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The Management of Technological Learning

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Mark Dodgson

The Management of Technological Learning

Lessons from a Biotechnology Company

Walter de Gruyter · Berlin · New York 1991

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Preface

Why is it that rapid technological change is a threat to some firms and an opportunity for others? This question is of fundamental interest to managers, academics and public policy makers concerned with the technological basis of competitiveness. It is the intention of this book to describe and analyse a key feature of the processes which allow technology to be used by firms to assist their competitive position. It is concerned with the ability of the firm to learn.

The book argues that the differential ability of firms to learn affects not only the competitiveness of individual firms, but can also direct the development of new technologies and industries. This argument is made in the context of the development of biotechnology, in circumstances where rapid and extensive change places a premium on learning capacities. Biotechnology provides an excellent example of the ways in which the pressures to commercialise new scientific discoveries highlight the advantages accruing to firms adept at dealing with novelty. One of the major actors in this commercialisation process is a new type of firm; the small, dedicated biotechnology company (DBF). The existence and future contribution of such firms depends on their ability to learn quickly.

The DBF, and the complex and changing nature of the relationships between academia, DBFs and large established firms, are major factors which have stimulated and directed the development of biotechnology. Attempting to analyse the emergence of a new technology, and its scientific and commercial development, is a phenomenally complex task. It is necessary to do so as it is only by understanding the past and current pressures on emerging technologies that one can attempt to influence their future development. Through an examination of the role played by DBFs – and one DBF in particular – and their competitive and collaborative relationships, the book attempts in a small way to contribute to the understanding of some of the factors which have affected and will affect the scientific and commercial progress of biotechnology. It aims to provide one piece of the jigsaw that is a complete picture of the evolution of a new technology.

The book reports on the development of an important DBF, Celltech Ltd. It provides one of the very rare examples of a study of how a firm actually accumulates technological know-how in order to establish a competitive position and to grow. It details the long-term learning processes by which a company builds its core technology base. A number of strategic management of technology issues feature, including: the management and organisation of Research and Development and technological collaboration; matching technol-

ogy strategy with human resource development strategy; and engendering a creative organisation and culture.

The high significance of DBFs in the emergence of biotechnology has attracted considerable attention from those concerned with explaining the technology's pattern of development. Hall (1987) describes the initial commercialisation of the science of biotechnology and focusses on the emergence of two of the earliest DBFs: Genentech and Biogen. Teitelman (1989) analyses the problems of financing its development, and takes to task much of the hype over biotechnology, by referring to another DBF: Genetic Systems. The case study of Celltech is used to refer to a broad range of issues, including scientific and financial, but it concentrates particularly on organisational and managerial concerns.

It will be argued that DBFs' past and future contribution to biotechnology's development and diffusion rests with strategies for fast technological learning: the ability to acquire, develop and operationalise technological know-how quicker than their competitors. It is this which potentially gives DBFs a comparative advantage over large multinational companies, and has been a major stimulus to high level of interaction between them and large established firms. The ability of DBFs to establish creative, well organised and highly motivated Research and Development (R&D) departments, to work effectively with the science base, and to benefit from collaboration with larger industrial partners are all features of technological learning, and are crucial to DBFs' competitiveness and the role they play in the propagation of the technology. It will be shown how developing and implementing such strategies requires considerable attention be placed on management and organisational issues. In consequence, these issues which are particular to individual firms, affect the development of a new technology as a whole.

The use of industrial case studies to illustrate complex situations is not uncommon in some of the social sciences. Ron Dore's (1973) comparison of British and Japanese industrial relations was based essentially on two case studies. Some of the richest industrial sociology has been based on studies of single firms, such as Beynon's (1973) study of Ford, Beynon and Nichol's (1977) study of 'Chemco', and Roy's (1958) and Burawoy's (1979) study of 'Allied'. The case studies are used as they are particularly revealing about much broader issues.

The book is structured in a format which mixes description with analysis. Chapter 1 is concerned with the impact of biotechnology on industry, and incorporates both theoretical and practical considerations. Chapter 2 describes Celltech in 1990. Chapter 3 describes its genesis, and illustrates subsequent chapters on how the company's activities and achievements are in many ways a legacy of its past. Chapters 4 and 5 are descriptive, intending to depict how companies grow. Chapter 6 is both descriptive and analytical and is concerned with the ways Celltech built a creative, learning organisation. Chapters 7 and 8

are also both descriptive and analytical and are concerned with how Celltech has build a leading technological capability on the basis of its internal and external learning activities. Chapter 9 addresses learning more systematically. It considers the link between strategy and learning and conceptualises the role of learning in competitiveness and corporate and technological development.

Many people have assisted my learning processes in the production of this book. I was extremely fortunate to be asked to write the history of Celltech, and learnt a great deal during the year I spent doing so. I am grateful to the Economic and Social Research Council's Designated Research Centre in Science, Technology and Energy Policy at the Science Policy Research Unit for funding the study and subsequent period when the book was written. Celltech Ltd and the British Technology Group generously contributed to the funding of the writing of the history. The study of Celltech is published as a SPRU Special Report (Dodgson, 1990a), and provides the basis for this book.

Many very busy people within Celltech were kind enough to give me their time during the research. I am particularly grateful to Gerard Fairtlough, John Jackson, Gwyn Humphreys and Geoff Brooker in this regard. My colleagues at SPRU have provided me with constant support and good advice. I am particularly grateful to Roy Rothwell and Keith Pavitt. Margaret Sharp's encouragement, insights and detailed comments have been immeasurably valuable. Thanks are also extended to Chris Freeman, Smail Ait el Hadj, Martin Bell and Aubrey Jones. Any shortcomings in the book exist despite my colleagues' attempts to prevent them.

Every company makes mistakes and endures often painful failures. Celltech is no exception. It has had its share of problems. Nevertheless, one of the major lessons I have learnt during the last two years studying and writing about Celltech is what can be achieved with vision and energy. These underpin the company's achievements, and many people inside and outside of the company have combined them to create Celltech. The two virtues are personified in Gerard Fairtlough, who has had the vision to see the necessity for new forms of organisation, and the energy to put his ideas into practice. Whatever the future holds for the company – and it es operating in very uncertain circumstances – its achievements so far are enough to prove that the imagination and creativity of Britain's scientists can be matched in the management of the commercial development of that science. This in itself is an important lesson.

Mark Dodgson July, 1990

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Biotechnology and Industry

Introduction

Biotechnology is one of the most important technologies to have emerged over the past twenty years. Along with information technology and new materials technology it is believed to be one of the 'generic' technologies which will underpin much future industrial growth. It is a radically new technology, capable of profoundly affecting existing ways of doing things, and has the potential to pervade a number of important industrial sectors. Biotechnology's novelty and scope inevitably causes considerable turbulence and change within firms, and in the relationships between firms using it. It has provided the basis for the development of a new type of firm: the dedicated biotechnology firm (DBF). The rapid changes occurring as a result of biotechnology provides the context in which the study reported in this book is placed. One of the cardinal questions posed is: how do industrial firms deal with comprehensive technological change?

The Emergence of Biotechnology in the Science Base [1]

Throughout this book the term biotechnology will refer to the 'new biotechnology' that has emerged in the past 15 to 20 years. It includes the use of recombinant DNA and cell fusion techniques, and bioprocessing technology, to make or modify products. The products targeted lie within three broad sectors: health care (therapeutics and diagnostics); agriculture; and waste management; although it also has applications in chemical biotransformations, energy and mineral recovery. Health care is currently the centre of corporate attention in biotechnology and will be the focus of this book. [2]

Two separate scientific discoveries formed the basis of the 'new biotechnology'. These were reported in the early 1970s in two research laboratories; one British, one American. Milstein and Kohler at the Laboratory of Molecular Biology (LMB), Cambridge reported the discovery of monoclonal antibodies (MAbs). Boyer and Cohen at Stanford University reported the discovery of recombinant DNA (rDNA). MAbs, or hybridoma technology, involves fusing

together cells with specific properties to create a method of producing large quantities of specific antibodies. Recombinant DNA, or genetic engineering, involves splicing a 'foreign' component into the genetic structure of an organism so as to change its characteristics or functions – eg to make it produce insulin or other useful proteins.

Although the science of these two process innovations was characterised by very considerable uncertainty and speculation, and expectations of actual products were unclear, biotechnology's potential excited high levels of interest from many quarters. To some extent expectations of it were measured against what had happened in information technology. The computer industry and IT provided a model whereby a new technology had rapidly created huge new markets and a number of very large new firms, as well as making some technologists and financiers very rich. Almost immediately the race was on to develop and commercialise the two scientific discoveries.

At this time the new skills of the biotechnologists resided almost entirely amongst scientists in universities and hospital schools. Following the model in electronics, many of these scientists in the US – molecular biologists, biochemists, microbiologists, and molecular geneticists – decided either to form or work closely with commercial organisations primarily in order to benefit financially from their scientific know-how. Since biotechnology's early commercial development depended critically on the transfer of these skills from the science base, [3] the DBF proved one of the most important mechanisms by which the links between the science base and industry were established.

The Dedicated Biotechnology Firm

DBFs began to emerge in the United States in the early to mid-1970s. It is estimated that there are now over 400 such firms in the USA, and over 80 in Europe (Office of Technology Assessment (OTA), 1988:5 and Orsenigo, 1989:152). The largest DBF, Genentech in the USA, 60 per cent of which was recently acquired by a large European drugs company for $2.1 billion, has sales in excess of $300 million and employs over 1750 people. Figure 1 shows the growth in the number of DBFs in the USA and Britain. It shows how since the early 1980s the numbers of DBFs being formed has declined. Indeed, a recent report to the US Congress relates how some analysts consider the number of viable DBFs to be declining (OTA, 1988:12). The reasons for this decline will be examined in later sections. As shown in Table 1, some leading DBFs have enjoyed rapid patterns of growth.

The emergence of DBFs in the USA has been attributed to a number of interrelated factors. Important amongst were: the development of the novel scientific techniques in universities and research hospitals; the ready availability

Table 1. Turnover in Some Leading DBFs (1988/89)

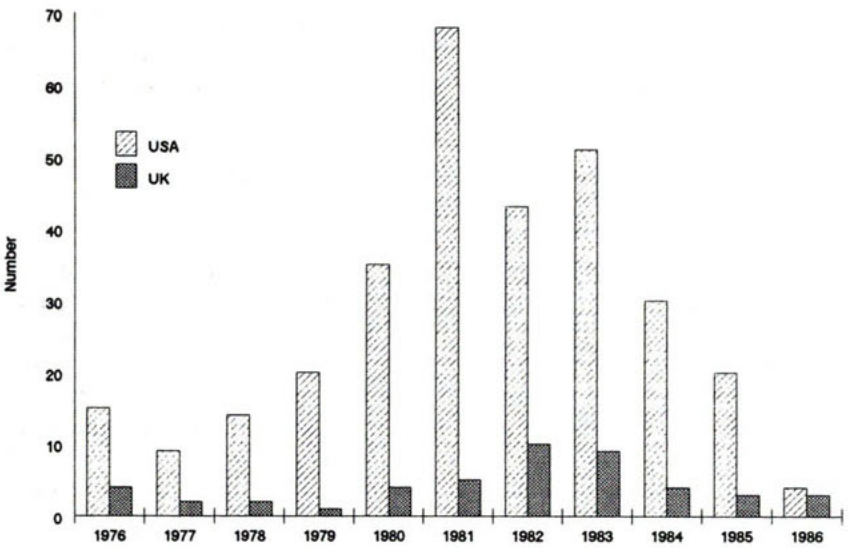
Company	Turnover £ Million
Genentech	118.1
Cetus	36.0
Centocor	36.8
Chiron (89)	20.0
Amgen (89)	46.8
Celltech (89)	19.7
Transgene	5.5

of venture capital; the entrepreneurial drive of scientists, venture capitalists and

Figure 1

Number of New Biotechnology Firms Established

USA and UK 1976–1986



Source: OTA, 1988, and Oakey et al., 1990