Mapping the future in science-intensive industries: Lessons from the pharmaceutical industry

J. W. Cortada
H. E. Fraser

Companies operating in industries that are subject to fundamental changes caused by innovations in science or technology search for ways to anticipate future business and scientific or technological developments so that they can react to them in profitable ways. Using the example of the pharmaceutical industry, which is currently moving from chemically based medications to targeted treatments based on biology, we demonstrate a process for forecasting how the future will look a decade from now. Illustrating the process with a variety of studies already done on this industry, we provide a strategy for mapping the future as well as an analysis of the strengths and limitations of our planning approach. We argue that this approach is applicable to both science-based and technology-based industries.

Executives and strategists always want to know how their industry is evolving and what it will look like for their chosen strategic horizon, whether it be 2, 3, 5, or even 10 years, in the belief that armed with such knowledge they can time their investments in new products, services, and infrastructure to coincide with the arrival of business opportunities. The latter, in particular, must not be overlooked in industries with fast-evolving science. In the pharmaceutical industry, for instance, if management in a company plans to move from smaller molecular weight products to biologics, which are typically larger and less stable molecules, a whole new way of manufacturing must be defined. This involves identification of the investment costs and associated lead times needed to accomplish the transformation, and thus must become part of overall strategic planning. Over the past three decades, numerous strategists and futurists have developed various ways of attempting to create planning methodologies. But, as historians and philosophers have long reminded us, precisely predicting the future is impossible, because we cannot account for all the unpredictable events that may interrupt a forecast or vision.[1] In recent years, we have seen stunning examples of the disruptive effects of negative events

on the future of various industries. The tragedy of 9/11, for instance, fundamentally altered subsequent patterns of behavior in telecommunications, finance, and foreign policy, and even led to two wars. SARS (Severe Acute Respiratory Syndrome), another example of an occurrence with seriously negative impact, disrupted business and personal travel all over Asia; developing over a period of weeks in China, it disrupted many industries, and nearly caused several Asian airlines to go bankrupt. Such surprises come at different speeds and from unpredictable sources and are a primary reason why historians remain unable to predict the future with any real certainty.

Economists, on the other hand, have been some of the strongest advocates of scenario planning and have built elegant econometric models to help define plausible views of the future. However, because of the limitations of the inputs to their models,[2] their predictions also suffer from the influence of unpredictable circumstances, events that students of chaos theory and networking have come to realize are profoundly influential factors.[3] Most recently, in an attempt to provide broader rigor to the whole process of understanding how organizations co-evolve with technology within the context of a services economy, Spohrer et al. have proposed approaches for applying the disciplines of science to an otherwise ambiguous reality.[4] Others, including consultants, academics, government policymakers, industry organizations, and, of course, management in industries, have also shown an increasing interest in mapping the future of specific industries.[5] In short, there is an appetite to plot out the future.

Because of the extensive use of a wide variety of technologies in essentially every industry, there is also the secondary issue of how an industry and its management can use new planning methods, such as the one described in this paper, to enable the incorporation of technology for innovation. In many cases, plans can be successful only if a corporation or government agency can translate them into successful deployment of technologies throughout the fabric of their everyday operations. Although the massive use of IT (information technology) in industry today makes it a key technology, other technologies also play important roles, particularly in science-intensive industries.

Despite the difficulties faced by industries in doing any form of meaningful planning, numerous constituencies continue to strive to understand the future and to take actions to exploit the opportunities identified for economic or personal benefit. The two key managerial requirements are to understand what lies ahead and to make decisions about how to deploy a company's assets in the future. As stated by Peter F. Drucker, one of the world's leading experts on business management, the fundamental job of managers remains "to direct the resources and the efforts of the business toward opportunities for economically significant results."[6] In short, the requirement to forecast the future remains as important a business task for management today as it was for leaders two thousand years ago, when pigeons and seers were the main sources of predictions.

NEED FOR A VIEW OF THE FUTURE

Over time, management has learned a great deal about which issues they need to understand and how these might be resolved over time. Most have accepted the concept of "thinking in time," as proposed by Harvard University's Richard E. Neustadt and Ernest R. May.[7] These important issues range from possible macroeconomic and political changes affecting their markets, to the evolution of products and technologies, and even to changes in the demographics of their own employees and customers.

One of the most important collections of perspectives to emerge in the past quarter century has come in response to the growing need to understand how both technological innovation and the influence of one's industry affect the potential future of a company. Business management professors Michael Porter and Clayton M. Christensen, and the historical record itself, have made abundantly clear the need to consider both of these influences.[8–11] Indeed, effective business strategies begin with an appreciation of what the future might look like in one's own industry or market.

Increasingly, analyses of an industry are incorporating a broader range of factors with the recognition that no organization or industry operates in a socioeconomic or political vacuum. In particular, analytical models today often take into account some combination of four specific dimensions, including political/legal, economic, social/cultural,

and technological factors (PEST). The PEST analysis model is widely used by business schools and strategy consultants to help define potential opportunities and threats that a company or industry might face.

Futurists are among the first to acknowledge that the uncertainty of the future will involve both positive and negative effects. As far back as 1970, Alvin Toffler warned in *Future Shock* about "the roaring current of change, a current so powerful today that it overturns institutions, shifts our values, and shrivels our roots."[12] John Naisbitt spoke of people "caught between eras," and the fact that "we experience turbulence."[13] As recently as 2004, the distinguished student of modern economies, Roger Alcaly, warned that changes would continue to be profound and called on everyone to understand the "new economy, particularly its signature information technology."[14] Futurists favor using processes which pull together strategic and operating plans that include the monitoring of industry trends and a continuous scanning of the environment for changes. They seek to identify driving forces, while remaining aware that contingency planning is needed to accommodate unpredictable events. These considerations then feed the vision, mission, goals, and strategies of individual companies.[15]

Ultimately, this entire process requires development of a point of view about an industry that extends beyond the normal planning horizon used today. This requirement has been made even more urgent in recent years by perceived and actual churn, particularly in industries that depend heavily on science and technology for their products and services or for how they do their work. Although now a cliché, the obvious must be acknowledged: change in science and technology, along with market realities, is occurring faster than ever, and change, therefore, is the inevitable and necessary by-product of modern reality. Examples occur continuously in such industries as telecommunications, computing, software, electronics, and pharmaceuticals. Methods for mapping futures, such as scenario planning, continue to evolve, but they are primarily focused on defining possible futures at the company level, or for a national economy. What to do at the industry level, however, remains an area ripe for research and enrichment. The fundamental thesis of this paper is that to improve the quality of its view of the future, a company must have a solid perspective about how its industry is changing, so that the actions and strategies of the enterprise can optimize its response to the realities that profoundly affect its performance. That perspective should include concerns about the role of IT, industry-specific scientific and technical innovations from any source, the changing economic and regulatory environment, and the culture of the industry and company.

Many constituencies can find use for such perspectives. Government policy makers can use such insights to reduce operating costs or to define new policies, such as how healthcare should be financed by the society at large. Industry associations can use such information to educate members on emerging technologies and practices, as the American Banking Association has done routinely regarding the role of IT for over half a century.[16,17] Academics, particularly those specializing in the affairs of one industry, need to constantly keep in mind that they are training students who will work in an industry. Thus, we find growing industry-centric specializations emerging in business schools. In the United States, for example, Ohio State University has focused on the retail industry, the University of Pennsylvania on banking and finance, Stanford University on the software industry, and Michigan State on the automotive industry. A similar list could be developed for European and Asian universities. In short, a growing list of public, private, and academic institutions are already starting to define the future and the actions businesses might take to thrive in that future.

IN SEARCH OF A BETTER WAY

The methodology described below addresses what various constituencies can do to map the future of the industry in which they operate or are interested, taking into consideration such realities of that industry as competitors, politics, regulatory practices, needs of customers and suppliers, and transforming technologies and science. We believe that it is possible to build a view of the future credible enough that senior management, in particular, will be willing to transform their products, their processes, and their organizations in order to optimize returns in the future. Moreover, it is possible to do this looking forward nearly a decade or more.

We further contend that the approach described below is applicable not only to traditional business

areas, but to so-called "high-tech" industries as well. Just as advances in science often occur in predictable forms, so too technologies have reasonably well-defined paths of development. Often, however, consequences can come as a surprise, as has certainly been the case in IT and medicine. For instance, in the 1940s it was believed that the most important medical application of transistors would be in hearing aids. The medicinal compound in Viagra** was originally used for treating high blood pressure and heart conditions in the 1980s.[18] In both cases, the long-term applications of these technologies proved very different from those originally anticipated.

■ The relevance of computing to the pharmaceutical industry continues to accelerate ■

Taking a view of the future also allows companies to deal with inevitable surprises, for example, a leapfrogging innovation from outside a given industry that leads to new forms of competition. Companies learn quickly that responses to positive trends and disconcerting surprises can be managed both by taking a multidisciplinary view of the future and by having people with a variety of backgrounds and knowledge help management understand and respond to such events. Because in our experience private sector management does less to define the future of its own respective industries than do the other constituencies mentioned earlier, our discussion is addressed directly to private sector executives.

Over the past decade, the importance of understanding the future has taken on a specific new urgency, due in part to the influence of rapidly changing technologies (primarily IT and telecommunications), but also to scientific advances in dozens of industries. In pharmaceuticals, despite slow adoption of the technology, the deployment of combinatorial chemistry and high-throughput screening (HTS) has transformed drug discovery processes by delivering a tenfold increase in the number of compounds generated for assays and a 100-fold increase in the number of compounds that can be screened.[19] Admittedly, the pharmaceutical industry's historical experience with new technologies has not always led to increased numbers of new drugs being introduced into the marketplace. This is largely true because prior technologies were not always particularly helpful in several key aspects of the drug development process, such as proving the profile, activity, and selectivity of a potential drug at the discovery stage or assessing the toxicity of drug candidates. Such limitations are changing today because of the growing availability of new tools, which will allow a more effective development process than was previously the case. By understanding what is happening in various technologies, one can begin to appreciate the changes that might come in the future that could represent a departure from prior experiences. The key, however, is to link an understanding of advances in tools to what is possible within a company, thereby creating a complete picture which allows formulation of a roadmap for future action.

For instance, when an expert on IT begins articulating developments in computing and modeling software relevant to the pharmaceutical industry, it makes sense to relate such developments to emerging R & D practices. Indeed, the relevance of computing to the pharmaceutical industry continues to accelerate, as is true in many industries. In the United States throughout the 1990s and into the 2000s, for example, some two-thirds of all capital expenditures were for IT; moreover, some 60 percent of all decisions to acquire technology were made by line management, not the traditional CIO and IT staffs. Clearly IT has acquired enormous importance across all lines of business and organizations.

Thus, we ask the question, "Can we develop a predictive methodology that works in industries undergoing change, such as the semiconductor, computer, automotive, airline, or pharmaceutical industries?" In our case study industry—pharmaceuticals—the high cost of R & D and the extensive time required to develop new products and treatments add to the complexity and urgency of this question. In a more stable, mature industry, such as consumer packaged goods or insurance, we could expect the answer to our question to be "yes," because the future in those industries is essentially an extension of the present and traditional scenario planning is a useful tool. Increasingly, though, we find that more and more industries are not that

stable today. Because under such conditions scenario planning is not an effective tool, the requirement to find ways of projecting into the future in changing circumstances is even more essential.

Some industries are slow to respond to a challenge because of the perception (and perhaps experience) that things are, in fact, moving more slowly today than the more dire predictions might suggest. Pharmaceutical companies often feel this way. Frequently the time it takes to develop and bring to market a new drug may be over a decade, and regulatory changes also come quite slowly. Thus, it would be quite understandable for management to accept the notion that the future will be more like the past than not. Accepted wisdom of this sort, however, can be misleading if underlying assumptions are undergoing change, brought on, for example, by the emergence of technologies from outside the industry (e.g., research results generated by scientists at universities or changes in computing that make it more attractive to use IT than ever before).

Understanding the future in a better way does not just focus on the never-ending dialogue about whether technologies (e.g., in IT, manufacturing equipment, or R & D tools) provide strategic advantage. That debate continues and changes as new technologies come onstream (into production), making new applications possible that at first provide competitive advantage and later become merely utilitarian. More important is the incorporation of understanding of key technological changes and other pervasive, indeed profound, socioeconomic transformations into the creation and implementation of a company's business plan. In short, just focusing on the economic value of IT is too simplistic a view, and one that historically has proven to be inadequate.

We describe next an approach that can be used to create a description of the future state of an industry. It is characterized by the twin sets of problems and opportunities posed by technological and scientific innovations. To illustrate the approach, we examine its application in the pharmaceutical industry; however, we have also applied this approach to other less volatile industries that are also subject to substantive changes, for example, the retail industry.

CHARACTERISTICS OF SCIENCE-BASED INDUSTRIES

We present here a list of the characteristics that account for the volatility and difficulty in forecasting the future in the pharmaceutical industry. However, our evidence suggests they apply to high-tech industries equally well:

- *Shifts in underlying science or technology*—For example, the shift in pharmaceuticals from low molecular weight chemical compounds to biologics (larger molecules that are inherently less stable in nature), the emergence of nanotechnology in IT, or the shift in U.S. public funding from physics to life science.
- *Relentless innovation in a technology*—For example, HTS in pharmaceutical companies.
- *Changes in regulatory practices*—For example, requirements for compliance from the Food and Drug Administration (FDA) or with the Sarbanes-Oxley Act requiring financial transparency and disclosure of risk.
- *Changing business models or inputs*—For example, declining labor costs as work moves to other countries or mergers and acquisitions.
- *Emergence of new competitors*—For example, biotechnology companies assuming the roles traditionally played by large pharmaceutical companies (so-called "big Pharma"), or IT Internet vendors assuming the roles for software, PCs, and PDAs (personal digital assistants).
- *Changing demographics*—For example, the aging of the human population creating shifts in demands for medications.
- *Changing geopolitical environment*—For example, the use of third parties to conduct R & D or the moving of activities to emerging economies such as China and India.
- *Increasing pressures on pricing and profits by government and other payers*—For example, U.S. legislation establishing pricing laws on healthcare items, or reference pricing preventing increases in the price of drugs in Europe.
- *Pressure to speed up the bringing of new products to markets*—For example, the success of AIDS activists in accelerating product approvals.
- *Shorter exclusivity of effective patent protection for new products and erosion in prices*—As an example, the period of market exclusivity for the first beta-blocker launched in the 1960s was 10 years compared with just 3 months for the COX-2 inhibitors launched in 1999.

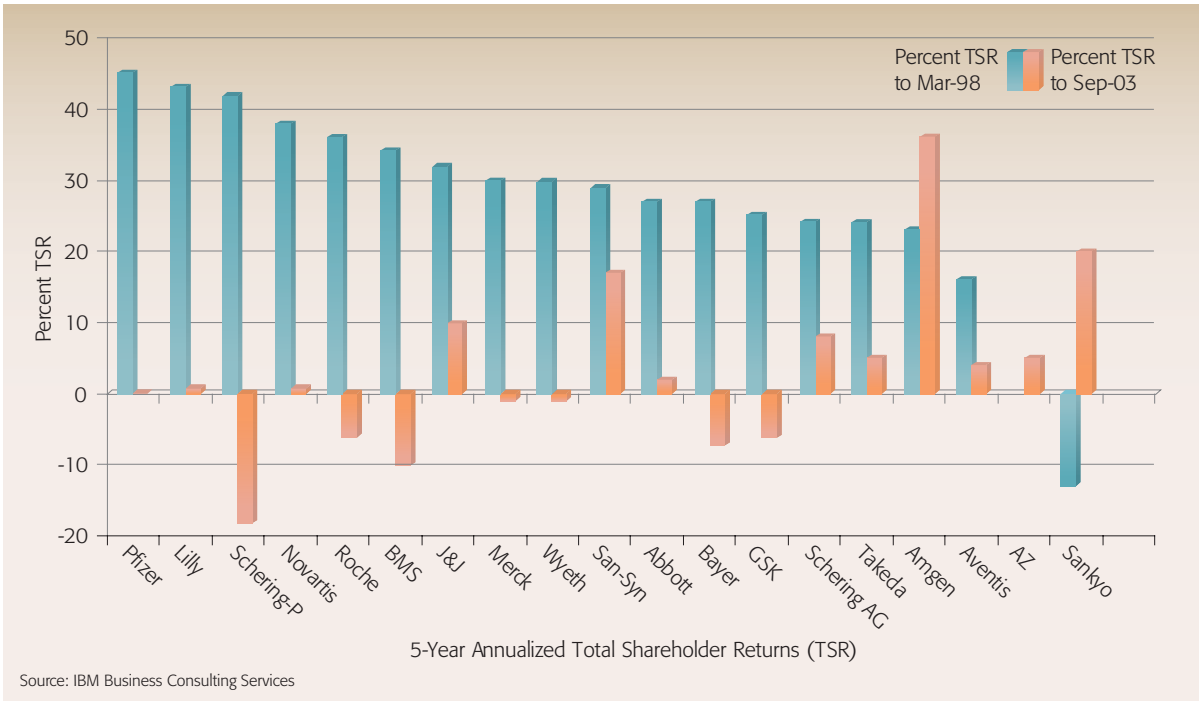

Figure 1
Total shareholder returns for the pharmaceutical industry

- *Increased public pressures on an industry reflecting changing expectations of customers and other stakeholders*—For example, increased consumer empowerment.

DEVELOPMENTS IN THE PHARMACEUTICAL INDUSTRY

As noted previously, we use the pharmaceutical industry as a case study to demonstrate how a new approach can be taken in looking at changes throughout entire industries. In particular, we draw examples from *Pharma 2005*[20] and *Pharma 2010*,[21] two studies of the pharmaceutical industry intended to predict that industry's future in the years 2005 and 2010, respectively. As ***Figure 1*** illustrates, this industry has seen its total shareholder returns (stock value plus dividends) drop by over a quarter since 1998. In an industry that has historically enjoyed double-digit growth, this new circumstance has proved profoundly disturbing. This decline grew out of two fundamental problems that have increased in size and severity over time: declining productivity in laboratories (the lack of a sufficient number of new products emerging from R & D), and increased therapeutic competition as a result of patent expirations, which in turn permitted generic alternatives that led to rapid declines in revenues and profits. These problems have been compounded by the fact that payers—usually insurance companies in the United States and government and healthcare agencies in the rest of the world—were (and are) simultaneously dictating new terms and conditions for doing business, thereby influencing the kinds of treatments for which they are prepared to pay. Although the population of many countries is aging, creating more demand for pharmaceutical products, companies in this industry are finding it increasingly difficult to leverage that demographic trend to realize economic advantage.

An equally important fundamental change involves the ongoing shift in science and medicine away from chemically based medications to new ones relying increasingly on biology, requiring new science and processes for R & D, manufacturing, and sales.[22] This shift is compounded by the fact that leading regulatory bodies around the world are mandating new, more stringent conditions for bringing products to market. The unknowns from the changes in science alone are enough to unnerve not only senior executives and investors, but also regulators.

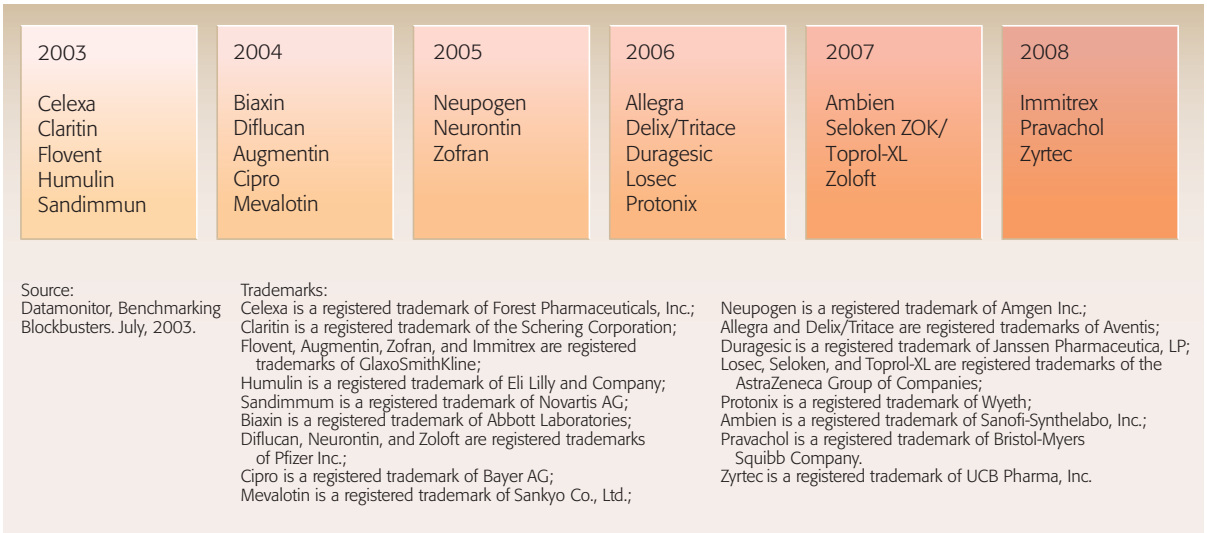

Figure 2
Blockbuster products whose patent protection expires by 2008

The implications of this new science are slowly becoming evident. *Targeted* treatments will increasingly become a reality. This means that instead of a medication being used to treat an illness the same way throughout the entire population of people afflicted with a given disease, in the future drugs and methods of treatment will be tailored to individuals. This new approach will require effective closed-loop processes for monitoring results and then altering the medications themselves to meet the needs of individuals, rather than whole groups of patients. Such changes will, in turn, lead to as profound a set of changes in the pharmaceutical industry as was the case in many industries when electricity replaced steam during the second industrial revolution.[23]

The challenge for management is, of course, to time correctly changes in how they organize and run their businesses to reflect these new realities. Some of the key issues are under management control (e.g., the type of R & D in which the company engages), but others are not (e.g., government regulatory practices and changes in laws). Understanding the interactions of what can and cannot be controlled will, over time, provide powerful insights for managing a company's business strategy. For example, this approach helps address such tactical questions as:

- How should the company pay for the development of drugs and clinical trials for a drug that is used to treat a very small number of people?
- How can the company more effectively use partnering and alliance relationships beyond just R & D organizations to optimize operations across the entire value chain, particularly for those components anticipated to experience enormous change in the future? In pharmaceutical companies, such considerations must include anticipated changes in the value chain as it transforms to support more targeted treatments in future years, as described previously.

On the business side, the period of patent exclusivity continues to shorten. Patents are public information, as are their expiration dates. ***Figure 2*** illustrates the range of "blockbuster" products which will lose patent protection by 2008, giving rise to vastly less expensive generic alternatives. It is important to understand the enormity of this issue. Patents are always expiring, but over the next few years an unusually large number of major blockbuster products will lose patent protection at essentially the same time, leaving the market open for generic producers to come in with products that drive down sharply the costs of the original patented products. In fact, $35.5 billion worth of products are forecast to lose blockbuster status by 2008, and there are only five products in the pipeline predicted to achieve blockbuster status by 2008. To put it in dramatic terms with respect to revenue, the result for the industry is as if one were to take the three top ranking "big Pharma" companies and the top

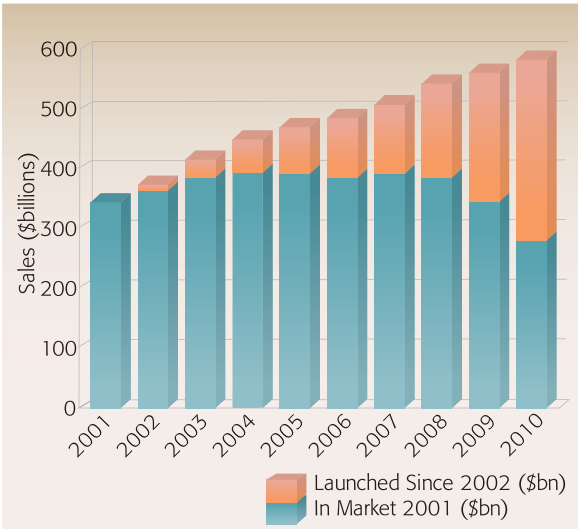

Figure 3
Predicted compound annual growth rates in the pharmaceutical industry

biotech enterprise and put them all out of business simultaneously.[24]

Figure 3 documents our analysis of how slowly the industry will launch new highly profitable branded products to replace these expiring blockbuster products. The industry itself now recognizes that it faces an impending economic crisis. Data on trends of aggregate patterns of payer behavior can also be cited to demonstrate that the future of this industry is changing dramatically. Collecting and understanding all these kinds of information are early steps in the process of comprehending the possible future of this industry.

Finally, emerging global geopolitical conditions are at work that should be addressed in such a planning exercise. Perhaps the most obvious is the trend toward outsourcing, particularly to biotechnology companies, as a primary strategy for drug discovery. In the period from 1999 to 2004, pharmaceutical companies increased the extent to which they outsourced R & D significantly. Outsourcing is a major, global phenomenon in this industry, enabling companies in many countries to build up capabilities in drug discovery that pharmaceutical companies increasingly will be able to leverage. Emerging economies such as India and China now play active roles in the industry, creating lower-cost sources of help but also nurturing potential future rivals for the large pharmaceutical companies. Any planning effort must answer the question of how this trend toward outsourcing will affect the industry in future years. More tactically, the implications for profit streams must also be addressed.

There is increasing consensus, and indeed evidence, that the transformations resulting from these trends will have significant impact during the careers of current senior executives. The acceleration of these factors was forecast as early as the 1999–2000 time frame in the original *Pharma 2005* report, emphasizing the importance of finding new ways to predict and understand the future of this industry.

MAPPING THE FUTURE: PHASE 1

The process for mapping the future begins by defining that future in high-level terms, so that management can next complete the secondary levels of information required to understand it and possibly respond to it in detail. Initially we define today's current trends and then create a vision for periods of time that extend far beyond normal comfort levels. In other words, we carry out standard scenario planning, but extend that exercise by at least 10 to 15 years.

This approach is exactly the opposite of what is normally done. Usually, a manager goes from today's situation (often called the as-is circumstance) forward 2 or 3 years to the to-be situation. In effect, the future is then defined as one of two or three variations of a straightforward extension of the present. This is classic scenario planning. In contrast, by taking the approach described in this paper, we can begin factoring in disruptions that are not extensions of today's patterns, such as the introduction of as yet unknown classes of medications, or natural disasters, or the evolution of unknown diseases.

By initially selecting a limited number of detailed research topics to explore regarding the future, we can make a great deal of sense of the resulting data and generate approaches that become the focus of future work streams. These results can be particular to a given industry (such as those regarding the future evolution of stem cell research and its potential by-products) or relevant to many indus-

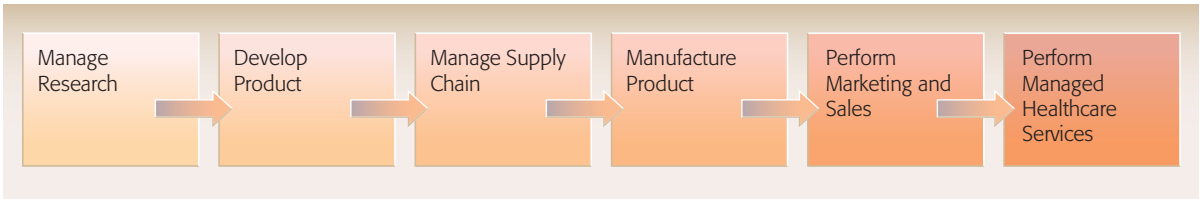

Figure 4
A typical value chain for a pharmaceutical company

tries (such as those involving outsourcing or changes in regulatory practices).

An initial period of intensive work by a task force gathering and analyzing material and interviewing thoughtful industry and company-level observers, regulators, analysts, financiers, and futurists is required before a second round can begin to articulate a view of the current and future situations. Many new questions can be expected to arise that will require more research and analysis. Eventually a plausible view of the future begins to emerge that both balances existing trends with future expectations and becomes a point of view that senior management can embrace. Indeed, at this point it is key to obtain buy-in from a company's senior management (on a global basis if the organization has a worldwide reach), who will be asked to reorient assets of the corporation to achieve the defined future faster than competitors.

The initial set of results describes the present situation and the anticipated future (e.g., the availability of biologics and other treatments), and then concludes with a set of actionable recommendations. In our study of the pharmaceutical industry, these conclusions involved strategic recommendations concerning new approaches to discovering drugs and new ways of developing products, manufacturing them, and bringing them to market. It also considered the implications of these changes for such key stakeholders as customers, suppliers, regulators, healthcare payers, and others.

For line management to be able to implement such recommendations, they should be defined in ways that address the changing roles of each element of an organization's value chain, as shown in ***Figure 4*** for a typical pharmaceutical company. It is important to understand that although the initial set of recommendations will be at a very high level (see sidebar), they can later become the basis for follow-on initiatives that drill down more deeply into the elements of a company's value chain.

The initial project should conclude with a statement of implications. For the case of the pharmaceutical industry and its partners (e.g., suppliers), the implications were profound. First, change of a most fundamental nature was underway and could not be ignored. Second, this change was so dramatic that successful companies in this industry would have to develop fundamentally new business models to succeed, something executives or industry experts would prefer not to confront, let alone have to act on. ***Figure 5*** illustrates graphically at a very high level what these changes might look like. When we first published this graphical representation, it drove home to many executives the realization of just how comprehensively their operations would have to change.

An equally important output of the initial project is a statement of economic impact, again at a high level so that more detailed future analyses can test and quantify possibilities and results. ***Figure 6*** shows projected economic impacts for pharmaceutical

A Disease-Driven Approach to Drug Discovery

Flipping the telescope around and looking at pharmaceutical R & D in terms of redefining diseases much more precisely not only provides opportunities for developing different treatments for different pathologies; it also provides opportunities for cracking medical problems that have proved intractable. One such instance is rheumatoid arthritis.

Source: *Pharma 2010: The Threshold of Innovation*, p. 24

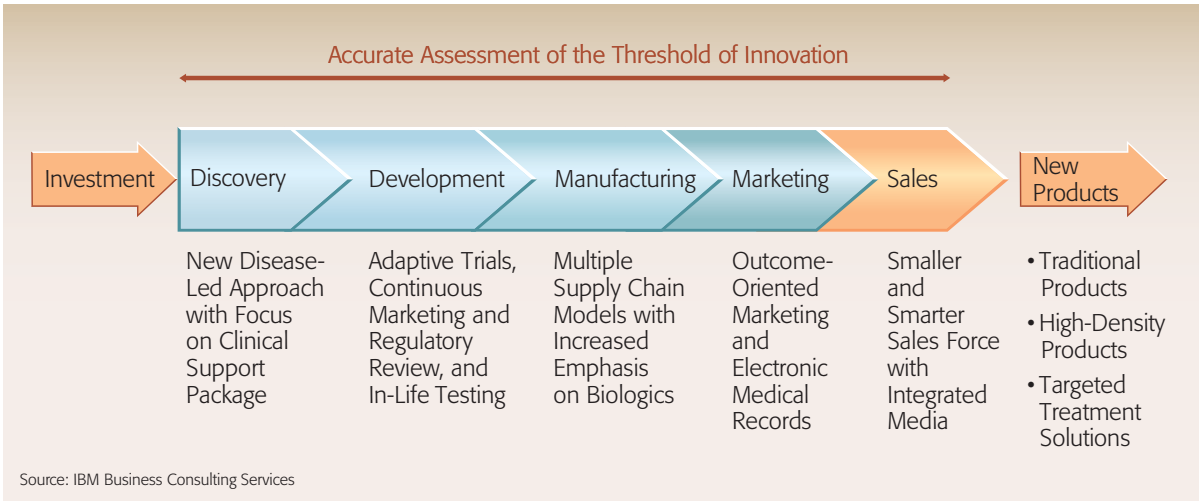

Figure 5
Proposed new business model for the pharmaceutical industry

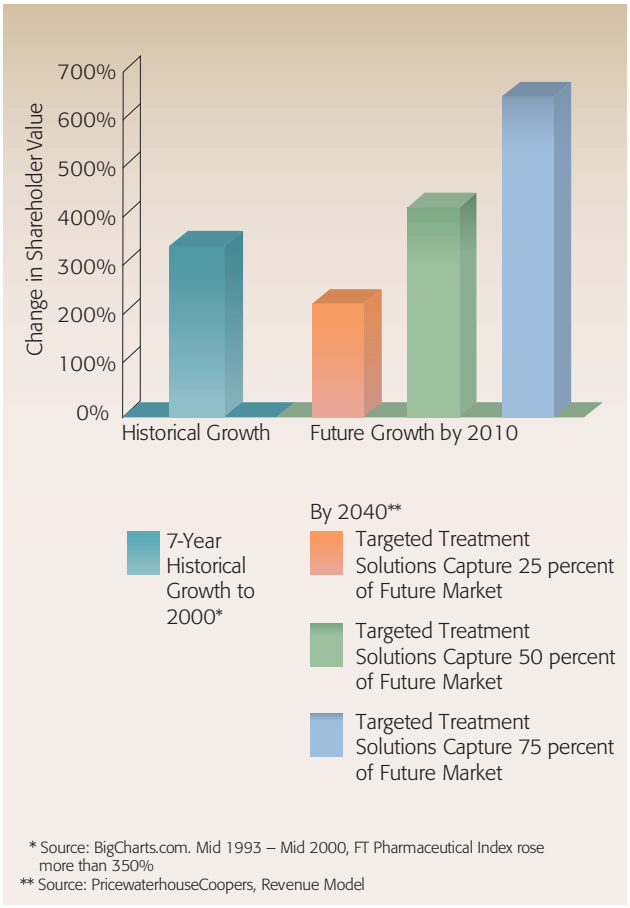

Figure 6
Projected industry growth depending on rate of transition to targeted treatment solutions

companies based on the speed at which a company moves from traditional products to targeted treatment solutions. In this figure, the projected revenue growth by 2010 is depicted for three different scenarios involving targeted solutions eventually capturing 25 percent, 50 percent, and 75 percent of the market by the year 2040.

It is then crucial to "socialize" the results of such a study throughout all the normal communications channels used by an organization, and also out to customers and suppliers. The physical product of the study can be quite lengthy, but it is essential to ensure that the message is communicated in a controlled and consistent manner. Shorter versions should also be prepared (the proverbial "executive summaries"). However, their use should not be a substitute for executives and managers reading the full version to understand their own future.

MAPPING THE FUTURE: PHASE 2

The second phase of the exercise involves taking the key elements of the value chain described in the first study and producing more detailed visions of the future for each of these value-chain components, as illustrated in ***Figure 7***. In the case of pharmaceuticals, this should include R & D, supply-chain management, and sales and marketing. ***Figure 8*** displays the table of contents of our *Pharma 2010* high-level study, which describes the future to 2010 in general terms, and next to it the table of contents of a specific supply chain study, also covering the

future to 2010, which was an outgrowth of the initial study.

There may often also be specific issues that are consistent with the macro view, but are not a formal part of the value chain. In the case of the pharmaceutical industry, it became very obvious that information technology would play an important role in each part of the value chain, to the extent that a study was conducted to identify which emerging technologies would be influential in the chosen time period, and what their effects could or would be. ***Figure 9*** shows the table of contents of a study of the implications of IT for the pharmaceutical industry as a whole through 2010. ***Figure 10*** identifies seven specific IT technologies critical to the welfare of this industry, as determined by key experts in the areas of IT, pharmaceutical research, and supply-chain management.

As mentioned earlier, a secondary, supportive, and ever-present concern in any analysis of the future involves the special role of technologies, particularly IT, not only for enhancing operational effectiveness but also for supporting innovations that augment a company's ability to grow or be more competitive.

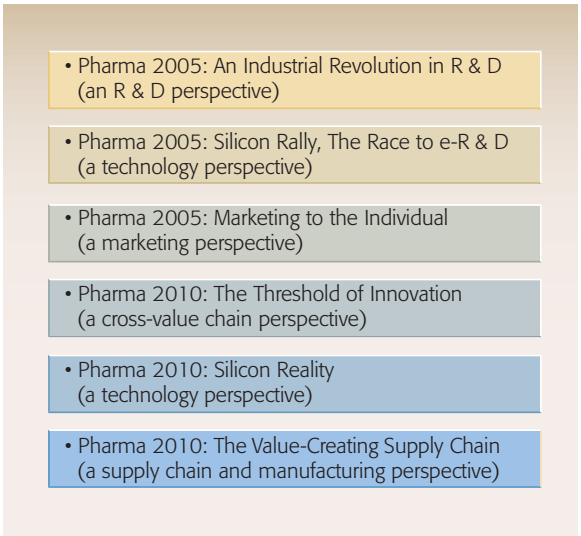

Figure 7
Pharma 2005 and *Pharma 2010* studies spanning the pharmaceutical value chain

Our study of the role of IT in the pharmaceutical industry through 2010 revealed several examples of the latter. For example, the massive increase in available computing power has made it possible to

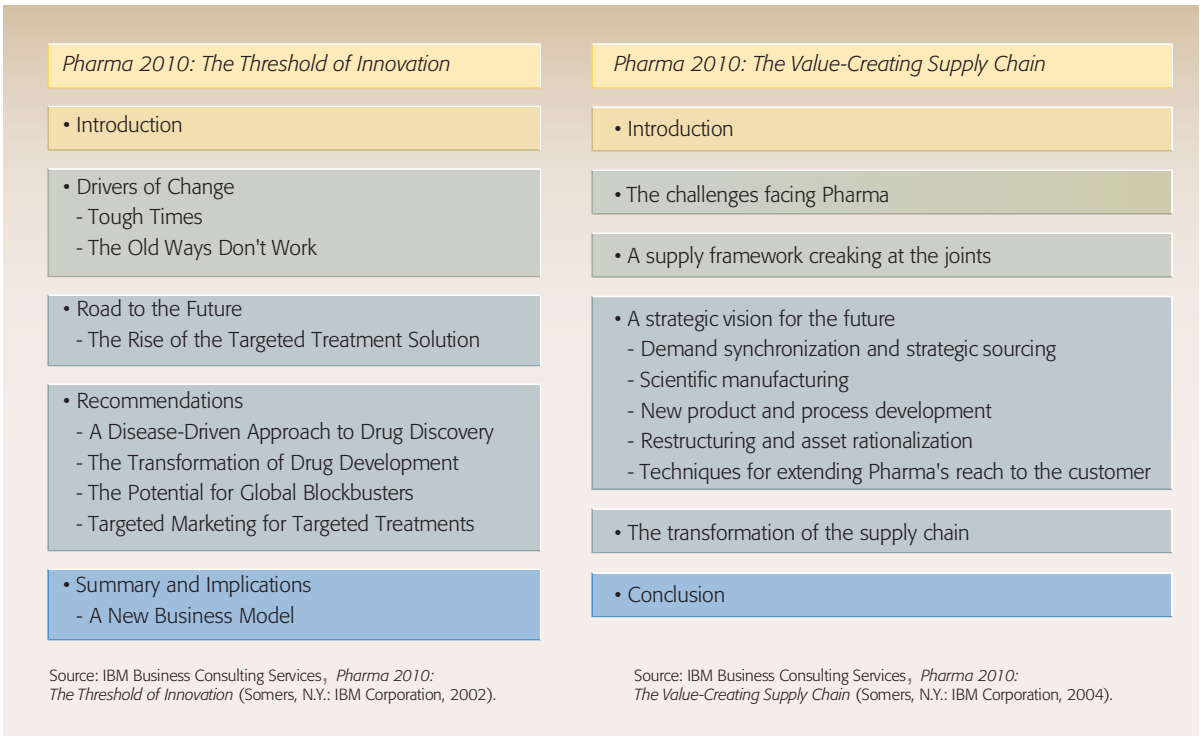

Figure 8
Tables of contents for Pharma 2010 studies

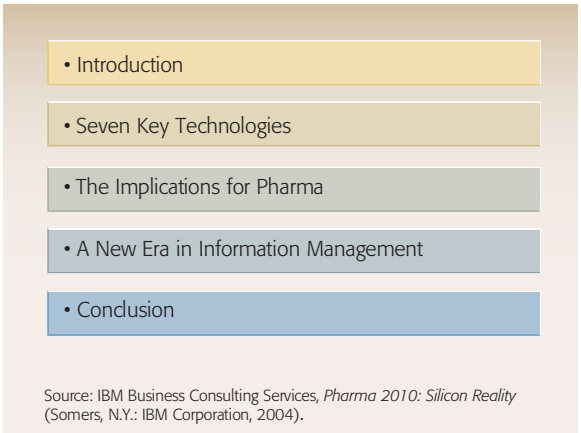

Figure 9
Table of contents of *Pharma 2010: Silicon Reality*

map the human genome, which is now fully sequenced. Advances in IT (e.g., data handling, the wider use of PCs, and high-performance workstations) have also enabled researchers to begin unraveling the subcellular mysteries of human life. Biologists, who in prior decades particularly lacked sufficient data and were often relatively inexperienced in the use of computers, have begun using these new technologies very extensively. In turn, this is driving two sets of activities: (1) R & D is becoming increasingly computer intensive and, perhaps more important for the long run, (2) these changes are influencing what kinds of research and

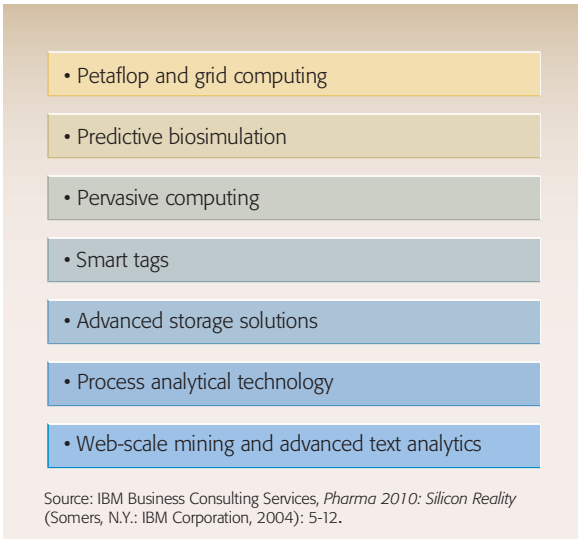

Figure 10
Seven major technologies affecting the pharmaceutical industry

product development are being undertaken.[25] These results became evident after the *Pharma 2005* study to the extent that this topic became a major work stream of the 2010 study. In blunt terms, no future vision of this industry could be created without paying considerable attention to the role of IT. In fact, we are now at the point where we can say that no major innovation in science or product development in this industry will occur without the direct use of IT. In particular, this includes those aspects of IT that allow computations, imaging, and management of databases in ways far more sophisticated than was possible even 5 years ago.

In fact, we have concluded that many innovations in IT itself will be driven largely by the needs of the pharmaceutical community and less so by those of other industries. This is an extraordinary conclusion because historically military, aerospace, industrial, and petrochemical needs have provided the fundamental economic incentives for such IT-centric industries as semiconductors and software to continue innovation, in the process shaping the potential uses of advances in computing to their own requirements.

There were two major aspects to our research into how IT can influence an industry that is as science-intensive as pharmaceuticals. First, we had to survey the IT landscape to see what new technologies or changes to existing techniques, tools, software, and hardware could be expected to occur over the next 10 years. It turned out that the IT community understood with a high degree of confidence the basic paths of evolution expected over the next decade. Second, we had to choose which of these streams of innovation would be most relevant to this particular industry, knowing that the list would vary from one industry to another. The research team followed these two steps to arrive at its list of seven technologies to monitor, work with, and exploit. Armed with that information, we could then inject a reasonable view of how technology would support corporate objectives (e.g., for growth and innovation), leading to roadmaps that individual companies could create and implement.

These kinds of analyses provide vision, feed strategic and tactical plans, cause competitive strategies to be created and implemented, and offer the basis for measuring the effects of changes on corporate performance that go beyond traditional

quarter-to-quarter stock-market performance or balance-sheet accounting. In particular, this detailed understanding allows management to balance prompt tactical action with investments in support of what they perceive to be their future.

MANAGING THE DETAILS

To a large extent, managing the process just described is relatively easy to articulate but complex to execute. Experience indicates these first studies vary widely in the amount of time they take to complete, often depending on the planning skills of the corporation and the extent to which senior management can marshal and protect the right talent (internal and external) to focus on what always begins as ambiguous and, indeed, unclear questions. It is imperative to include in these discussions thought leaders from within the company (not just executives), and industry, consultative, and academic experts. Using a futurist can stretch the team's thinking beyond the normal horizon, as can the requirement to gain insights from all critical stakeholders. In this industry, government regulators must be included.

Team members should be specifically targeted. This will become a high-profile project, and many will want to participate. Admission should be granted to those who have ideas and knowledge to contribute. Participants should not be selected simply because they are senior executives or to ensure that all parts of the enterprise are represented. A writer with industry experience should be included. (In this instance a medical journalist is appropriate.) Reviewers of the study results should come from inside and outside the enterprise and industry. Implementing useful team tools (e.g., Lotus Notes* team rooms) to collect and communicate the large volumes of information that inevitably are collected remains a critical early step, as is establishing a budget for research materials, travel, printing collateral publications, and related expenses.

A key problem is that normally the "right people" are often too busy doing work critical to the mission of the company, and thus they, or their management, are reluctant to give up the time such a project requires. Rather, management typically assigns second- or third-tier people to such a task. We believe that senior management must put in place the necessary incentives to motivate the right people to participate. There is a direct correlation between the involvement of the right individuals and the success of both the vision and the strategies that are developed, not to mention success in their execution. Each company is sufficiently different that it is possible to become too prescriptive about how to solve this problem. A workable approach might be having individuals dedicated to the tasks at hand and doing much of the preliminary work, who also on a regular basis bring in other individuals for specific blocks of time (e.g., a few days every month, or a week here or there, plus a continuing and regularly scheduled set of meetings). A designated executive should be responsible for results, but it is also important to make people aware of the prior successes and failures of strategic-planning initiatives in order to provide lessons learned and encourage positive performance. Often, if the task force believes senior management will act on bold recommendations, they willingly volunteer and find the necessary time. But as with all planning initiatives, if management, financial considerations, or corporate culture result in no action being taken, the future-mapping process described in this paper will fail.

We find that identifying the "right" thinkers is a broader problem than just including employees who understand their industry and organization. Properly mapping the future requires individuals who also are deeply knowledgeable about impinging industries. For example, in the case of the pharmaceutical industry, enlisting the expertise of individuals in the healthcare and insurance industries is essential. These are normally a collection of academics, government industry watchers, consultants expert in related areas, and even employees in other industries. All must be brought to the process and their thinking integrated into the final results. Failure to do so can lead to major blind spots, such as ignorance about highly relevant developments in other industries.[26]

Complicating the staffing of the task force is the fact that the scope must be global, even if the company thinks it is not, because global circumstances dictate the future's outcome. Experience in preparing these studies also confirms the need to ensure that the team and other secondary participants come from around the world, so that the study is not biased with a view typical of one country or one part of the organization, but rather is seen as incorporating the various perspectives and skill bases that inevitably

exist globally. Secondary studies can be done either sequentially or concurrently, but only after the initial major study has been completed and socialized within the enterprise and among customers and suppliers. These new studies must also follow the same rules as the original project and typically take months rather than weeks to complete.

One final basic rule: the future is not static, and therefore this cycle of examination should be ongoing. The base project should extend the scope of its analysis out 10 to 15 years and be repeated approximately every 5 years. Secondary studies can be ongoing throughout this period, as management develops an appetite or need to change an aspect of the business. For example, one should not launch remodeled R & D operations without first doing such a study to gain an understanding of how R & D might be done in the future. In fact, this industry is currently in extensive efforts to resolve this issue because of the sharply rising costs of R & D in the face of a depleting pipeline of new products.

We find that the studies improve, become more believable, and prove more robust as managers and participants gain more experience in the process. Thus, a 10-year study of the semiconductor industry of 2015 will be a better study than one might have done earlier for the same industry to 2010, or, of course, to 2005. Others who conduct new forecasting studies have the same experience; results simply become better.[27] This is why, for example, IBM's Research Division has prepared a technology forecast on a continuous and formal basis since the mid-1970s, a survey that profoundly influences the technology decisions of senior management.

MORE LESSONS LEARNED

The pharmaceutical industry has taught us that when an industry is profoundly changing, a company must focus on those major visceral forces causing change in the overall industry, not just on the company itself. In this instance, changes arose from the transformations of science and of the attitudes of consumers, regulators, and payers. Moreover, doing such a study as early as possible in the period of change confers the opportunity to identify strategic competitive opportunities that might not be seen yet by rivals.

Clarity of purpose and focus are essential. Developing a point of view of an industry is far more profound and relevant than the more popular approach normally taken by industry pundits, who like to look at specific solutions, offerings, services, machines, and software. All of those topics are really by-products of more substantive influences on a changing company, market, and industry.

■ Many innovations in IT technology itself will be driven largely by the needs of the pharmaceutical community and less so by those of other industries ■

A highly regarded senior executive has to be the champion of the process and needs a core team that travels down the path of activities from beginning to end. The company's own employees will be mixed together with industry experts and possibly consultants to form an effective team. Teams can change in composition as they move from topic to topic; indeed, they must in order to help ensure that deep skills and insight are always brought to bear on the project. One of the hardest jobs for team members will be to balance the pull of their day-to-day jobs with the need to complete the long-term project to foster the future success of their company.

Industries learn from one another, but the future may arrive at different rates in different industries with respect to the use of a given technology, scientific application, process, or practice. Thus, it is important to understand what other industries are doing and anticipating. Since various types of documentation exist about activities in other industries, this is a useful activity for understanding the scope and consequences of developments elsewhere. For example, the railroad industry at one time wanted to tag each box car to track its location and contents. Work toward that goal led to very early designs (1960s) for what a decade later the grocery industry converted into bar codes (1970s), which retail industries embraced widely in the 1980s, and which became ubiquitous for a myriad of applications by the 1990s. Each industry learned from the prior work and expectations of the other.[28] Numerous examples can be cited, but the point is clear: things that work in one industry have a

propensity for moving to others; the competitive advantage normally goes to the early to midterm adopter. The last to adopt merely maintains "table stakes," as happened famously in the banking industry with automated teller machines (ATMs).[17]

Comparisons can center on emerging science and technology or on practices. We recommend for the pharmaceutical industry, for example, that companies understand how research and development is done in the semiconductor industry, which shares similar R & D process issues and which could someday face its own issues regarding rates of innovation. Again focusing on pharmaceuticals, the aeronautics manufacturing industry has much to teach about regulatory requirements for record keeping regarding safety and maintenance. Ongoing use of records in airplane manufacture and maintenance has been in place for decades; today, the U.S. Federal Food and Drug Administration is increasingly imposing similar requirements on drug manufacturers to track their entire supply chains, and is even beginning to call for additional records covering use of medications by patients.[29]

Using a professional writer from the beginning of the process forces everyone to explain themselves clearly and helps ensure that the final deliverables are understandable to the audiences to which they are directed. Research support should be just as skilled and professional. This is especially important in high-tech industries, such as computing, communications, aerospace, and pharmaceuticals, because people in those industries have refined skills for accessing existing and needed data and other materials. Such people also form an audience that is so highly educated that it has a refined set of expectations for "completed staff work."

Developing a deployment plan for communicating results should begin nearly at the start of the project; some of our colleagues would argue that such planning should start on the first day. Communication should be comprehensive and formal across the entire corporation, in the same manner, for example, as one would do for the announcement of a new CEO or merger, and with the same thoroughness and formality. A small group should initially control all content, so that the messages delivered are consistent across the enterprise for many months. A controlled launch is essential. A controlled launch also provides two additional by-products, the importance of which should not be underestimated:

1. An internal appetite for information is created.
2. A splash is likely outside the company among stakeholders and even the public at large.

RESULTS SO FAR

Ultimately, no exercise of this importance will long survive if there are no positive results to report. An examination of what happened with *Pharma 2005* is instructive. Recall that the purpose for this kind of exercise is not so much just to predict the future, much as one would predict the weather, as it is to understand how circumstances are changing and to define what a company or industry must do to succeed. To continue the weather analogy, its purpose is to understand that the seasons are changing, that we will probably have colder weather approaching, and thus that we must make sure we have warm clothing and our houses can be heated. The true test of this exercise, therefore, requires that management be able to link macro economic and business trends to a myriad of other issues in an organized manner such that they are believable and actionable; thus the trends can provide the basis for the very highest strategic considerations for a company or industry.

Understanding macro-socioeconomic, business, and regulatory trends proved the easiest part of both our 2005 and 2010 exercises. The reason for this success can be attributed largely to reliance on team members knowledgeable about the industry, who did research on the major forces at work within it. This demonstrated the value of the early work steps that called for setting hypotheses about the future, conducting research on them, testing ideas with experts, and boiling down various trends to the most important. Explaining how a trend was unfolding proved of great value. For example, the proverbial "everyone" may have known that ultimately targeted treatments would become the norm, or that the industry's pipeline of new products was shrinking. The most interesting questions were (1) by how much? (2) how fast? and (3) what did these trends mean for the way business operated? Addressing those secondary issues proved important in constructing a coherent overall view of the future. Success at this second level of detail varied. On the one hand, management in this industry accepted the logic of the scenarios that were painted

(e.g., "if this trend occurs, then these actions will have to be taken"), but there was debate about the rate of change and when it was coming. In the case of the 2005 study, timing of the arrival of new trends was aggressive; so far, for the 2010 study, the prediction about timing of arrivals appears more accurate. In the 2005 study, the team focused enormous attention on the R & D side of the business, and much that was described in that report is coming to pass. In the 2010 study, the scope expanded to cover many aspects of what a business did, from R & D all the way through delivery of products to patients. Many of those issues have yet to unfold, as they speak to topics that are yet to occur.

Anecdotal evidence from presentations and conversations with management in the industry indicates that while these leaders continue to debate the timing of when trends will emerge and affect them (some agree with our timings; some think things will take longer), there is little disagreement about whether they will happen. To a large extent this result can be explained by the consensus-building efforts of the teams that put these reports together. There was great value in explaining how events and issues that on the surface did not seem linked came together. Nowhere was this more evident than at the level of the secondary studies which focused on specific processes and technologies. For example, in *Pharma 2010: Silicon Reality*,[23] management could understand both how the emergence of new IT tools would affect some specific function (e.g., operation of supply chains) and how these tools could be used to advantage if management so chose (e.g., massive computation in R & D). In short, such a report served as direct input into more traditional strategic-planning initiatives. In this case it often involved IT operations throughout an organization.

Another way to measure results is to track who listens. At first, management listened to the 2005 story because the authors of that study had direct access to these people. In fact, we were very surprised at how interested CEOs became in our original studies. In time, the industry knew of this work and so increasingly the team either was invited to present its point of view within a company or began receiving invitations to discuss the study at industry conferences. By the time the 2010 study had been prepared, access to management at all levels and to industry conferences was commonplace. We concluded that this resulted from the fact that the approach filled in important gaps in people's understanding of unfolding events, threats, and opportunities to an extent that could lead to specific actions. In short, strategy could be set based on a fundamental understanding of where the market was going. The same holds true within organizations that already maintain ongoing strategic planning processes. In both cases there is a need to communicate findings, provide feedback on results year after year until employees understand the basic elements, begin executing against the plan, and then track and report results. In short, any planning initiative moves from being a one-time event to an ongoing process tuned to the realities of a company's market. In the case of our mapping exercise, the process calls for a more rigorous linking of future trends to the activities of an organization to take advantage of anticipated opportunities while minimizing negative surprises that could have been anticipated.

In the case of the pharmaceutical companies, managers collectively came to realize that certain issues now had to be addressed differently, including refurbishing their fundamental R & D and supply-chain practices. There is also a focus on the science itself, which an increasing number of industry watchers are learning to measure in business terms.[30] In short, management has been given the opportunity to tip the balance of trends in their favor.

What then should the final report card look like? One possibility is that success could be measured by shareholder value. This metric is a favorite with many industry watchers, but it is also a lagging indicator of macro changes in performance as well as circumstances in the market that may be outside the scope of a company's control (e.g., results of wars and economic recessions). The challenge is how to link such a measure to a specific component of one of these studies. Alternatively, success could be predicated on the number of new products that make it through the pipeline. We believe metrics can be created at that level, including, as a specific example, the fraction of new drugs emerging from biological research as opposed to traditional chemically based work. The relative percentages of revenue coming from products that were introduced in the past year, 2 years, and 5 years form another possible measure of success. The industry has yet to

create the level of metrics required to support this kind of planning; however, it has started, with particular focus on the issues raised in the 2005 report. In the case of the 2010 study, it is too soon to tell.

Experience would suggest, however, that metrics of performance at the highest level are not as valid as are those already familiar to management at the process and operational levels. If the mapping exercise indicates that, for example, the supply chain needs to be transformed to reflect different operational capabilities, then the performance of the supply chain should be evaluated. Metrics for such a process are widely available. The same would apply to other operational processes that are transformed as a result of this strategic-mapping exercise. It should be kept in mind that because of the long-term nature of this work, results will not become evident until years later, often only in hindsight. For a generation of management raised on the principle that quarterly results are to be prized over longer-term achievements, we point out that research on short-term versus long-term approaches clearly suggests the long-term approach is better.[31] Our methodology supports those findings.

STRENGTHS AND LIMITATIONS OF THE APPROACH

Like any planning exercise involving a view of the future, this approach has its strengths and limitations, although we do find that the strengths outnumber the weaknesses. Based on two iterations of this study in the pharmaceutical industry and several initial studies in other industries, we conclude that the approach is applicable to a spectrum of companies. This is an important finding because as borders between industries are dissolving, creating such views across wider portions of a market is not only essential to good strategy development, but also to insight about economic opportunities that lie outside a company's traditional boundaries. Thus, this approach would be extremely useful in the telecommunications and media industries, which are increasingly merging and forming new economic models and organizations transcending traditional industry and corporate borders, and which are also profoundly driven by changes in science, technology, and regulations.

There is also a growing emphasis on the need for companies, industries, and whole economies to increase their levels of innovation in order to generate new sources of profit and economic well-being. We have noted that tools and techniques can be ported from one industry to another. Obviously they can also move from one economy or region to another. It is no accident, for example, that the European Union has made innovation a strategic imperative at the exact time that it is trying to absorb ten new countries into its union.[32] It is just as clearly not a random coincidence that companies in disparate industries, such as IBM in IT services and Corning in glass-based products, have made innovation a mantra. We suggest that the methodology just described can lead to specific sources of innovation.

A growing interest among senior management concerns how best to take apart their businesses as intact components (people, processes, markets, and data) and either reconfigure or outsource them. Our methodology makes it possible for executives to create criteria for selecting what and how to change within their organizations, and what to acquire as a consequence of changing circumstances.

In reviewing these projects with participants and executive management, several clear strengths emerged. The project provided a structured approach, and both participants and management liked the fact that it became a regular exercise, an extension of management's view of the environment. Also, its global nature proved to be an important benefit, as did having senior level support, particularly for the research teams. We envision that in high-tech companies, where senior executives must have deep technical knowledge themselves, as in semiconductors, this requirement for direct personal involvement is essential. The output is of high value to those who have to take actions based on the findings, yet focused sufficiently to lead to immediate tactical and longer-term strategic actions.

The key advantage of this approach over traditional scenario-planning techniques is that a company is not purely extrapolating from today's environment. For instance, by stepping outside its current horizon, a company is given the freedom to think beyond traditional views of its industry. The future does not necessarily need to be a minor variant of today's model. In a long-lived industry such as pharmaceuticals, this can be unnerving for some,

but rewarding for those willing to explore the possibilities.

The approach presented in this paper is relatively easy to describe; the hard part is focusing with the discipline of a formal process. This is not work for amateurs or casual participants. Engaging experts in an industry from academia, consultancies, and industry-watcher organizations is essential, as is the use of futurists and others familiar with strategic planning. The fundamental problem is that while the process is logical, even highly methodical and scientific (i.e., structured), it is also an art (involving, for example, creativity, brainstorming, and scenario planning), so much so that after all the data are collected, one still has to rely on intuition borne out of the experience of working in the industry in question. Thus the formal scenario-planning process must also be coupled with activities that cause one to think "outside of the box." Inspiration, aspiration, and just plain "wacky" ideas also must be in the mix.

As should now be obvious, the project is time-consuming; there is no quick shortcut one can take to reach the same results. Our experience so far has been to look at one industry at a time, rather than comparing multiple industries to each other; therefore, we believe the existing process has a built-in weakness, namely a bias toward an insular view constrained to a single industry's view of itself.

Nevertheless, one key practice gives enormous strength to our approach: the proper makeup of the core team working on defining the future. First and foremost, there must be a team; no single individual has the imagination, time for research, or knowledge to define a creditable future. Second, the mix should include scientists and engineers, general and line management, and futurists, while engaging the thinking of those whose orbits are finance, economics, and scholarship. This intellectual diversity must be factored into the entire process, beginning at the planning stages. We cannot overstate the importance of diversity of insights and knowledge.

To date we have not implemented what should be an essential practice: comparison of one industry's potential future with those of other industries that have proven themselves to be sources of influence or where the future has already arrived in some form or another (as in the use of some new scientific strategy). By forcing comparisons, we can avoid creating too insular a view of an industry. Such an approach, for example, was taken by General Motors and other automotive companies in the late 1990s when they struggled with the question of what to do about electric cars, which at the time were based on technologies that were just not cost-effective and did not provide enough range. To be sure, they monitored innovations in batteries that were occurring in the computer and semiconductor industries, but they concluded that hydrogen represented a better future. Both options had to be gleaned from outside the automotive industry. Such comparisons would be logical next steps in the evolution of our methodology.

Although we have applied this approach to looking at one industry for over half a decade, there is much yet to learn. We believe that the approach is applicable to most industries, in particular, manufacturing and science-based industries, but we have yet to test it out in pure service industries, such as banking, insurance, or government. Governments especially represent a mystery because of their massive scope of public work; our technique is only just now beginning to be applied to this part of the world's economy.[33] One major problem is developing a global view because governments vary a great deal, as do the societies in which they operate. Moreover, old habits typically lead government officials to think their world is different from everybody else's. The "unknowns" in service industries are shared by almost every other managerial practice, most of which were originally designed for stable industries in manufacturing. As the world's economy becomes increasingly service-oriented, much work will have to be done to adapt existing methods of management to new circumstances; forecasting and mapping the future are merely two items on the long list to be transformed. Our own efforts to bring rigor to the study of service industries are intended to provide opportunities for these futuristic point-of-view studies to be conducted.

One open question that we raised previously regards the ability of our process to predict or articulate the negative effects of some new circumstance or technology. We also know that some companies have historically been slow to adopt a new technology for a variety of reasons. (For example, combinatorial chemistry and HTS were not fully

adopted in the pharmaceutical industry for at least 4 to 5 years after the necessary technology had become available and proofs of concept were complete.) Our approach has not yet incorporated

■ Studies of the future state of an industry, science, or technology are becoming increasingly important in the development of a company's business strategy ■

an assessment of how well an enterprise responds to changing circumstances, because for that to occur, an organization would first have to lay out a plan for reacting to changes, attempt these changes in an organized manner, and then go back and reflect on the effectiveness of the plan and its execution. However, there is nothing in the described process that would preclude a company doing so. Indeed, there are many existing processes for doing just that, which have been in use for years. The question does raise the issue, however, about how valuable retrospective assessments are to a company. While outside the scope of our discussion here, we point out that such retrospective analyses are becoming an increasingly popular activity among strategists.[34,35]

We also have much to learn about the transfer of knowledge during the course of such an exercise. To be sure, we have found that the appointment of a knowledge manager to collect and maintain data for future studies is valuable; yet use of knowledge management (KM) practices remains an emerging field of managerial and operational performance.[36,37] Preliminary findings suggest that having a KM manager makes sense, and that the role of a KM manager should be further refined.

When the question was asked, "What could be done differently based on experiences gained in the pharmaceutical case studies?" several ideas emerged. First, it should be verified that an industry's entire value chain is subject to study by the project team. Second, it is important to insist that participants be drawn from all the major geographical regions in which the industry and the sponsoring organization operate today, or might realistically operate in the near future. Third, if a company is doing this kind of study, team members should work with marketing and sales to ensure that they have product offerings and services in support of the vision created for the industry's future. Fourth, all the materials used in the study should be cataloged in a highly organized manner and be ready in anticipation of a mid-term update of the data or in preparation for the next study, ideally 5 years later. Finally, all key stakeholders should be involved from essentially the beginning of the project.

With regard to the secondary theme introduced at the start of this paper on the role and effects of technology, we learned that this issue is essential to any analysis of the future of an industry. In fact, the theme must be incorporated into the basic work stream of the initial study, and we would also recommend that it be the subject of one of the earliest secondary projects. We did not fully realize this when doing our 2005 study, but clearly understood the importance of such effects by the time the 2010 study was completed. Thus, the topic of IT became the subject of one of the earliest 2010 follow-on studies. A final question involves whether it is possible to move to just an articulation of the future role of IT or some other technology without having done the broader industry-centric analysis of the future. We think not, because the forms technologies take and their reception in the marketplace are driven less by technical innovation and more by their cost and functionality. To be sure, this raises the age old debate about who the heroes of the Information Age are: the engineers who invented the computer or the business managers who bought the machines and thus made it possible for IT suppliers to pay the inventors a salary. However, as historians are increasingly demonstrating, it takes both to make IT evolve and for industry to use it effectively.[38,39]

CONCLUSIONS

Studies of the future state of an industry, science, or technology are becoming increasingly important in the development of a company's business strategy. The more volatile an industry, science, or technology becomes, the more essential such formal exercises are in contributing to the economic well-being of an organization. Methods now exist for creating future points of view that are creditable and that can lead to specific tactical action on the part of a company.

These are proving to be effective in galvanizing a company within its industry.

These studies take time and initiative. They require the attention and participation of senior management and experts at all levels of the organization, must be carefully coordinated in their development and launch, and must be managed with discipline and great seriousness. The future success of an organization, and its senior management, depends upon it.

Finally, we should realize that such an exercise is just the beginning of any strategic initiative because it does not tell an executive what to do after the future is mapped. Each organization is unique in terms of its history and starting point in the process. Thus, each company's future path will also be unique, but ultimately creation of an accurate roadmap will help make the journey successful.

ACKNOWLEDGMENTS

We thank the Life Sciences and Pharma team that worked on *Pharma 2005* and *Pharma 2010* and provided us with insights for this paper.

CITED REFERENCES AND NOTES

1. J. L. Gaddis, *The Landscape of History: How Historians Map the Past,* Oxford University Press, New York (2002), pp. 86–87.
2. M. M. Waldrop, *Complexity: The Emerging Science at the Edge of Chaos,* Simon & Schuster, New York (1991), p. 140.
3. D. J. Watts, *Six Degrees: The Science of a Connected Age,* W. W. Norton, New York (2003).
4. J. Spohrer, D. McDavid, P. P. Maglio, and J. W. Cortada, "Convergence and Coevolution: Towards a Services Science," to be published.
5. For example, see R. W. Oliver, *The Coming Biotech Age: The Business of Bio-Materials,* McGraw-Hill, New York (2000), pp. 7–25, 115–143.
6. *Peter Drucker on the Profession of Management,* N. Stone, Editor, Harvard Business School Press, Boston, MA (1998), p. 67.
7. R. E. Neustadt and E. R. May, *Thinking in Time: The Uses of History for Decision Makers,* Free Press, New York (1986).
8. M. E. Porter, *Competitive Strategy: Techniques for Analyzing Industries and Competitors,* Free Press, New York (1980).
9. C. M. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail,* Harvard Business School Press, Boston, MA (1997), pp. 187–206.
10. J. W. Cortada, *The Digital Hand: How Computers Changed the Work of American Manufacturing, Transportation, and Retail Industries,* Oxford University Press, New York (2004).
11. *Strategic Change,* IBM Institute for Business Value, http://www-1.ibm.com/services/strategy/.
12. A. Toffler, *Future Shock,* Random House, New York (1970), p. 1.
13. J. Naisbitt, *Megatrends: Ten New Directions Transforming Our lives,* Warner Books, New York (1982), p. 1.
14. R. Alcaly, *The New Economy,* Farrar, Straus and Giroux, New York (2003), p. 4.
15. For an example, see the approach taken by one futurist: Institute for Alternative Futures, http://www.altfutures.com/.
16. See the ABA Banking Online Journal, http://www.ababj.com/.
17. J. W. Cortada, *The Digital Hand: How Computers Changed the Work of American Financial, Telecommunications, Media and Entertainment Industries,* Oxford University Press, New York, to be published.
18. J. Kling, "From Hypertension to Angina to Viagra," *Modern Drug Discovery* **1**, No. 2, 31–38 (1998), http://pubs.acs.org/hotartcl/mdd/98/novdec/viagra.html.
19. *Pharma 2005: An Industrial Revolution in R & D,* PricewaterhouseCoopers, Basingstoke, UK (1998), reprinted by IBM Corporation (2002).
20. *Pharma 2005,* 3 volumes, PricewaterhouseCoopers, Basingstoke, U.K. (1998), reprinted by IBM Corporation (2002).
21. *Pharma 2010: The Threshold of Innovation,* IBM Corporation (2002), http://www-1.ibm.com/industries/healthcare/doc/content/resource/thought/390030105.html.
22. For a review of the profound role of science in this industry, see *Pharmaceutical Innovation: Revolutionizing Human Health,* R. Landau and B. Achilladelis, and A. Scriabine, Editors, Chemical Heritage Press, Philadelphia, PA (1999).
23. *Pharma 2010: Silicon Reality,* IBM Corporation (2004), pp. 1–4.
24. "Amgen's Star Performance," *SCRIP Magazine,* 35 (February 2004).
25. Our reference to "subcellular" alludes to systems biology, protein folding, and for some readers, might also need to include protein structure prediction. The first is often quite limited by the lack of sufficient experimental data to produce predictive models of the cell. Protein dynamics are only just now being subjected to computational analysis, but we predict more will occur over the next 10–15 years.
26. For example, if a biology professor developed a strain of grass that did not grow more than one inch and a manufacturer of lawn mowers was not aware of this activity, that firm could suffer a rapid decline in sales of this equipment as consumers rushed out to plant the new seeds.
27. *Expanding Meanings of Health,* Institute for the Future, Menlo Park, CA (January 2004).

28. S. A. Brown, *Revolution at the Checkout Counter,* Harvard University Press, Cambridge, MA (1997).
29. *A Risk-Based Approach to Pharmaceutical Current Good Manufacturing Practices (cGMP) for the 21st Century,* U.S. Food and Drug Administration, http://www.fda.gov/cder/gmp/.
30. A. Arundel, "Measuring the Economic Impacts of Biotechnology: From R & D to Applications," in *The Economic and Social Dynamics of Biotechnology,* J. de la Mothe and J. Niosi, Editors, Kluwer Academic Publishers, Boston, MA (2000), pp. 83–100.
31. J. Collins and J. I. Porras, *Built to Last: Successful Habits of Visionary Companies,* HarperBusiness, New York (1994).
32. A. Murray, *The Lisbon Scorecard: The Status of Economic Reform in the Enlarging EU,* Centre for European Reform, London, UK (March 2004).
33. The IBM Institute for Business Value has launched a study of the fundamental changes underway in the world of central governments, using the same techniques as those applied in other global industries such as retail and pharmaceuticals.
34. For a description of trends, see J. W. Cortada, "Learning from History: Leveraging Experience and Context to Improve Organizational Excellence," *Journal of Organizational Excellence,* 23–29 (Spring 2002).
35. The lag time between when a technology is viable to use and its adoption has existed for a long time in all industries and is an issue that has been studied. For example, see M. Albrecht, and J. W. Cortada, "Optimizing Investments in Information Technology," *National Productivity Review,* 53–60 (Summer 1998).
36. T. H. Davenport and L. Prusak, *Working Knowledge: How Organizations Manage What They Know,* Harvard Business School Press, Boston, MA (1998).
37. E. Lesser and L. Prusak (eds.), *Creating Value with Knowledge: Insights from the IBM Institute for Business Value,* Oxford University Press, New York (2004).
38. For a recent example of this kind of scholarship, see M. Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry,* MIT Press, Cambridge, MA (2003).
39. For an earlier study that addressed this issue directly, see J. W. Cortada, *The Computer in the United States: From Laboratory to Market, 1930 to 1960,* M. E. Sharpe, Armonk, NY (1993).

Accepted for publication August 26, 2004.
Internet publication January 13, 2005.

James W. Cortada
IBM Institute for Business Value, 3113 West Beltline Highway, Madison, Wisconsin 53713 (jwcorta@us.ibm.com). Dr. James W. Cortada is a researcher and team leader at the IBM Institute for Business Value, where he performs and directs research on the pharmaceutical and public sector industries, and on managerial issues related to the use of information technology. He is the author of over two dozen books on information technology. His most recent books include *Making of the Information Society* (Pearson, 2002) and *The Digital Hand: How Computers Changed the Work of American Manufacturing, Transportation, and Retail Industries* (Oxford University Press, 2004), the first of a three-volume set that will examine the IT activities of 45 industries. Dr. Cortada has been with the IBM Corporation for 30 years in a variety of sales, consulting, management, and research positions.

Heather E. Fraser
IBM Institute for Business Value, 76–78 Upper Ground, Southbank, London SE1 9PZ UK (hfraser@uk.ibm.com). Heather E. Fraser is a managing consultant at the IBM Institute for Business Value, where she performs and manages research projects on the life science and pharmaceutical industry. She has led a number of studies, authored publications, and spoken at conferences in the areas of investigational product supplies, recruiting patients to clinical trials, technology transfer, the future of the supply chain in the pharmaceutical industry, and focused manufacturing. By profession, Heather Fraser is a pharmacist and has over 20 years of experience in the pharmaceutical sector, having held positions in industry, consultancy, and retail pharmacy. ■