Editorial

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Modern biotechnology by which we refer to techniques involving manipulation or change of the genetic patrimony of living organisms, has had three types of impact on the pharmaceutical, agro-business, agricultural, and chemical industries. It has initiated a radical change in the nature of the search process for the creation of new chemical entities (creation by rational design rather than by trial and error methods); it has led to the creation of radical and incremental product innovations; and finally integration of biotechnology in manufacturing processes has served to bring down the costs of production.

The modern biotechnology sectors in the industrial sense began with the creation of US start-ups in the pharmaceutical sector such as Genentech (created in 1976), Genex (created in 1977), and Biogen (created in 1978) that were based entirely on modern biotechnology. These firms referred to as new biotechnology firms or NBFs, were created by scientists who were aware of the potential economic profit that could issue from investment in their fields, and who at the same time were able to attract financial support from equally imaginative venture capitalists [1]. Such NBFs pursued an aggressive knowledge-deepening technology strategy, improving their knowledge base in their chosen scientific fields and patenting their discoveries.

As it was realized that dramatic scientific 'breakthroughs' might be few and quick returns were unlikely, the needed level of support from venture capitalists was not forthcoming for the NBFs. They had to turn to major corporations who in turn were 'awakening' to the importance of acquiring and deepening competence in biotechnology. Thus in the late 1980s strategic alliances began to be formed between the US NBFs and the large Multinationals or MNCs (both US and European), with the large firms financing the research of the NBFs, in return for some kind of production and marketing rights. Such cooperation was necessary because while the early NBFs possessed the scientific competence, they had neither the capital nor the complementary competencies to conduct clinical trials, undertake the prolonged processes of getting regulatory approval, upscale the manufacturing, or create the market and actually market the product [2]. The large diversified firms were willing to pick up the bill for the R&D expenditure because it represented a means for them to implement 'scope economies' in basic biotechnology R&D. By financing R&D projects with what represented to them small or moderate sums of money, rather than buying out NBFs or incurring in-house investment costs, the large firms could investigate the potential of NBF projects without committing themselves too deeply and expensively to any particular technology, thereby avoiding the negative effects of a 'technological lock in'.

With the learning that occurred in pursuing such aggressive technology strategies, the picture changed again by the early 1990s. Some of the highly successful NBFs vertically

integrated into manufacturing and a few became fully integrated firms marketing their own product. A number of NBFs whose work was deemed as promising were acquired by the large diversified firms. Large firms established strong in-house research competence in their areas of interest and began to match the expenditure of the NBFs [3]. Thus by integrating research and production activities, the large firms could avoid sharing tacit knowledge on the production process with their collaborators. Similarly, by integrating into production the NBFs could also avoid dependency relationships with their partners. Furthermore vertical integration enabled both kinds of firms to reduce the transaction costs of outsourcing, develop the business competence necessary to evaluate the allocation of resources within the firm to the different types of technologies, and maximize the profit from commercialization of innovations. At present the biotechnology sectors in the USA continue to exhibit all of the above trends, namely creation of NBFs, vertical integration of NBFs, inter-firm strategic alliances and diversification of established firms into the biotechnology sectors.

Among the other late comer countries of the developed world the integration of biotechnology was characterized by a variety of evolutionary patterns [4]. The late comer countries had to deal with two kinds of problems: 'resource' problems and 'incentive' problems. Except for Great Britain, the academic communities and research centers of Western Europe and Japan suffered from a scientific retard. Thus knowledge in the disciplines relating to biotechnology had to be first created through public investment. Then 'incentives' for the transformation of scientific competence into industrial competence had to be provided either through the market or through public programs. Needless to say both of these types of problems were further exacerbated in the case of the developing countries. Though biotechnology was widely perceived to be holding the key to their pressing problems such as feeding their nations, achieving sustainable development and remedying damage caused by environmental pollution, developing countries were further burdened by severe financial constraints and inefficient markets.

In this context the objective of this special volume on biotechnology is to understand and identify trends in the evolution of the biotechnology sectors in different parts of the world by focusing on one or more components of their national system of innovation such as firms, research establishments, financial institutions, government, and consumers. It also attempts to provide insights for management through an examination of the strategic positioning of firms for the integration of biotechnology in different parts of the world. However the focus is on the countries of the triad since they continue to dominate the global scene in terms of the number of firms, the number of patents and the number of publications relating to the biotechnology sectors.

We launch the debate with an article by De Looze *et al* on the latest trends in publications and patent applications in genomics, one of the fast growing fields of biotechnology. Then we have three articles that focus on the industrial scene in the USA by A. Persidis, B. Clarrysse and J. Vila. This is followed by a study of two specific industries: the global seeds industry by J. Bijman and the pharmaceutical industry in India by S.V. Ramani and M.S. Venkataramani. The focus then shifts to consumers with the study of D. Macer who examines the role and impact of public perceptions of biotechnology. Then the volume closes with three articles that attempt to provide insights for managers and policymakers. Firstly, T. Reiss explores in depth the problems of integration of biotechnology in late comer countries through a detailed study of the evolution of the biotechnology sectors in selected late comer countries, namely Japan, Britain and Germany. Then W. Hamilton discusses the agenda for further academic

research and management practice in biotechnology firms. Finally, D. Audretch and P. Stephan evoke some features of comparison between the US and German biotechnology sectors.

References

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