Book Reviews

Science Business: The Promise, the Reality, and the Future of Biotech, Gary P. Pisano, Harvard Business School Press (2006), 237 pages, ISBN: 1591398401

Science business attracts lots of attentions in these days. It is true also for Korean society. Korea has been discussing the possibility to establish an international science business belt. In fact, we have been witnessing that scientific results become new businesses and industries. There are lots of companies in so-called high-tech industries that are originated from science. Science can generate huge amount of value and employment. Therefore, individual companies have tried to transfer scientific results into innovative products and national governments have poured great efforts to nurture science businesses. However, it is not easy task to establish science business. We need a systematic approach not only at firm and but also at national level. In other words, we must effectively nurture and manage science business. In this sense, this book explores very important topic for the development of our society.

This book deals with science business especially focusing on biotechnology. This book starts with the assumption that in biotechnology the science is the business. The history of science business of biotechnology has started in 1976 when Genentech, the first biotechnology company, was founded by a venture capitalist and a Nobel Prize-winning scientist. Since then the significant challenges of integrating science and business have driven the biotechnology sector to pursue novel organizational and institutional experiments. This book defines science business or science-based business as commercial enterprise or collection of enterprises that attempts to both create science and to capture value from it. Science business actively participates in the process of advancing and creating science. Therefore a significant part of the economic value of the enterprise is ultimately determined by the quality of the science upon which it rests. Biotechnology is a science business. There are many companies, e.g. Genentech, Celera, Amgen, Merck, that have contributed to the advancement of biotechnology and they have had close links with universities. This book emphasizes that science business, in order to be successful, requires different kinds of organizational and institutional arrangements and different management approaches.

This book argues that science businesses are challenged by the characteristics of science. It identifies three characteristics of the science of biotechnology: (1) the profound and persistent uncertainty requires mechanisms for managing and rewarding risk, (2) the highly complex and heterogeneous nature requires mechanisms for integration across disciplines and functional areas of expertise, and (3) the rapid cadence of scientific progress requires mechanisms for cumulative learning. Therefore, the challenges of managing the science business are very difficult. The management challenges of science business are novel and as such cannot be addressed with indiscriminate borrowing of existing practices and approaches of other high-tech industries. The fit between the science and the business matters.

Therefore this book is composed of three parts. The Part I (chapters 2, 3 and 4) has a title of "the Science of the Business" and is about the characteristics of the science of biotechnology, arguing that the critical characteristics of the scientific landscape (uncertainty, heterogeneity, and rapid change) have important

implications for the problems that this science business must solve. Uncertainty drives the need for risk management, heterogeneity calls for integration, and rapid advance has implications for organizational learning. The Part II (chapters 5, 6, 7), under the title of "the Business of the Science", explores whether the sector is organized (i.e., has the "right anatomy") to address these challenges. Chapter 5 provides an in-depth analysis of anatomy and Chapter 6 examines the performance of the sector over thirty years. Chapter 7 argues that the disappointing performance of the sector is partially a result of the lack of "fit" between the anatomy of the sector and the requirement of the science. The Part III (chapters 8 and 9) has a title of "the Science-Based Enterprises" and provides the implications for business strategies and models, university research, and funding for science business.

We will look into the details of each chapter. As the first chapter of Part I, Chapter 2, under the title of "Mapping the Scientific Landscape", examines the drug science from a historical perspective and the most important technologies and stream of advance, which are categorized into three areas: new modes of synthesis, new information about biological mechanisms of disease, and new drug design and screening methodologies. Based on these analyses, this chapter provides three characteristics of the drug R&D and biotechnology. First is the dramatic expansion of the landscape for drug development. For example, scientific advances have greatly expanded the number and range of potential therapeutic agents and the number of potential targets. Second, not only has the landscape grown larger, it has grown more complex and heterogeneous. Biotechnology and drug research today draw on a broad range of scientific disciplines, tools, and methodologies. Therefore the challenge of integration has never been greater in the pharmaceutical and biotechnology industry. Finally progress in drug science has been cumulative so that it needs both traditional and modern technologies, tools and methodologies. Many of technologies and approaches complement, rather than substitute for, one another. Therefore, the organizational learning in this science business should be cumulative. The challenge on this sector is not only mastering new technologies, but also maintaining capabilities in existing ones.

Chapter 3, under the title of "the Complex Anatomy of Drug R&D", introduces the mechanics of the drug R&D process from start to finish. Drug R&D is highly complex, expensive, time consuming, and fraught with risk. As potential drugs directly affect human being, regulation is very visible. Chapter 4 deals with deeper understanding of drug R&D and its organizational challenges. It identifies two salient characteristics of drug R&D that have important implications for organizational process of drug R&D. First, the process is highly risky due to the profound and persistent uncertainty, which is rooted in our currently limited knowledge of human biological systems and processes. Second, the nature of the process is integral and it cannot be broken neatly into different pieces. In this chapter, the author argues that, contrary to the general assumption that the new science of biotechnology will dramatically reduce the organizational challenges of drug R&D by both reducing uncertainty and by simplifying the process, the science increases the uncertainty and organizational complexity.

Based on the discussions in the previous chapters in Part I, this book identifies three themes for successful science business: risk, integration, and learning. To function as a business, the biotechnology sector needs appropriate mechanisms for efficiently managing risks and encouraging and rewarding risk-taking. To perform well, this sector requires appropriate mechanisms for bringing together and integrating the right mix of cross-disciplinary talents, skills, and capabilities. This sector needs also mechanisms for capturing and leveraging learning from technological and organizational experiences, particularly because failure is so common in this sector.

As the first chapter of the Part II, Chapter 5, under the title of "the Anatomy of a Science-Based Business", analyzes the emergence of biotechnology sector, the evolution of firms' capabilities, the role of existing pharmaceutical companies and the emergence and evolution of the market for know-how. Here the anatomy encompasses: (1) the direct participants in the industry (start-up firms, established companies, universities, not-for-profit laboratories, investors, customers, etc.), (2) institutional arrangements that

connect these players (capital markets, market for know-how, product markets, grant allocation process), and (3) the rules that govern and influence how these institutional arrangements work. This chapter classifies three generations of biotech industrial development: (1) the first generation: large molecules and FIPCOs (fully integrated pharmaceutical companies), (2) the second generation: reintegrating chemistry, and (3) the third generation: genomics, platforms, and the industrialization of R&D. Throughout its thirty year history, the biotechnology business has evolved in tandem with changes in technology. When it comes to the science, there is not one biotechnology revolution but many. New waves of science drove the entry of firms specializing in and building capabilities in the science. Firms have tended to stay relatively focused in specific technological capabilities. All new biotechnology firms were active sellers in the know-how market. They sought funding and access to markets via collaboration with established pharmaceutical companies. As a result there have been lots of alliances and collaborations among biotech firms and large, well-established pharmaceutical companies, so that the market for know-how in the science business has grown over time.

Chapter 6, under the title of "the Performance of the Biotech Industry", explores the financial and operating performance of the biotechnology industry. This chapter argues that, contrary to the general expectation of high performance of this industry, this sector in aggregate has yield disappointing returns compared with alternative investments. While revenues have grown exponentially, profitability has been close to zero throughout the life of the industry. For the pharmaceutical companies, which were confronted with R&D productivity crisis, it was assumed that biotechnology firms could offer a way out of it. However, this chapter argues that the expectations of R&D productivity boom are not born out in the data and both pharmaceutical and biotechnology firms still have productivity problems. This chapter emphasizes that the biotechnology sector will be very profitable only when it consists of the right types of firms, the right strategies and models, and the right institutional arrangements. In other words, a healthy biotechnology sector needs to look and operate differently than the sector we see today.

Chapter 7 has a title of "the Monetization of Intellectual Property" and discusses the underlying forces of this science business. It argues that three interrelated forces drive the business of biotechnology: (1) the transfer of technology from universities to the private sector through the spawning of new firms, (2) capital markets including both venture capital and the public equity, and (3) the market for know-how in which young venture trade intellectual property (IP) for various forms of alliance with established companies. Together these forces comprise a system for monetizing intellectual property. Biotechnology became a business when the know-how emerging from scientific research became IP that was valued, bought and sold through various channels. Together, university-spawned firms, the funding mechanisms, and the market for know-how constitute a system for biotechnology innovation. Universities initiate the science, highly motivated academic entrepreneurs with deep knowledge of the science carry that science into the commercial sector through the formation of new firms, aided first by venture capitalists, then by the public equity markets, and finally by more established firms with both capital and new competence in development and commercialization. This chapter emphasizes that the system should effectively manage risks, achieve integration, and facilitate long-term learning. It also evaluates the system of biotechnology innovation and argues that the biotechnology sector does certain things well, e.g., generating many experiments, encouraging risk-taking, learning through imitation, but it falls short in other areas, e.g., integration, learning from experience.

Part III has a title of "the Science-Based Enterprises". It starts with the summary of the problems in the science business of biotechnology in the previous chapters: the scientific and commercial promise of biotechnology has been impeded by the way the business is structured and operated. There are more specific problems as follows. Whereas the effective development and application of the technology requires integration, the business of biotechnology is driven by specialization and

fragmentation; whereas the uncertainty and novelty of the science requires rapid diffusion of high fidelity information, the business strategies of biotech firms impede information flow; whereas the science requires long-term cumulative learning, the biotechnology firms face market pressure to optimize short-term perceptions of value. These problems have arisen not only due to exogenous and institutional conditions but also due to the behaviors and strategies of biotechnology and large pharmaceutical companies. This part deals with both themes.

As the first chapter of the Part II, Chapter 8 has a title of "the Organizational Strategies and Business Models". This chapter focuses on the strategies and business models of biotechnology and established pharmaceutical companies. Broadly there are two kinds of strategy or business model for biotechnology companies: vertical integration and licensing. The selection of strategy hinges on how well markets for know-how work. When markets for know-how are working well, out-licensing strategies can be very effective. On the contrary, when conditions exist that impair markets for know-how, vertical integration strategies are needed to overcome critical barriers to innovation. There are four basic factors that need to be considered in determining whether or not a market for know-how will work: (1) the degree of information asymmetry, (2) the need for investments in specialized assets, (3) the tacitness of the know-how, and (4) the degree to which the relevant intellectual property can be protected legally. There is a broad range of technologies and projects that span the spectrum of these four factors. This suggests that different business models will be viable and appropriate for different kinds of technological innovation. In biotechnology, there have been four broad classes of technological innovation: (1) novel research methods and tools, (2) identification of novel mechanisms of action targets, (3) creation of novel compound types, and (4) development of novel treatment modalities and therapeutic markets. Very different business models are needed for these classes of biotechnology innovation. In pharmaceutical industry, given the breadth of technologies, most firms will have to pursue a mixture of arrangements contingent on the technology: the most innovative drugs being developed through vertical integration, the least innovative drugs being procured on the market for know-how, and the drugs of moderate novelty and complexity being accessed through longer-term alliances with selected partners. In this science business, alliances and partnerships will continue to play a role. In order to achieve the requisite integration and learning, however, alliances need to provide a credible long-term commitment; there must be open flows of information; governance must be flexible enough to enable adaptation to changing environments: both parties must learn from each other. Therefore this chapter argues that it is more effective to have fewer, deeper collaboration than many, shallow link, especially for more scientifically or technologically novel projects.

As a final chapter of the Part III and the book as a whole, Chapter 9, under the title of "the Path Ahead", explores what institutional changes may be required to support economically healthy science-based enterprises. There are three kinds of institutions of the science of biotechnology: academic research laboratories, government research institutes, and government funding. These institutions are increasingly weaving together with the institutions of business, such as venture capital, patenting, and licensing and collaboration with for-profit enterprises. Universities in this sector should provide more integrated, cross-disciplinary research and training. A shift in university mentality and policies is needed: Universities should not focus on maximizing licensing revenue but on maximizing the contribution to the scientific commons. This chapter emphasizes to promote translational research that translates basic scientific findings and concepts into specific product opportunities. It suggests two potential approaches to fund translational research. One is to consider extending the reach of government funding further downstream into translational research. A second approach comes from private-sector funding, which can come in various forms: Pharmaceutical companies may supply both the resources and the incentives to conduct some translational research on their own or in collaboration with universities; Consortia of companies may fund translational research programs at academic institutions; Venture philanthropy,

which are not-for-profit entities, e.g. the Bill and Melinda Gates Foundation, can fund this research. This chapter stresses a fuller disclosure of information, e.g. clinical trial results, which make more information available for companies. This will not only lead to netter investment choice, but also help with the R&D productivity problems facing this sector. This chapter also suggests a concept of quasi-public corporation whose majority stock held by a single entity with a long-term investment and strategic interest. Through this concept biotechnology companies can pursue longer terms R&D strategies.

This book is about the science business in biotechnology. This book agrees that the biotechnology sector as science business has not yet been profitable. We are in the beginning stage of science business. There are several areas of science, e.g. nanotechnology, nuclear fusion and others, to be science business. However, it will take long time for these new sciences to become profitable science business, as we have seen in the case of biotechnology. I think that this book makes great contributions to the future development of science businesses by providing the directions, major issues, and strategies of science business. In particular, this book suggests the following specific implications. First, this book emphasizes that technological innovation must co-evolve with organizational and institutional innovation and that science business needs new organizational and institutional innovation. In this sense, I agree with the author and Alfred Chandler's argument that through the past century the modern corporation has continued to evolve in concert with both technological innovation and institutional arrangements. Second, this book emphasizes the fit between science and business for the successful development of science business. We need to take both scientific and business characteristics fully into account in order to make a successful science business. Third, this book has a comprehensive perspective on science business so that it discussed not only firms' strategies and business models but also institutional arrangements and policy options. Therefore, this book covers both micro-level and macro-level management of science business.

In this sense, this book gives us very helpful implications for conducting and nurturing science business. However there are a few drawbacks of this book. First, this book places too much emphasis on pharmaceutical industry and its relationship with biotechnology. As biotechnology has widespread impacts on many other industries, this book should have discussed the science of biotechnology more comprehensively. Second, this book regards the sources of science as universities only and discussed their role in the science business. However, there are many governmental or public research institutes, e.g. National Institute of Health (NIH), in the development and commercialize biotechnology. This book should have discussed the role of those public research institutes in the science business of the biotechnology. Third, a system approach would have been needed for the discussion of the science business. It seems that this book does not discuss the relationships between scientific players and business players in the science business of biotechnology.

As the science business is still in the beginning phase, we have to learn a lot not only about firms' strategies, business models, and behaviors but also about institutional settings, financial structure, and role of major players in science business. In this sense, management of technology (MOT), which is a new academic and practical area to connect science and technology with business and management, will play an important role in the development of science business. We must conduct series of intensive studies on how to develop science businesses including biotechnology, nanotechnology and others. We also identify and analysis many successful cases of science businesses. Science business is an important area of management technology. We have to study science business very diligently and learn a lot from it.

Reviewed by Sunyang Chung
Department of Technology Management
School of Business, Konkuk University
Gwangjin-gu, Seoul 143-701, Korea
E-mail: sychung@konkuk.ac.kr