (source: Pharma publications, 1998).

<sup>41</sup> US patents for 75 large American drugs expire in 2005. These had sales of 50 billion dollars in 2000 (source: Gwyne P, 'Research Fellows', Red Herring, April 2000).

suffice in the initial stages of development. Depending on which stage of development the biotechnology firm is in, primary sources of finance include business angels, venture capitalists and the public market (Birndorf, 1999, Hurwitz, 1999, Sussman, 2000). As previously noted, the amount of finance available through these sources is influenced by economic cycles and the attraction of other industries. A positive climate for biotechnology firms allows more of them to access financial capital. When the industry in general is valued low and venture capitalists do not see the opportunity of making profitable exits through public offerings, few firms are able to attract investors.

I have touched upon a few institutional issues that have a large impact on the pursuits of opportunities in the areas focused on in this thesis. The examples given show that the logic of processes of opportunity-pursuits in biotechnology business, presented in this thesis, is embedded in a broader picture.

## 6 METHOD – OVERALL ASSESSMENT

The aim to gain further insight into processes of opportunity-pursuits in biotechnology business led me to conduct a series of studies. Because of the fact that biotechnology business is science-based and the firms are closely connected to the academic world, I focused the first study on finding out where knowledge-production takes place, what the collaboration-patterns look like and how they have changed. A feasible way of performing such a study was to use bibliometry, a quantitative method through which data on number of published articles within biotechnology-related journals can be analyzed. As is frequently the case in quantitative research, the results gave rise to questions about factors that may lay behind the trends. After finding out that an increasing number of firms collaborate with researchers in academia I wanted to understand how firms, based on science, are created and how they develop their business further. In order to explore these two processes I performed two studies using a qualitative method of case-studies based on in-depth interviews (Yin, 1984, Eisenhart, 1989, Creswell, 1994). Finally, I wanted to explore possible obstacles in pursuits of business development. This last study was performed through an operationalization of a theory, using data from interviews. The method enabled identification of risk issues and possible responses by firm managers in biotechnology firms. The collective material from the studies enabled an analysis from a process perspective regarding pursuits of opportunities, including images of the creation of links between actors and the collaboration that may emerge through interaction (Johannisson, 2000b).

This overall assessment begins with a description of the data collection procedure and a section on analysis and ends with a discussion on limitations in relation to performed studies.

### **Data collection**

The bibliometric dataset for Study I is based on the CD-ROM editions from *Science Citation Index™* (SCI). SCI includes the most important 10-15% of all scientific journals in medicine, natural sciences and engineering. All papers with the word "Sweden" in the address field were downloaded. The dataset covers the period 1986-1997 and includes,

after some screening, 25,045 articles with an impact factor of five<sup>42</sup> and higher in the selected journal categories (see Table 3 Study I for journal categories).

Regarding the empirical data used in Studies II, III and IV, individual, in-depth interviews were conducted. This allowed the use of a semi-structured method of interviewing with a protocol. To help avoid mistakes, a draft case study report was sent to all the respondents to give them the opportunity to point out if I had understood their information correctly (Yin, 1984, Creswell, 1994). Using case study protocols made it feasible to match patterns between the cases within each study, which is useful with respect to internal validity and reliability (Yin, 1984). Such protocols also enable replication.

A main reason for not using direct observations as a method is the high level of secretiveness in the venture capital business and in biotechnology firms (Robson, 1993). Even if I had gained access to perform such studies, the time needed to spend at one site to cover the research questions in the studies would have been too long to allow several cases to be performed. I thus prioritized establishing patterns by assessing several cases from which I could draw data and perform cross-analyses.

## **Analysis**

### **Units of analysis**

Cable and Shane (1997) and Powell and DiMaggio (1999) claim that studies at the micro level are needed to gain understanding at the macro level. Cable and Shane (1997) used game theory framework of the Prisoner's Dilemma to develop a model of the relationships between entrepreneurs and venture capitalists. The authors concluded, however, that the subjectivity in the model calls for the unit of analysis to be dyads of entrepreneur - venture capitalist rather than the general process. Their conclusion is a reflection of the importance of choosing the unit of analysis best suited for the research question. It also acknowledges that the choice is bound to influence the results of the study (Davidsson & Wiklund, 2000).

The particular unit of dyads of founder - venture capitalist is analyzed in Study II. The focus is on individual founder and individual lead venture capitalists. The research

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<sup>42</sup> Impact factors are based on the mean number of citations a journal has received to its articles during 1981-1996. The impact factors were taken from Journal Performance Indicators Diskette (JPID) produced by SCI.

questions were limited to cases in which these two individuals had collaborated in specific ventures and included questions about the individuals' background and actions taken in relation to the firm creation. As the individuals told their stories of the process of firm creation, the role of other individuals was also discussed. Thus, the early stage venture can be viewed as the unit of analysis (Yin, 1984). As such, the persons included in the case studies are limited to those that in some way contributed with the resources for the creation of the venture or had a role in the development of the venture up until (not including) phase III of financing. For practical purposes, the focus was thus more on passed than present processes. The study of these ventures was geographically limited to the area of Silicon Valley, USA.

The unit of analysis in Study III was strategies used by established biotechnology firms. I interviewed top management within five firms as well as external persons with direct relations to the firms. The interview questions were designed to assess the firms' positioning, financing and competence. The focus of the case studies was on how the firms worked strategically at the time of the study (present), but background (historical) information was included to gain a better understanding of the reasons underlying the firms' strategic choices. The geographical limitation was the area of Stockholm, Sweden. This study gave a broad picture of several aspects of the biotechnology business and subsequently allowed in-depth studies of any one of these aspects.

Study IV was performed to highlight one of these aspects, namely, risk. The unit of analysis was risk behavior at the firm level. This study, using empirical data from the five case studies in Stockholm and interviews with three firms in Boston, as well as secondary material, focused on providing a picture of risk issues and possible responses by firm managers at different stages of a firms' development. The limitation of stages is the time between the early phases of an existing biotechnology firm and the possible initial public offering.

The unit of analysis in Study I was published articles. Authors of published articles were identified and grouped according to their organizational belonging. The analysis was made on the level of all the different organizations where this kind of knowledge production occurs, which was mainly academia and industry. The analysis thus included the organizations in Sweden that perform and publish research related to biotechnology.

Their performance (output regarding number of papers and impact factor) and collaborations over a 10-year period were analyzed.

### **Pattern theory**

After Study I, which is quantitative, I have worked inductively, exploring opportunity-pursuits in search for patterns that may be helpful in understanding and explaining processes of pursuits. In the work on the different studies, the conceptual framework and the general discussion I have analyzed various perspectives, put together different factors, formed categories, related certain events with others, etc. This work was done in an attempt to reach patterns that explain the types of processes studied. These patterns can then be used to help predict behavior. This procedure is in accordance with Creswell (1994) and Yin (1984), who point out that an end product in the form of a pattern or visual model represents a theory developed by the researcher. With this approach, theories are not used as a tool to test or verify, but may emerge during the work with data collection and analysis. My application of pattern theory is also clarified by the fact that my work contributes with interconnected sets of concepts and relationships, but unlike casual theory, it does not contain causal statements (Creswell, 1994).

### **Limitations of the studies**

A limitation of the study on knowledge production is that it only includes published articles. Knowledge production can be measured in other ways and, in relation to business, it would be of interest to study patents. Such data were however not available to perform studies on.

The data used in study II, III and IV were mainly derived from in-depth interviews. The collection of information from more than one respondent in the case-studies performed served to limit the bias that may be a problem when there is only one person interviewed, as well as to reduce potential problems associated with an individual's lack of introspection<sup>43</sup>. Interviews with both parties verify facts in the case stories; moreover, such interviews enable detection of what emphasis each party places in their narratives (Yin, 1984). The respondents are active in three different types of organizations:

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<sup>43</sup> Zacharakis and Meyer (1998) point out that most studies on VC decision-making are based on reconstructed information and that the result of the studies is dependent on the VC's ability to accurately relate to their own decision process. Their research, using a real-time method, shows that VCs are not good at introspecting, although they are very consistent in their decision process. Zacharakis and Meyer's results imply that some past research may need a different interpretation.

academia, biotechnology firms and venture capital firms. Persons within one sector do not always use the same terminology as persons in another; nor do they share the same perceptual framework. Hence, the researchers' ability to relate to the respondents is bound to influence the results.

For the research to be reliable, it is necessary that the respondents are well suited to answer the research questions (Creswell, 1994). The venture capitalists interviewed in the firm creation study (Study II) were chosen according to the criteria of good reputation (verified through media and individuals in the community), specialization in biotechnology, early-stage involvement and location. The particular ventures that became the case studies were selected at the beginning of each interview, and were cases where the venture capitalists had been the lead investor. Another criterion for the case was that it had gone through at least two rounds of financing and was located in Silicon Valley. Thus, given the venture, the selection of the founder followed naturally. Two of the founders were not available for interviews; in these cases, other representatives of the biotechnology firm made themselves available for the interview. It is possible that the data collected in these two cases would differ somewhat if these two founders had been interviewed. However, because of the use of the “double interview” strategy, it is not likely that a possible difference would have been significant or altered the overall pattern of the findings. Another limitation of Study II pertains to a dependency on interviews as data source. The reason is that documentation regarding actual events in the biotechnology firms before IPO is rarely available. Furthermore, many issues explored in this study are based on the personal experiences of the respondents.

The business leaders interviewed for the study on business development (Study III) were chosen based on their position in the firm. The unit of analysis in these cases was on the firm level. A variation in the following criteria was sought in the selection of firms: range of activities, number of employees, age of the firm and ownership structure. Two of the firms selected denied access. Accordingly, two other firms with similar characteristics were selected. It is possible that the data collected would have varied somewhat if other firms had been chosen, but because the aim was not to generalize but rather create an understanding of certain dynamics, I believe that the final results would not have deviated significantly.

#### Method – overall assessment

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Research based on case studies is limited in scope, which reduces the generalizability of the results (Yin, 1984, Eisenhardt, 1989). Replicating the findings by studying the pursuit of opportunities and interaction under a variety of conditions would make the results less specific, as discussed in the previous chapter.

This chapter raises the questions of whether the research plans could have been designed differently and whether the way I handled possible impacts of limitations was adequate. In any case, I believe that the present research has increased my insight into the research process, which will be beneficial in the future.

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