SPECIAL ARTICLE

RELATIONSHIPS BETWEEN ACADEMIC INSTITUTIONS AND INDUSTRY IN THE LIFE SCIENCES — AN INDUSTRY SURVEY

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Abstract *Background.* Despite growing acceptance of relationships between academia and industry in the life sciences, systematic, up-to-date information about their extent and the consequences for the parties involved remains scarce. We attempted to collect information about the prevalence, magnitude, commercial benefits, and potential risks of such relationships by surveying a representative sample of life-science companies in the United States to determine their relationships with academic institutions.

Methods. We collected data by telephone from May through September 1994 from senior executives of 210 life-science companies (of 306 companies surveyed; response rate, 69 percent). The sample contained all Fortune 500 companies in the fields of agriculture, chemicals, and pharmaceuticals; all international pharmaceutical companies with sales volumes similar to those of the Fortune 500 companies; and a random sample of non–Fortune 500 companies in the life sciences drawn from multiple commercial and noncommercial directories. Both the survey instrument and the survey methods resembled those of our 1984 study of 106 biotechnology companies, allowing us to assess the evolution of relationships between academia and industry over the past decade.

Results. Ninety percent of companies conducting life-science research in the United States had relationships involving the life sciences with an academic institution in 1994. Fifty-nine percent supported research in such institutions, providing an estimated $1.5 billion, or approximately 11.7 percent of all research-and-development funding received that year. The agreements with universities tended to be short-term and to involve small amounts, implying that most such relationships supported applied research or development. Over 60 percent of companies providing support for life-science research in universities had received patents, products, and sales as a result of those relationships. At the same time, the companies reported that their relationships with universities often included agreements to keep the results of research secret beyond the time needed to file a patent. From 1984 to 1994, the involvement of industry with academic institutions has increased, but the characteristics of the relationships have remained remarkably stable.

Conclusions. After more than a decade of sustained interaction, universities and industries seem to have formed durable partnerships in the life sciences, although the relationships may pose greater threats to the openness of scientific communication than universities generally acknowledge. However, industrial support for university research is much smaller in amount than federal support, and companies are unlikely to be able to compensate for sizable federal cutbacks. (N Engl J Med 1996;334:368-73.)

RELATIONSHIPS between academic institutions and industrial organizations have again become a topic of lively policy debate in the life sciences. As in the early 1980s, policy makers interested in reducing federal expenditures are suggesting that with the proposed cuts in funding for the life sciences, sponsorship by industry may be a substitute for government support.[1-3]

This idea may seem somewhat less radical now than it did a decade ago. The academic community involved in the life sciences is much more comfortable today with relationships with industry than it was in the early 1980s.[4,5] This level of comfort, however, does not seem to be based on systematic knowledge.[6] There are very scant empirical data about the prevalence of relationships with industrial concerns, their characteristics, or the risks and benefits for the parties involved. With this in mind, we recently surveyed a representative sample of 210 domestic and international life-science companies to determine their involvement in academic–industrial relationships in the United States.

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METHODS

We drew our sample from a comprehensive list of private firms conducting business in the life sciences in the United States. Our list included all biotechnology firms in published directories[7-9]; firms that received Small Business Research Program awards from the federal government for life-science projects from 1985 through 1992[10,11]; firms that had Cooperative Research and Development Agreements in the life sciences with the federal government[12]; all Fortune 500 companies for 1992 in the fields of agriculture, chemicals, and pharmaceuticals; and all internationally based pharmaceutical firms with U.S. operations and annual sales at least equivalent to those of the smallest Fortune 500 companies. This comprehensive list included a total of 73 Fortune 500 companies; 1315 smaller, non–Fortune 500 companies; and 30 international pharmaceutical companies.

To be eligible for the survey, a firm had to conduct or sponsor research in the life sciences. Eligibility was determined in screening interviews with representatives of each firm. Before screening, the sample contained all the Fortune 500 and international pharmaceutical companies and a random sample of 336 non–Fortune 500 companies. The screening yielded a final eligible sample of 66 Fortune 500 companies, 211 non–Fortune 500 companies, and 29 international pharmaceutical companies. The people interviewed were most often senior executives with administrative responsibilities for research and devel-

opment, such as chief executive officers and vice-presidents in charge of research and development.

The survey was conducted over the telephone from May through September 1994 by interviewers from the Center for Survey Research of the University of Massachusetts. Among 306 companies surveyed, the representatives of 210 completed the interview (overall response rate, 69 percent). Table 1 shows the characteristics of the firms in the sample.

Except as noted otherwise, the statistics reported here are weighted to reflect the oversampling of the Fortune 500 and international pharmaceutical companies. The medians, ranges, proportions, frequencies, and totals reported are based on actual responses to the survey questions; firms that did not answer a question were excluded from the analysis of the responses to that question. Medians are presented in Tables 1 and 2 rather than means because there were skewed distributions. For all proportions, we report 95 percent confidence intervals. The statistical significance of differences between medians was calculated by the median test. P values of 0.05 or less were considered to indicate statistical significance.

RESULTS

Characteristics of Relationships between Industry and Academia

As Figure 1 shows, over 90 percent of life-science companies in the United States had some relationship with academia. The most prevalent type of relationship involved the use of university faculty members as consultants (88 percent). More than half of life-science companies (59 percent) supported university research, and 38 percent participated in training by supporting the education of students and fellows through grants, fellowships, or scholarships. About half the companies that supported university research supported clinical trials along with other research; 2 percent supported only clinical trials. Although they were not the most prevalent form of relationship between academia and industry, those involving research were among the most important, especially to academic institutions, because they provided resources to support ongoing investigations by faculty and trainees. Therefore, the balance of this paper concentrates on relationships involving research.

The respondents to our survey reported that their companies supported more than 1500 academic research projects in 1994, at a cost of over $340 million. In industry as a whole, we estimate that in 1994 companies funded more than 6000 projects and expended nearly $1.5 billion for academic research in the life sciences. The National Institutes of Health (NIH) has estimated that institutions of higher education received approximately $10.7 billion from nonindustrial sources in 1993 to support life-sciences research.[13] If we assume a 5 percent increase from 1993 to 1994 and add to it our estimate of industrial support in 1994, we project that in all, extramural support of academic research in the life sciences — from inside and outside industry, and provided to both universities and affiliated nonprofit organizations — accounted for $12.8 billion in 1994. Of this, industry provided $1.5 billion (11.7 percent). The National Science Foundation estimates that in 1993 industry supported 7 percent of university research and development in all scientific fields.[14]

Because of economic pressure on pharmaceutical manufacturers and other life-science businesses, questions have arisen about whether these companies will reduce overall expenditures for research and development, and for research relationships in particular. Two thirds of respondents whose companies had such relationships said that they expect to increase their support of life-science research greatly or somewhat over the next five years through agreements with U.S. academic institutions. Only 7 percent expected their support to decrease.

The responses to our survey suggested that research relationships tend to be brief and limited in size. Seventy-one percent are funded at less than $100,000 a year. Only 6 percent of responding firms provide annual funding of $500,000 or more. For 84 percent of respondents whose firms have relationships with academia, the typical relationship lasts two years or less (Fig. 2). The generally short duration of the relationships and the small amounts of funding involved suggest that the research they support tends to be targeted — that is, applied rather than fundamental.

Nevertheless, given that industrial firms support many projects, the small percentage of projects that are large or long-lasting represents a considerable number. For example, we estimate that in 1994 industries supported approximately 280 academic research projects funded at $500,000 a year or more. Similarly, 6 percent of companies supporting academic research reported that their agreements typically lasted more than three years. Arrangements of this size or length[15] undoubtedly involve research that is quite fundamental.

Benefits to Companies

More than 60 percent of companies investing in academic research have realized patents, products, and

Table 1. Characteristics of the Firms in the Study Sample.*

CHARACTERISTIC	LARGE FIRMS	SMALL FIRMS
1994 sales, life sciences		
No. of firms responding	61	120
Sales (millions of $)		
Median	900	2
Range	0–10,000	0–550
1994 research-and-development budget, life sciences		
No. of firms responding	60	126
Budget (millions of $)		
Median	45	1
Range	10–2300	0–100
Full-time employees		
No. of firms responding	68	136
No. of employees		
Median	13,500	63
Range	3–250,000	1–9000
Date firm founded		
No. of firms responding	68	137
Year		
Median	1936	1983
Range	1837–1990	1867–1994

*A large firm was defined as a Fortune 500 firm or an international pharmaceutical firm of equivalent size. A small firm was any other firm studied. Because not every question was answered by every firm, the numbers of firms do not total 210.

sales as a result (Fig. 3). Using data on companies' overall numbers of patents and products in the past five years, on patents, products, and sales resulting from investments in research, and on the firms' investments in university and nonuniversity research over the same period, we calculated the numbers of patents issued and products developed for each $10 million invested. Sponsorship of university research produced returns in patents, products, and sales per dollar invested that did not differ significantly from the return on investments in research conducted elsewhere.

Although research relationships with academic institutions can produce benefits with immediate commercial value, industries perceive themselves as depending on the academic sector more for access to ideas, knowledge, and talented potential researchers than for specific marketable products or services. Fifty-six percent of companies with research investments depend very much or at least somewhat on faculty members to "keep staff current with important research," 53 percent depend on them to provide ideas for new products, and 37 percent depend on them to aid in recruiting able researchers. Only 29 percent of companies reported that they depend somewhat or very much on faculty members to invent products that the company will license.

Difficulties of Collaboration

We asked the company representatives whether they had encountered any problems in their relationships with academic organizations that had the potential to disrupt the relationship or the negotiations leading to it. The most common obstacles cited were university bureaucracies that made it too complicated to conclude an agreement (mentioned by 54 percent of firms) and university regulations that interfered with the negotiation or contract (49 percent). Thirty-four percent of companies reported having disputes with their academic partners over intellectual property. Thirty-three percent said that changes in the direction of academic research had reduced its usefulness to the sponsoring company. Thirty percent reported that conflicts of interest had developed when the academic institution became involved with another company. Twelve percent reported concern that there had been misconduct in research or questionable scientific practices on the part of academic scientists.

Because academic institutions had attempted to improve their management of research relationships by instituting new policies regarding conflicts of interest and other matters, we asked the representatives of companies whether specific types of policies had "ever prevented your firm from developing a research relationship." Only 14 percent cited regulations designed to prevent conflicts of interest among faculty members,

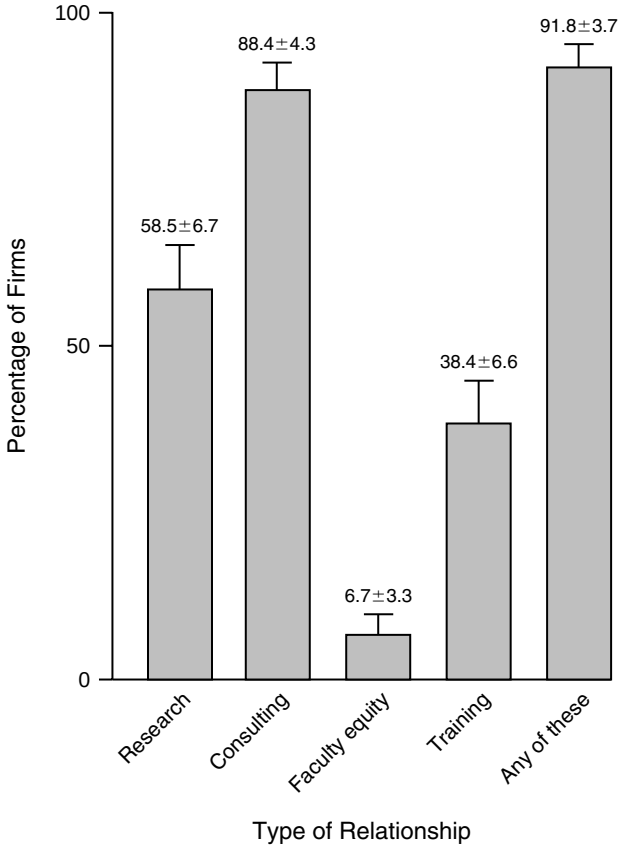

Figure 1. Prevalence in 1994 of Various Types of Relationships between Academic Institutions and Industry.
Values are percentages ± half of the 95 percent confidence intervals.

Table 2. Comparison of Patents, Products, and Sales Resulting from University Research Supported by Industry with Those Resulting from Industry-Supported Research Elsewhere, during the Five Years Preceding the Study.*

Return on Investment in Research and Development (per $10 million)	Large Firms	Small Firms
Patents		
No. of firms responding	37	53
Median no. of patents		
Academia	1.7	6.7
Elsewhere	1.2	3.5
P value	0.488	0.082
Products		
No. of firms responding	36	53
Median no. of products		
Academia	5.0	26.8
Elsewhere	1.4	27.9
P value	0.620	1.0
Sales		
No. of firms responding	28	54
Median sales (millions of $)		
Academia	18.3	22.0
Elsewhere	88.0	29.5
P value	0.112	0.702

*A large firm was defined as a Fortune 500 firm or an international pharmaceutical firm of equivalent size, and a small firm as any other firm studied. P values were derived by the median test of the difference between the value for research by academic institutions and that for research outside such institutions.

and only 6 percent cited requirements that the financial interests of faculty members be disclosed publicly.

Withholding of Data

We asked the representatives about their companies' policies and experience regarding the confidentiality of data emerging from academic research. Among those whose companies supported research relationships with academic institutions, the great majority (82 percent) said that their companies sometimes require academic researchers "to keep information confidential to allow filing of a patent application." Such a requirement is standard practice at most academic institutions.

Nearly half the respondents (47 percent), however, said that their agreements with universities have occasionally required academic institutions "to protect confidential proprietary information resulting from the research that your company sponsors longer than is necessary to file a patent application." More than half (56 percent) said that in practice, the research they support in universities often or sometimes results in information "that is kept confidential to protect its proprietary value beyond the time required to file a patent." Finally, 58 percent stated that their companies typically require academic investigators to keep information confidential for more than six months in order to file a patent application. The NIH has indicated in recent policy statements that 30 to 60 days is a "reasonable" period to delay the release of information while such an application is being filed.[16]

We asked respondents what types of information, in their experience, had actually been kept confidential beyond the time needed to apply for a patent. Seventy-two percent replied that such data had occasionally involved "know-how useful to the production of a product [or] . . . to commercialization of a process." Fifty-six percent said that the information had involved experimental methods; 53 percent, a plan for future experimentation; 27 percent, a gene product; 25 percent, a gene sequence; and 12 percent, the location of a gene (Fig. 4).

Graduate students and postdoctoral fellows may be particularly affected by industry policies on secrecy, because they may rely on the prompt publication of research findings in order to secure their first jobs after completing their studies. Approximately 57 percent of companies engaged in research relationships with academic institutions reported that confidential, proprietary information sometimes or often emerges from their sponsorship of graduate students and postdoctoral fellows; 88 percent reported that their arrangements require students and fellows to keep such information confidential.

Changes over the Past Decade

A comparison of data from the current study with those from our 1984 study of 106 biotechnology companies[17] permits an examination of some trends in industrial support of academic research in the life sciences over the past 10 years. Firms used academic consultants and supported the training of graduate students and postdoctoral fellows at similar rates in 1984 and 1994 (90 percent vs. 88 percent and 38 percent vs. 38 percent, respectively). After adjusting our 1994 sample to make it more comparable to the 1984 sample (by eliminating international pharmaceutical companies and companies supporting only clinical research), we found that life-science firms were significantly more likely to support academic research in 1994 than in 1984 (57 percent vs. 46 percent, $P = 0.05$).

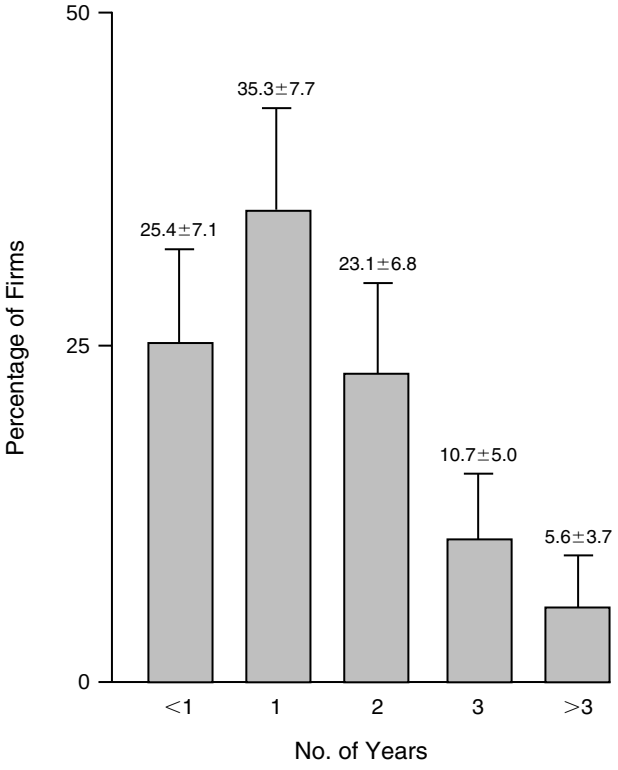

Figure 2. Duration of Research Relationships between Academic Institutions and Industry Involving the Life Sciences, 1994. Values are percentages ± half of the 95 percent confidence intervals.

In both 1984 and 1994, research agreements tended to be limited in scope and short in duration. In 1984, 72 percent of companies reported that their typical research relationship with academia lasted two years or less, whereas 84 percent of companies made such statements in 1994 ($P = 0.12$). In 1984, 63 percent of research contracts were for amounts under $50,000, whereas in 1994, 71 percent were for amounts under $100,000 (the equivalent in buying power to $63,000 in 1984, after deflation with use of the NIH Biomedical Research and Development Price Index) (Schuttinger J, NIH: personal communication). No comparable data are available with which to explore changes in very large, long-term relationships.

Discussion

Our data indicate that participation by life-science companies in relationships with academic institutions

generally, and in relationships involving research particularly, was common in both 1984 and 1994 and seems to have become more frequent over the intervening decade. Evidence of the persistent and even growing support of university activities by industrial firms contradicts a view commonly held early in the biotechnology revolution — namely, that life-science companies would retreat from relationships with academia when they became more familiar with the new techniques of biologic research created in American universities during the late 1970s and early 1980s.

A commonly held view is that industry supports academic research because of immediate commercial benefits. Both our previous research and our current data are generally consistent with this view. University research appears roughly similar in productivity to investments in research elsewhere. On the basis of these measures of commercial return, industries in the life sciences would appear to have no reason to reduce spending on academic research sooner or more sharply than they would reduce research-related spending in nonacademic sites.

The evidence that short-term commercial returns are not the only or the predominant reason that life-science companies participate in research investments should also be reassuring to universities. In both 1984 and 1994, companies were more likely to benefit from research relationships by gaining access to new knowledge, ideas, and talented potential staff members than by acquiring marketable inventions. These additional benefits suggest that academic settings may offer certain advantages over other sites as places to conduct industrial research. If these advantages explain the strong and continued interest of life-science industries in academic institutions, then the future of relationships between industry and academia generally, and those centered on research in particular, may depend in a major way on the intellectual vitality of the academic health sciences.

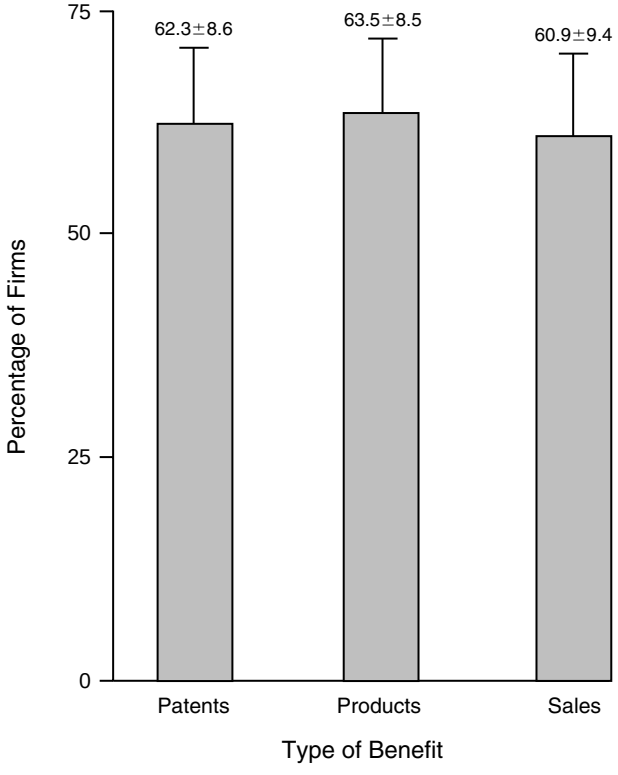

Figure 3. Percentage of Firms Responding to the Survey That Had Patents Issued, Products Marketed, or Sales Revenue Obtained within the Five Years before the Study at Least Partly because of University-Based Research Sponsored by the firm.

Values are percentages ± half of the 95 percent confidence intervals.

Another general insight that emerges from our data is that academic institutions may not be able to depend heavily on industrial support to maintain their intellectual vitality. There are two reasons for this. First, although it is a substantial complement to federal support, industrial sponsorship remains small as compared with NIH funding. It therefore seems unlikely that industrial funding could make up for any appreciable reduction in funding from the NIH. For example, to compensate for a 10 percent reduction in NIH funding of universities in 1994 (a reduction of $620 million), industry would have had to increase its outlays by 41 percent — an unlikely development in the short term, and perhaps in the long term as well.

A second reason that universities would be unwise to depend heavily on industry to sustain their capabilities in the life sciences is that such support may not generally be conducive to maintaining the level of excellence of fundamental academic research in those fields. Both in 1984 and at present, we found that most research contracts with industry are small and short-lived. These findings suggest that most industrial support of academic research in the health sciences is likely to continue to be targeted. To the extent that the quality and vitality of the academic health sciences depend on fundamental rather than applied research, industrial funds are less likely to maintain that quality and vitality than funds from other sources, especially the federal government.

Our past work has suggested that secrecy is more common in industrially supported research than in research supported otherwise.[18] Elsewhere in this issue of the *Journal,* Rosenberg discusses some of the implications of secrecy in medical research.[19] The data presented here indicate that, at least on the basis of reports by industrial concerns, such higher levels of secrecy result in part from the policies and expectations of industrial partners in research. Furthermore, the information withheld in the course of research relationships may involve findings of general interest to academic colleagues, including those useful in repeating and confirming the work.

Our findings about the prevalence and consequences of secrecy should be interpreted with caution. The perceptions of company officials about the role and prevalence of confidentiality requirements in agreements with academic institutions may not correspond accurately to the actual behavior of academic scientists. At a minimum, however, reports by industrial respondents in this survey suggest the need for further study of the extent

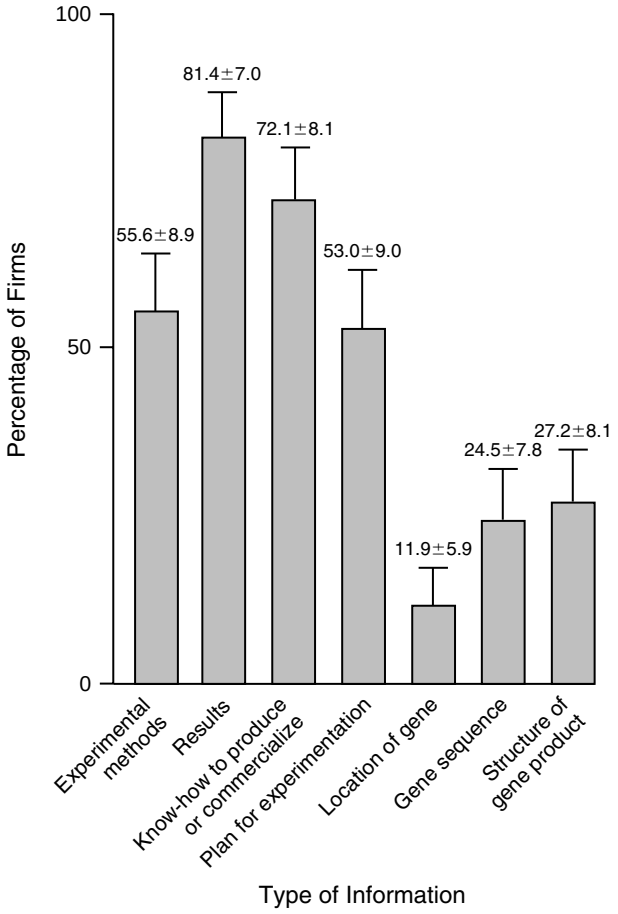

Figure 4. Percentage of Firms Responding to the Survey That Reported That Information Had Been Kept Confidential during a Relationship with an Academic Institution beyond the Time Needed to Obtain a Patent, According to the Type of Information Involved.

Values are percentages ± half of the 95 percent confidence intervals.

and implications of secrecy in research relationships with academia.

Our own research has several limitations that could affect our results and their interpretation. First, the views of those who did not respond to our surveys of life-science companies might have differed systematically from the views of the respondents, leading to bias in our findings. Second, our measures of the commercial returns associated with relationships involving academia have inherent limitations. Numbers of patents and products may not indicate the true value of the intellectual property derived from such relationships, especially as compared with the returns firms derive from other types of investments.

Despite these limitations, our findings suggest that research ties with academic institutions have demonstrable benefits for sponsors, that these benefits persist over time, that life-science companies remain financially committed to university research, and that universities are well positioned to compete for industry funds. At the same time, conducting industry-sponsored research poses real challenges for academic institutions. In the opinion of sponsoring firms, bureaucratic obstacles remain a major problem. Also, academic institutions may understate or underestimate the extent to which relationships with industry promote secrecy among university investigators and the extent to which such secrecy may affect scientists in training. University administrators who wish to preserve an open academic environment in the life sciences and to honor their fiduciary obligations to scientific trainees would be wise to examine more closely the formal agreements they draw up with sponsoring companies and to track the actual participation of faculty and trainees more closely with respect to the withholding and sharing of data.

Relationships between industry and academia are essential in order to meet a major goal of public policy: the translation of research findings into practical applications that improve the health and living standards of the American people. To realize the full benefits of association with industry and minimize risk, universities may need to manage these relationships more tightly. For their part, federal policy makers should recognize the likelihood that reducing government support of research in the life sciences will alter the balance between industrial and nonindustrial financing in ways that adversely affect not only academic institutions, but also their clients in industry.

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