Research and Development (R&D) Management and Technical Expertise: Creating An Effective Managerial Environment for Maximizing Productivity

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While academic scholars and business leaders have focused a great deal of attention on maintaining the proper managerial environment for maximizing productivity in the research and development (R&D) process, the views of the scientists, who are the producers of research, are frequently given little attention. This paper addresses the issue of effective management in centralized corporate R&D laboratories of high-technology industries and suggests a number of management-based mediation strategies to foster organizational changes. Interviews with 72 scientists and 18 managers working in six corporate laboratories in 1996 and 1997 revealed a number of factors that are responsible for hindering the research enterprise at their companies. Scientists overwhelmingly identified managerial practices such as a philosophy of general management, the role of business in dictating research, de-emphasis on basic long-term research, and an increase in meetings as factors hindering effective research. Managers emphasized financial and market considerations such as the high cost of research and competitive pressures for the existing environment for research. Both groups agreed on the increasing difficulties they face in transferring research from the laboratory to product development and manufacturing.

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Introduction: Effective Management of the R&D Enterprise

In an era of global competitiveness, industrial R&D holds great promise for improving the nation's economic well being. The process of industrial R&D, in which scientific principles and properties of the natural world are transformed into commercial products and processes, consumes large amounts of resources (frequently over many years) before economic gains from product sales are realized.

Increasingly, corporate leaders seek managers who are leaders. Tichy and Devanna (1986) argue that transformational leaders are key components of successful companies. Such leaders are able to innovate, to implement change, to develop future goals for their organizations, and to inspire colleagues to join them in building that future. Parry (1999) identifies similar characteristics in corporate leaders, including being able to articulate desirable futures for the company, to set achievable goals, to implement actions to achieve those goals, and to act in a socially responsible and ethical way.

To develop better leaders, U.S. industry has been sending managers to various institutes such as the Center for Creative Leadership and the Center for Leadership Studies. There is some disagreement on the extent to which leadership can be taught and learned in a formal setting. For instance, essential elements of leadership such as curiosity, talent, charisma, and resonance are difficult to teach (Bennis 1993). Yet, most scholars agree that a significant part of leaders' growth comes from their work experience (Tichy & Devanna 1986). American companies, therefore, must focus on both - formal training and the work environment - to ensure that the process of innovation is a successful one.

One of the key issues with which corporate management must grapple is how to effectively manage scientists who perform research. Within the corporate structure of most R&D companies, this group occupies a unique position. They are often viewed differently from other employees, because they are perceived to be self-stimulating,

independent, and capable of giving direction to their own efforts. Scholars have proposed that managers must grant scientists the autonomy they need to be creative (Badawy, 1986; Shapero, 1985). Otherwise, scientists would experience a clash between their expectations and the opportunities available in the industrial setting (Bacharuch, Bamberger, & Conley, 1991; Raelin, 1991).

How can corporate management create a research environment that allows scientists to build on their strengths and let creativity emerge while at the same time ensure that research is both cost-effective over the long-term and directed towards products and processes that can be introduced into the marketplace? To address this issue, interviews were conducted with 72 scientists and 18 managers in six centralized corporate R&D laboratories of high technology industries in 1996 and 1997. Based on total R&D funds as a percentage of net sales and the number of R&D scientists per 1,000 employees, two corporate R&D laboratories were selected in each of the following industries: computers and office machinery, electronics-communications, and pharmaceuticals. Approximately 12 scientists and three managers from each laboratory who had been in the company for at least five years were interviewed.

Both scientists and managers were asked to identify and then rank factors that they believe to be responsible for the difficulties in performing research in their laboratories. In addition, scientists were asked what helps and hinders them from doing their research and what types of support would help them to be more productive in their research. Managers were asked about their main emphasis in improving the work environment in their companies and what changes they felt would make the laboratory more productive.

Factors Inhibiting Effective Management of the R&D Process

Table I summarizes the results of the interviews conducted for this study.

Table I

Perceived Obstacles to High Performance in Corporate R&D Laboratories

Obstacle	Number of Scientists Responding "Yes" N=72	Rank	Number of Managers Responding "Yes" N=18	Rank
-Emphasis on General gement	57	1	0	6
Ineffective Organizational Structure	48	2	2	5
Move to Business-Oriented Research	43	3	4	4
Too Little Emphasis on Long-Term Research	40	4	11	3
Inability to Transfer Research	37	5	15	2
Financial Market Pressure	27	6	18	1
Too Many Meetings	18	7	0	6

General Management: The Need for Technical Insight

Scientists overwhelmingly identified the philosophy of general management - the abstract body of knowledge largely independent of substantive fields generally taught in management schools (McGill, 1991) - as the major factor hindering research activities in their laboratories. During interviews, several disparaging remarks were made about what was termed the "general management syndrome", including "[mangers] don't understand research", "the technical sophistication [of managers] is lacking", "[managers] are not expert in [the] field" and "[managers] are good in assigning a price tag but don't have technical insight".

Unlike professional managers trained in a business school, centralized corporate laboratories have managers who

have a degree in science or engineering. Corporate management has created a managerial ladder for scientists who desire to be promoted to managerial positions (Raelin, 1991). However, once scientists become managers, they are encouraged to adopt general management skills. They are no longer involved in research; instead, they select projects, assign technicians, secure access to equipment, hire scientists and others, communicate between scientists and top management, do budgeting and fiscal planning, and maintain favorable working conditions.

Corporate laboratories represented in this study revealed that the immediate manager of scientists manages 5 to 10 scientists. The second and third levels of managers supervise approximately 25 and 50 scientists, respectively. According to scientists, as one keeps going up the hierarchy, the number of scientists being managed by managers increases. At the same time, the technical knowledge of managers about scientists' research decreases. Even when managers have the same background as scientists, their knowledge acquired earlier quickly becomes dated since managers are not involved in research.

Managers responded that they are unable to keep up with the scientific and technical contents of projects and spend time with scientists on substantive topics because they are overwhelmed with too much work not related to research. Managers identified legal rules and regulations, public relations, dealing with financial markets, and monitoring worldwide events in the industry as issues which occupy the great majority of their time. In addition, pharmaceutical managers spend considerable time learning standards and guidelines set by the Food and Drug Administration for marketing pharmaceutical products.

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shows a clear preference for insights that comes from "hands on" experience, interviews conducted for this study revealed that corporate management promotes a "hands off" philosophy. Such findings are consistent with the observations made by experts on the problems threatening U.S. technology (Hayes & Abernathy, 1980; Jacobs, 1991; Lieberman, 1988; McGill, 1988, Meek, Woodworth, & Dyer, 1988; Morone, 1993). A survey conducted by the National Science Board Committee on Industrial Support for R&D (National, 1991) stated that "general management practices" is one out of the two most important factors responsible for the erosion of U.S. technology leadership. Richard M. Cyert found that "industry today is saddled with people in top positions who do not understand technology" (Port, 1989, p. 16). For example, when the Palo Alto Research Center of Xerox Corporation invented an embryonic personal computer in advance of its rivals, the top management did not have the slightest grasp of what software was all about (Smith & Alexander, 1988).

A general management philosophy that a manager with a technical background can manage scientists from many disciplines is somewhat problematic for corporate R&D laboratories because managers should be able to make a technical assessment of the scientist's work before making funding decisions. As a group, managers are competent to manage the laboratory and allocate resources to various scientific projects. A manager cannot be expected to possess as much knowledge of particular areas as the scientists in those areas do. However, too wide a gap between scientists and managerial staff in project-specific knowledge tends to generate serious misunderstandings between the two groups. To make managers technically proficient, there should be greater interaction between managers and scientists on technical concerns. Periodic seminars or workshops in which scientists present their ideas informally can improve technical understanding of managers as well as communication between scientists and managers. Managers could create electronic work sites to promote technical conversation with scientists. They could plan Friday night

social events to interact with scientists. This could also enhance cross-disciplinary communication among scientists.

Inappropriate Organizational Structures: The Challenge for Front-line Managers

Closely linked to general management is the issue of inappropriate organizational structures. The most common form of organizational structure in most corporate R&D laboratories is a pyramid - scientists report to immediate managers who in turn report to still fewer managers until all lines merge to the senior executive of the R&D laboratory (Morone, 1993). Corporate laboratories in the pharmaceutical industry have more layers of managers than those in computer and electronics-communications industries. The idea behind the existing organizational structure is that planning work can and should be separated from doing work.

Scientists pointed out that the "rigid" communication imposed by a hierarchical organizational structure causes them to spend considerable time convincing layers of management to support their research projects. A second problem reported by scientists is that managers at higher levels are often "unable to understand" the particulars of a proposed or on-going project. Yet, a third problem is the number of people who have to be convinced to support a project. A "multi-layered review process" is seen as taking away valuable time that might be spent on research and preventing quick decisions.

Some managers also cited problems in the organizational structure. In corporate laboratories, information flows from top to bottom until it reaches the front-line managers. As information flows from one layer to the other, it tends to absorb the agenda of the individuals from whom it passes. Further, while goals are often clearly communicated, strategies to achieve these goals often are not. Managers find themselves in a position of having to develop strategies based on policy or other broad statements of senior management. Both scientists and managers view this "lack of clear

direction" from senior management as generating a vacuum that too often becomes filled with speculation and confusion. Although, in theory, scientists are encouraged to communicate directly with any manager if the need arises, in practice, scientists feel that they have to clear everything they do through successive layers of management.

Commentary. Rapidly changing business conditions have made it necessary for the corporations to anticipate rather than to react. R&D managers need to reach some consensus with senior managers on what the corporate R&D laboratory ought to be doing. R&D managers should communicate goals clearly to scientists. Once goals have been communicated, scientists should be allowed to formulate strategies to realize those goals. They should be left with their peers to work on the project with a potential target date because they have expertise and are committed to pursue their specialty. Managers should reduce layers of review process because they impede the progress. Instead of formal presentations and reviews, managers could rely on electronic technologies for instantaneous communication with other managers as well as with scientists.

Business Oriented Research: Scientists as Salesmen

Since the mid-1980s, corporate management in many R&D laboratories has been restructured to link research directly to development, engineering, and manufacturing (Varma, 1995). Earlier, technical interests dominated the link between research and business. Now, research is being carried out in the context of business interests (Jaskolski, 1996; Purdon, 1996). The balance of funding for corporate R&D has shifted from corporate sources to business divisions, which are more closely monitored through customer-contractor relationships (Edelheit, 1998; Myers & Rosenbloom, 1996,). This change in the funding source serves to enforce cooperation between research and business. Corporate laboratories in computers, office machinery, and electronics and communications are increasingly receiving

research contracts from corporate sponsors. Similarly, pharmaceutical companies have been shifting from prescription drugs to over-the counter business. In sum, companies are modifying products to fit customers' needs and concentrating on being the absolute minimum-cost producer.

This fusion of business and research, or what one respondent called "[scientists] thinking like businessmen," was of great concern to scientists interviewed for this study. A number of scientists bemoaned what they viewed as their laboratories becoming "overly dominated by business." Business divisions, which increasingly provide direct financial support for research activities, naturally support projects that are important to them. To scientists, this means that the focus of their activities increasingly becomes finding details about funding sources, discovering the needs of those who are funding the research, learning the language of business, building working relationships with several customers, and dealing with outside managers in addition to R&D managers.

R&D managers, on the other hand, pointed out that making a direct link between business and research is necessary to maintain their competitive edge in an increasingly competitive global market. Consequently, they now place emphasis on "focusing research on customer's needs" and "creating partnerships with business [divisions]." R&D managers expressed two concerns about this shift in funding. The first is that they believe decisions on projects are now made primarily by business divisions. Second, they think that business managers rely mostly on their interaction with R&D to show how business works, rather than spending Time educating R&D managers on business concepts.

Commentary. Lack of commercial guidance in most centralized corporate R&D laboratories in the past has resulted in decentralization of research to business divisions (Edelheit, 1998; Myers & Rosenbloom, 1996; Purdon, 1996; Varma, 1995). R&D managers could improve communication links between the laboratory and business

divisions by using computer technology and telecommunications so different groups can work together on a project. Further, R&D managers could allocate some time, perhaps one day a week, to scientists to work on creative ideas. This would satisfy scientists' intellectual curiosity as well as would not disrupt profit and margin. Along with learning business values on-the-job, R&D managers should go through some classroom training so they can feel more in control.

De-Emphasis on Long-term Research: Scientists as Firefighters

Scientists interviewed for this study noted a declining emphasis on basic long-term research. As market-driven R&D has shifted the focus from fundamental research towards business-oriented development, many scientists view themselves as "firefighters" - being called on to quickly solve existing problems quickly instead of developing theoretical research which may have applications in the future.

Since the mid-1980s, research projects that are risky and Long-term have been terminated in most corporate R&D laboratories (Cahners, 1997). Funding is being shifted away from high cost projects with uncertain payoffs to the development of more short-term - and more profitable – technologies. Even the chemicals industry, which has in the past been theory-based, has been cutting back on risky research and limiting experimentation because of a falling rate of innovation, flat sales, and intense competition (Achilladelis, Schwarzkopf, & Cines, 1990). Corporate laboratories studied for this project revealed that pharmaceutical manufacturers are placing greater emphasis on repackaging of existing compounds, while computer companies have shifted to information science instead of doing basic research in computers.

Scientists and managers pointed out that since funding for research is coming directly from business divisions of companies, research is more frequently linked to the needs of those divisions. Usually, they are interested in addressing

specific questions for their immediate needs and expect to see a return on their investment in a short time. They have neither the time nor the desire to consider the long-range needs of their business. Most managers interviewed also expressed concern that research funds are not supporting the work that goes beyond the immediate needs of business divisions.

Commentary. There is a general agreement among business leaders, academic scholars, and policy makers that U.S. industry must support research to develop new products and processes that would open new markets or restructure old ones (Academy, 1990). They think that corporate R&D laboratories need to support some research in new areas even if it is a high-risk path to follow. Otherwise, overseas competitors will have the opportunity to outpace their U.S. rivals as domestic companies lose the scientific edge necessary to develop new products and processes. Scholars have shown that an increase in the company's rate of productivity is directly related to the level of long-term R&D (see Griliches, 1984). Morone (1993) finds that successful firms are whose corporate strategies are shaped by technology opportunities. However, interviews show that managers are driven by short-term goals even when such a perspective is in conflict with some of their aspirations of building a good quality research organization.

Because the long-term competes for the resources with the short-term, R&D managers need to set some funds aside for research that does not fit into the existing products and processes, but still is within the company's goals. Since support for long-term might disrupt profit and loss records, a sub unit needs to be operated which would attract scientists to work on the cutting edge of their fields. Managers have to take risks and support long-term projects until it becomes evident that they are no longer promising. One manager speaking out that a laboratory must support a long-term project might make the difference.

Failure to Transfer Research: The Constant Battle to Integrate Research and Manufacturing

By supporting corporate R&D laboratories, companies have successfully transformed themselves. By the mid-1980s, however, it appeared that not all research conducted in corporate R&D laboratories was being successfully transferred or used by the companies that invested in research (Dertouzos, Lester, & Solow, 1989; Smith & Alexander, 1988). Instead, foreign suppliers have been meeting the demand for high technology products both in the U.S. and overseas (Reich, 1988). One reason for American inventions being coupled with Japanese control of the market is the connection between research and innovation, which is based on a linear model (Thurow, 1992). In most corporate R&D laboratories, scientists generate new facts and theories, which is followed by applied research for testing. Finally, research is transferred to development for conversion into products and processes. With shorter product life cycles, more emphasis is needed on decreasing the time between invention and product development.

Scientists and managers interviewed have come to view the "assembly line" model of research and manufacturing as a serious barrier to innovation. Both scientists and managers pointed out numerous obstacles in transferring technology from corporate R&D in highly diversified companies. They felt that knowledge produced at the laboratory is too far advanced for use by business divisions. If the product development process lags too far behind, advanced research ideas have limited scope. Further, scientists' research usually suggests changes or replacements of products and processes, which are rather expensive. Even though existing technology is outmoded, it frequently cannot be abandoned because R&D costs have not been fully recouped.

According to scientists and R&D managers, business divisions are often hesitant to try new technology because they perceive it to be disruptive to their demanding routine. Often, the opportunity which scientists and managers see in

new technology is not the same for business managers. R&D managers feel business divisions lack technicians and workers who could operate new technology. Due to such problems, R&D managers think that it is rather difficult to convince business managers to accept developed technology. Some scientists felt that R&D managers lack business and communication skills that are needed to sell new technology to business managers. In pharmaceutical laboratories, for example, one of the major problems in manufacturing a drug is that many compounds die in the clinical testing due to the rigorous testing guidelines set by the Food and Drug Administration.

Commentary. These findings support studies conducted by Sheth and Ram (1987) and Souder and Padmanabhan (1989) on barriers in transferring technology from corporate R&D. Their findings are based on empirical work conducted in manufacturing divisions, which identified the problems in receiving the technology. Interviews with scientists and managers showed similar problems in supplying the developed technology.

For a successful technology transfer, R&D managers must understand the organization and inner workings of the business divisions. Constant interaction with the business divisions would help ensure that business managers see the same opportunities in the proposed work as do the scientists and R&D managers. In addition, R&D managers should foster communication between the scientists and the business division that would make use of the research. Recruiting someone from the business division to help facilitate the transition would show that R&D managers are not relying solely on the scientists' justification that the work is beneficial.

Increasing Financial Pressures: The Search for the Bottom Line

All 18 managers interviewed for this study regarded a constricting financial climate as not being conducive for high-quality research. Scientists also acknowledged that financial

pressure tends to constrict managerial decisions. Both groups pointed out the increasing expense of research and a commensurate emphasis on efficiency within their organizations. The implication of this restrictive fiscal climate is that while managers believe in a long-term research policy, they are unable to pursue it. In the existing financial market, it is difficult to undertake long-term projects because investors in equity markets demand return on their investment in a short time. Further, senior management is making cuts to reduce outstanding debt on companies. This leads managers to support short-term projects that will make immediate economic gains. In contrast, long-term scientific research is risky because there may not be much to show on paper for some years.

In this environment, support for long-term projects Is likely to lead to a drop in profit and stock prices. R&D managers think only by making things work in the short term will they be able to support some long-term projects in future. They also pointed out that the cost of capital for R&D projects in the United States is far higher than it is in other major industrial countries. They think that U.S. companies do not invest heavily in research because government does not give tax incentives. Further, they face a shortage in the scientific workforce and thus pay high salaries.

Some scientists also felt that R&D managers are cautious of taking risks on long-term projects because such a risk may have a significant effect on their promotion if the projects are not successful. According to them, managers' performance are evaluated on short-term financial gains. Further, they like to move up the managerial ladder within a short time period. If they initiate a research project, which is likely to take more than five years, then senior management will not view their performance favorably and their successor will get the rewards. Such issues leave little incentive for managers to support research for the development of new products and processes.

Commentary. Hayes and Abernathy (1980) criticized the new management orthodoxy that puts greater

dependence on short-term return on investment in evaluations of the performance of individual managers. They believe an environment that does not unduly penalize failure best encourages innovation. Interviews show that managers themselves admit that they are preoccupied with quarterly earnings and stocks prices that tend to distract them from achieving long-term goals.

Managers need to be liberated from short-term fluctuations in earnings because long-term investment and careful planning are good for the company and the American society. They need to think how to survive over the long run in the global competitive environment. Their central emphasis should be producing technologically superior products and processes, and not companies' earnings. They need to look at the balance sheet after some progress has been made in producing a new product or a process. They need to take a pride on what they and their scientists have been innovating. Managers should develop a deep sense of loyalty to the company. When something goes wrong, they should evaluate factors affecting productivity instead of moving to a new job.

Frequency of Meetings: Time as a Zero Sum Game

Meetings between scientists and managers are carried out to exchange ideas, clarify company goals, evaluate projects, and review progress. However, scientists interviewed expressed concern about the frequency and agenda of managerial meetings. They complained that managers are "hooked on meetings" and referred to a "meeting addiction." Time is a zero-sum game: there is a finite amount of time and if managers win by having meetings then scientists lose by losing research time. Scientists feel that there is too much work and very little time; so they are concerned with the number of meetings and the purpose they serve. With ongoing changes in the funding system, scientists have to spend a significant amount of time doing marketing for their projects to acquire funds from business managers and sell their ideas to both R&D as well as business managers.

People who have to be convinced about the importance of projects have different interests and they look for different things. So scientists have to change their presentations accordingly. In other words, several meetings with different presentations are involved in getting support for a single project. Since scientists frequently work on more than one project at a time, the amount of time spent on such activities is significant.

Commentary. Meetings between managers and scientists are the simplest way to interact. However, managers must consider whether there is a need for a particular staff meeting. Further, meetings should be short, infrequent, and regular. They need to be efficiently run with a specific agenda. Meetings about administrative details such as policy changes in the laboratory, in the security system, and in the service departments should be settled via e-mail or handouts.

Where Do We Go Next?

The United States operates in a global economy in which nearly 70% of the goods produced in the country compete with merchandise from abroad. Major industrialized countries have challenged the preeminence of American leadership in high-technology goods. Some have blamed the high cost of capital and inflation, as well as lack of work ethics. Others have cited government policies such as regulatory policy, product liability laws, and occupational health and safety regulations. Critics of U.S. industry have argued that the most important cause of deteriorating industrial performance is the management failure. Reich (1988) criticizes the paper entrepreneuralism of managers in rearranging assets on paper to improve cash flow, instead of enlarging the economic pie. The MIT commission on Industrial Productivity charged that management is far too preoccupied with short-term results and quick profits, slowed up by outdated strategies, firmly attached to parochial technologies based on yesterday's mass production, and profligate with human resource (Dertouzos, Lester, & Solow,

1989). Corporate management has also come to believe that international differences in competitiveness have been affected by factors other than the economic environment and government policies, such as management styles.

Successful innovations need to have the right social network in place. Some networks of social relations between managers and scientists are more applicable than others. The principles on which managers rely to manage scientists emphasize manage-by-the-numbers formulas and traditional corporate structures. Management's primary role in corporate R&D has become to be a judge of scientists, a financial planner of projects and an accountant for the research. However, for corporate R&D laboratories to succeed, managers need to a) be "technically astute" to understand ideas and results produced by scientists, b) assess feasibility and potential marketability of technical ideas, c) translate good technical proposals to potentially marketable ones, d) communicate general corporate goals and strategies to the scientists, in particular, e) translate them concretely into the goals of their groups, and f) serve as a link between scientists and those of business divisions. Because managers are in a position to make organizational changes, they need to initiate a number of human resource mediation strategies to make corporate R&D more productive.

There is a need to de-emphasize general management philosophy and hierarchy as the essential skills and features for running corporate R&D; instead, emphasis should be placed on technical and human managerial skills that are necessary to understand the organization and its people. Managers need to establish links with scientists on technical and social matters. Periodic seminars, workshops, informal gatherings, high-speed electronic media, and computer technology could promote

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managerial knowledge of scientists' research. Managerial meetings involving evaluations and reviews of projects should be changed to technical planning meetings to expedite research efforts by removing roadblocks. Managers should have open offices close to scientists so scientists can interact freely with them. Traditional isolated manager suites convey rank and tend to cutoff the links between managers and scientists. Managers should favor teamwork with scientists over hierarchy. A more casual business attire on the part of R&D managers might help to break down some of the hierarchical barriers that often exist and to foster a more team-like environment. To improve working environment, managers could create a web where scientists could post their suggestions anonymously.

Because research has not generated financial gains for the companies, top management of many leading high-technology companies has been involved in restructuring the laboratory to directly link research to business division (Buderi, 1998; Edelheit, 1998; Jaskolski, 1996, Myers & Rosenbloom, 1996; Purdon, 1996; Ransley, 1997; Varma, 1995). Consequently, scientists have become aware of business needs and the business managers have become familiar with scientific expertise available to them. Scientists acquiring funds from business divisions by linking their research to the needs of those divisions has enhanced communication and improved the link between corporate R&D laboratory and the company's business divisions. However, this has decreased the likelihood of major breakthroughs occurring in technological innovation, or new products and processes being developed for which new markets can be created. R&D success is built on accumulating detailed technical knowledge of products and processes, and it is rarely an outcome of sudden breakthroughs. Continued short-term goals for corporate R&D are making investment in R&D an exception instead of a norm and causing a concern among scientists as well as managers.

R&D managers could implement a number of human capital strategies to make long-term research the focal point

of their laboratory, but not the only point. First, they have to fight for reallocating resources for long-term research and then work to protect such programs. They have to declare that it is more important to support research than to look at the bottom line. Second, managers should create a small sub unit within the company that will focus on the emerging markets rather than on the development of products and processes for existing markets. They should staff the unit with scientists whose careers would depend on its success. Third, they should clarify to scientists that long-range research should be business-driven instead of science-driven. Scientists have to advance scientific knowledge upon which business could capitalize. Fourth, they have to let scientists establish links and form alliances within the company as well as outside with the frontiers of science. Technical advances in electronic communications now allow Scientists to rapidly transfer of ideas and knowledge worldwide. Fifth, managers need to lobby for tax credits so their companies can have incentives for long-term research.

Scientists and managers' involvement in issues that are central to the future of their company is not going to lead automatically to commercial success. Scientists' research results have to be converted into products and processes, which have to be brought to market before competitors. Scientific knowledge alone cannot be a basis of business success. Managers have to establish a social network between the laboratory and business using various methods. Managers could create a new communication system in which people from different groups including research and business divisions get together for a day or two for sharing and learning. Mangers should make sure that such system has a minimum structure and very few formal presentations so participants could focus on issues central to the company. Similarly, managers could hold regular workshops aimed at developing a more entrepreneurial mindset for scientists and more appreciation for research mindset for business people. Managers could design a checklist that would show when research and business are real partners, when they are aligned, and when they are detached.

Finally, the best scientist-based mitigation strategy is having scientists decide mutually with their managers what the goals for their research are, how long would it take to meet the stated research goals, and what criteria should be used to evaluate the performance. Similarly, scientists with their managers need to establish an electronic network within their laboratory, with other departments, with business divisions, and with the outside environment. Without such a network, scientists may end up losing sight of the latest frontier in science and the changing needs of the business divisions.

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References

Academy Industry Program. (1990). *Corporate restructuring and industrial research and development*. Washington D.C.: National Academy Press.

Achilladelis, B.G., Schwarzkopf, A., & Cines, M. (1990). The dynamics of technological innovation: The case of the chemical industry. *Research Policy*, 19(1), 1-35.

Bacharuch, S.B., Bamberger, P., & Conley, S.C. (1991). Negotiating the 'see saw' of managerial strategy: A resurrection of the study of professionals in organizational theory. *Research in the Sociology of Organization*, 8, 217-238.

Badawy, M.K. (1986). How to prevent creative mismanagement. *Research Management*, 29(4), 28-35.

Bennis, W.G. (1993). *An invented life: Reflections on leadership and change*. Reading, MA: Addison-Wesley.

Buderi, R. (1998). Xerox R&D managers learn to build business value into their products. *Research Technology Management*, 41(3), 9-11.

Cahners Research. (1997). *Research and development's basic research survey*. Des Plaines, IA: Cahners.

Dertouzos, M.L., Lester, R.K., & Solow, R.M. (1989). *Made in America*. Cambridge, MA: MIT Press.
Edelheit, L.S. (1998). GE's R&D strategy: Be vital. *Research Technology Management*, 41(2), 21-27.
Griliches, Z. (Ed.). (1984). *R&D, patents and productivity*. Chicago: University Press of Chicago.
Hayes, R.H. & Abernathy, W.J. (1980). Managing our way to economic decline. *Harvard Business Review,* 58(4), 67-77.
Jacobs, M.T. (1991). *Short-term America*. Boston: Harvard Business School Press.
Jaskolski, S.V. (1996). New role for R&D: The challenge of growth. *Research Technology Management*, 39(6), 13-18.
Kerr, S., Glinow, M.V., & Schriesheim, J. (1977). Issues in the study of professionals in organizations: The case of scientists and engineers. *Organizational Behavior and Human Performance* 18, 329-345.
Lieberman, E.D. (1988). *Unfit to manage*. New York: McGraw-Hill.
McGill, M.E. (1991). *American business and the quick fix*. New York: Henry Holt.
Meek, C., Woodworth, W. & Dyer, W.G. (1988). *Managing by the numbers*. Reading, MA: Addison-Wesley.
Morone, J. (1993). *Winning in high-tech markets*. Boston: Harvard Business School.
Myers, M.B., & Rosenbloom, R.S. (1996). Rethinking the role of research. *Research Technology Management*, 39(3), 14-18.
National Science Board. (1991). Why U.S. technology leadership is eroding. *Research Technology Management*, 16(2), 441-452.
Parry, K.W. (1999). Short take: The case for organizational leadership audits. *Management Development Forum*, 2(1), 133-141.
Port, O. (1989, October Special Issue). Back to basics. *Business Week*, 4-18.

Purdon, W.A.B. (1996). Increasing R&D effectiveness: Researchers as business people. *Research Technology Management*, 39(3), 14-18.
Raelin, J.A. (1991). *The clash of cultures: Managers and professionals*. Boston: Harvard Business School Press.
Ransley, D.L. (1997). Assessing the R&D-business relationship. *Research Technology Management*, 40(4), 12-18.
Reich, R. (1988). *The next American frontier*. New York: Times Books.
Shapero, A. (1985). *Managing professional people*. New York: Free Press.
Sheth, J.N., & Ram, S. (1987). *Bringing innovation to market: Breaking the corporate and customers barriers*. New York: Wiley.
Smith, D. & Alexander, R. (1988). *Fumbling the future: How Xerox invented, then ignored, the first personal computer*. New York: William Morrow.
Souder, W.E., & Padmanabhan, V. (1989). Transferring new technologies from R&D to manufacturing. *Research Technology Management*, 32(5), 38-43.
Tichy, N., & Devanna, M.A. (1986) *The transformational Leader*. New York: Wiley.
Thurow, L. (1992). *Head to head*. New York: William Morrow.
Varma, R. (1995). Restructuring corporate R&D: From autonomous to linkage model. *Technology Analysis & Strategic Management*, 7, 231-247.

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