Networks for Learning and Knowledge Creation in Biotechnology

Scientists in the biotechnology industry are responsible for many inventions that have led to the development of a vast array of products and technologies, in the areas of therapeutics, diagnostics, and agricultural and veterinary products. This has been possible through various intra- and interorganizational collaborations between the academic and private sectors, and through the establishment of networks for learning. In *Networks for Learning and Knowledge Creation in Biotechnology*, Amalya Lumerman Oliver shows how, in many respects, the organizational structure of the industry parallels one of its most important innovations – recombinant DNA (rDNA). She shows how the concept of recombination may be used to explain a number of organizational features, including new biotechnology firms, the formation of university-based spin-offs, scientific entrepreneurship, and trust and contracts in learning collaborations and networks. The result is an integrative account of how multiple theoretical perspectives can be used to understand the structure of the biotechnology industry.

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This book is dedicated to my father, Haim Lumerman, who is my source of inspiration and whose deep love and stamina have always guided me.

If only you stayed with us a bit longer . . .

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Oliver A. L. (2001) Strategic alliances and the learning life-cycle of biotechnology firms. *Organization Studies*, 22, pp. 467–489. (Parts reprinted by permission of Sage Publications Ltd, © Sage Publications, 2001.)

Oliver, A. L. (2004) On the duality of competition and collaboration: Network based knowledge relations in the biotechnology industry. *Scandinavian Journal of Management* 20, pp. 151–171. (© 2004, reprinted with permission from Elsevier.)

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Introduction

The biotechnology industry has been characterized by a wealth of interorganizational collaborations and networks for learning, a feature that resulted in and contributed to the high level of innovation in the industry. In this industry, scientists in the biological sciences developed drugs, diagnostics, waste management systems, agricultural products, or veterinary procedures through various intra- and interorganizational collaborations. These dense and crucial collaborations contributed to some unique features of industry structure, of types of organizations operating in the industry, and of the scientists involved in the process of scientific discoveries.

This book offers insights into organizational processes, structures, and outcomes which are associated with these networks of collaborations. The insights are based on integration of several "recombination features" of organizational elements that emerged in the biotechnology industry. In many respects, the emerged organizational structure of the industry is isomorphic with the central initial technology-invented recombinant DNA (rDNA). Thus, the book focusses on the following general question: How does our understanding of institutions, organizations, goals, learning, intellectual property rights, and collaboration forms contribute to our understanding of the emerging networks?

Hence, based on previous and ongoing research, the book highlights the following elements of recombination.

- *Recombinations of institutions themselves*: universities and biotechnology firms; through extensive collaborations of various types and alliances between universities and biotechnology firms, products are developed. These collaborations lead to various recombinant forms of organizations and interorganizational networks.
- *Recombinations of organizational elements within new firms*: biotechnology firms are trying to make money whilst attracting and retaining academically trained scientists who will continue to

undertake academic-style research, leading to new institutional forms that are based on the recombination of university and industry institutional elements.

- *Recombinations of business goals and scientific goals*: universities have now adopted many new business norms that are expressed in various features of recombinant goals. These mixed goals may have an impact on the operation of universities and on scientists' research behavior and choices.
- *Recombinations of collaboration and competition*: the complexities of the research and development processes lead to recombinations of interorganizational collaboration and competition trajectories.

These features are introduced in the nine chapters of this book. Chapter 1 deals with collaborations in the organizational context: issues of micro-, mezzo-, and macro-studies, and introduces the overarching framework of the book. It begins with the concept of "collaboration" and then introduces the levels of analysis that are crucial for understanding the knowledge creation and learning processes within and between organizations. The chapter aims to show how different levels of analyses – such as the industry level, multiple interorganizational level, dyadic level, organizational level, and scientists' network levels – are crucial for understanding knowledge creation and learning in biotechnology. The chapter argues that the use of various methods of interorganizational network analysis may bring to the fore hidden processes if based on a multi-level and multi-unit approach. An example argument illustrates that what may be seen as networks of collaboration, with the aid of additional types of network data, can be seen as intents for competition or appropriation. The aim of Chapter 1 is to establish the analytic elements that will be used further in the book, and to illuminate the complexity involved in a multi-level, multi-unit of analyses framework.

The second chapter provides an overview of the biotechnology industry through the lenses of organizational and networks scholarships. The organizational literature does not only exhibit a steady increase in the number of studies on the biotechnology industry all over the world, but also a widening of the spectrum of related organizational topics related to this industry covered by such studies. Although initial organizational studies of the biotechnology industry focussed mainly on interorganizational networks of collaborations, new research is also focussing on patents, scientific citations, strategy, firm emergence, entrepreneurship, intellectual property rights, trust, learning, and university–industry technology transfer.

The aim of the second chapter is to provide an integrative map of the research conducted so far on organizational aspects of the biotechnology industry. The chapter also reviews the available literature on related "knowledge-intensive" industries (such as information technology (IT) or nanotechnology) in order to search for possible similarities or differences, and to question these patterns.

The emergence of an industry with unique features may lead to the evolution of new organizational forms, which either did not exist previously or had gained only minor representation thus far. The task of Chapter 3 is to discuss issues related to organizational forms for learning and knowledge creation that are dominant in the biotechnology industry. The structure and process associated with the organizational forms of new biotechnology firms (NBFs) are discussed, along with university–industry collaborations, university–industry research and development (R&D) consortia, university spin-offs, and incubators.

Entrepreneurship in science is not a new phenomenon. The history of science provides evidence of many scientists who were also entrepreneurs. However, in the context of the biotechnology industry this phenomenon becomes both more dominant and widespread, as well as wider in terms of the different features of entrepreneurship it represents.

Chapter 4 focusses on the individual-level phenomenon of scientific entrepreneurship. "Scientific entrepreneurship" or "entrepreneurial scientists" are recombinant conceptualizations which have not been commonly used in either scientific or entrepreneurship literature. In this context we witness research on academic scientists who establish knowledge firms, or on university "star" scientists who work collaboratively with firm scientists. Modern processes that aim to capture the value of intellectual property rights entail the process of claiming patents over scientific inventions in order to licence the rights to future use of these inventions by interested parties. Claiming for patents rights over academic research may serve as another feature of entrepreneurial scientists.

This chapter asks the general question: What defines the "entrepreneurial scientist?" Specifically, it focusses on explaining scientific collaborations by scientific capital (various ranges of specializations), intellectual capital (patents), academic tenure, research settings (institutional affiliation), and valorization of human capital (laboratory size).

The issue of science and discoveries in the context of private versus public knowledge creation and learning from an academic perspective is explored in Chapter 5. Knowledge creation and learning in the biotechnology industry cannot be understood without clarifying the institutional arrangements and norms under which such knowledge is created. Universities and industry operate under different institutional arrangements and norms, yet they collaborate constantly in order to create the knowledge needed for innovation in biotechnology. This chapter, written together with Julia Porter Liebeskind, aims to explore the rich details of two breakthrough inventions in order to offer a better understanding of the academic perspective on the normative decision-making process regarding the patenting and protection of intellectual property rights of academic knowledge. The chapter follows the historical debates over the decision to patent or not to patent discoveries that emerged from academic research, and asks whether the decisions that were made had an impact on the diffusion of these discoveries.

The core of Chapter 5 is based on a discussion of intellectual property rights in the general context of open and closed science. To demonstrate these issues, we present two case studies of pioneering inventions in biotechnology that were either not patented (monoclonal antibodies) or not exclusively licensced (rDNA). These two fascinating cases of ground-breaking inventions illustrate how academic science was affected by the norms of industrial science. The debates over questions of whether and how to patent academic research reflect one feature of recombination – of "open science" as unpatented academic research and of "closed science" as patented industrial research. This chapter also discusses issues related to the nature of public research and the current trend of privatization of university intellectual property rights. In addition, it highlights some points of conflict between scientific discoveries directed for the benefit of the public at large (the commons) and capturing knowledge for privatization needs and profit-making.

Biotechnology-related basic research conducted in universities is considered to be a requisite for the development of industry applied research. As a result, the role of university–industry technology transfer offices and patent applications has become increasingly significant in the past two decades. Chapter 6 deals with the search for university–industry technology transfer. The technology transfer process is based on recombination of basic academic knowledge with applied industrial knowledge. This chapter is dedicated to the effort to understand the search process for technology transfer collaborations from the academic point of view. It is based on qualitative in-depth interviews with academic scientists, technology transfer officers, and university R&D vice-presidents, and offers a rich description of contrasting metaphors for the search for technology-transfer collaborations. I name the two types of metaphors: "linear" versus "chaos" metaphors and analyze the central assumption and logical building blocks that lead to two distinct modes of the search process.

Previous research provided some tangible evidence that commercial interests have the potential to, and in fact sometimes do, have an effect on the nature of trust in academic science. By offering a wide range of evidence found in the area of academic biotechnology research we can examine how the success of commercially oriented collaborative research calls for a number of different forms of trustworthy behavior on the part of collaborators. Chapter 7 is dedicated to describing and illustrating the role of trust in scientific collaborations. It argues that that owing to the recombination of commercial interests into academic research, a broader form of trust is required to support the research relationship than is required to support a normal academic relationship.

In Chapter 8, the discussion moves from the micro- to the macro-level of analysis, and shifts the focus to NBFs. The chapter deals with organizational learning and strategic alliances whilst focussing on recombination and duality of competition and collaboration. It is based on a dialectical approach associated with illustrated duality. This dialectic is based on the conjuncture of two sets of elements throughout the organizational learning process – exploration for new, unique, and innovative research and development directions, and exploitation of the chosen dominant design for the R&D focus of NBFs. As indicated in the literature, the learning process in biotechnology is heavily attributed to strategic alliances between biotechnology firms. However, it is argued that it is essential to establish a dialectical view of the learning process associated with product development in the biotechnology industry. Therefore, only by understanding the internal dynamics of exploration and exploitation over the life-cycle that is associated with organizational learning, can we decipher the recombination of collaboration and competition in strategic alliances. In addition, at different levels of analysis, as well as in different institutional environments, we may observe the duality of collaboration and competition. The major contribution of this chapter is an epistemological and methodological one. I propose that the use of an assisting tool, titled the "flexible prism" methodology, is important in order to "break" the single light into the spectrum of colors that frequently coexist within strategic alliances. This will enable us to understand that collaborations and competition are not orthogonal but are interwoven within exchange-based collaborative strategic alliances. In order to further elaborate on the suggested duality, a discussion on the issue of positive externalities of competition and negative externalities of collaboration is added.

Chapter 9 suggests new directions for organizational research in the biotechnology industry. This chapter summarizes the general findings and arguments presented in the book, and offers new directions for research. The new research directions are related to trust in knowledge-based collaboration, levels of analyses in studying learning networks, process issues in interorganizational collaborations, as well as including failure or conflicts within interorganizational collaborations.