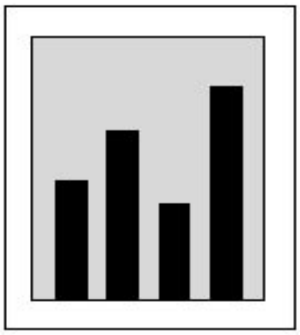
OTA Survey Results 3

Almost simultaneously with, but not linked to, steep increases during the 1970s and 1980s in federal support for biomedical research, came legislation addressing technology transfer to the private sector. As described in chapter 1 and appendix A, these laws allowed the government, universities, and industry to negotiate patents and exclusive licenses on federally funded research. For industry, exclusivity is particularly important (1,79), and the prior dicta that federal inventions were required to be nonexclusive posed a barrier to commercialization of federally funded research results.

The growth of molecular technologies as tools for the application of basic biological knowledge and the enormous potential for commercial gain from such discoveries—buttressed in part by the new technology transfer laws—set the stage for new institutional arrangements between government, universities, and industry. Fifteen years after Congress began to systematically encourage transfer of federally funded research results, how do industry and university technology transfer officials view the evolution of federal technology transfer? That is:

- What types of collaborative arrangements have proved most useful? What have been university and research institutions' experiences? How much income has been generated? How many patents have been obtained? What measures, if any, could the federal government adopt to improve technology transfer?
- Similarly, what has been industry's experience with agreements involving the National Institutes of Health (NIH) or the U.S. Department of Energy (DOE)? Does industry view them as successful? And from their perspective, what measures, if any, might improve federal technology transfer?



- Finally, what about federal scientists? For example, are scientists at the NIH—which funds the bulk of the federal government's biomedical research—more likely to hold patents, publish more frequently, or have their work more frequently cited if they are involved in formal collaborations with industry? Are NIH scientists who hold patents more, or less, likely to publish or be cited?

OTA examined these questions by conducting several surveys:[1] technology transfer officials at research institutions and universities, biotechnology research and development (R&D) executives, biomedical researchers receiving extramural NIH funding, and a bibliometric and patent survey and analysis of NIH intramural scientists.

UNIVERSITY AND RESEARCH INSTITUTIONS' PERSPECTIVES ON TECHNOLOGY TRANSFER

Two events primarily influenced university and research institutions' interest in technology transfer related to federally funded biomedical research. First, as mentioned previously, with enactment of the Bayh-Dole Act of 1980 (Public Law 96-517), Congress explicitly sought to encourage commercialization of government-sponsored research. Second, and more importantly for development of products from biomedical research (19,83,84), the U.S. Supreme Court ruled in 1980 that a living composition—in this case an artificially selected oil-eating microorganism—could be considered an invention and therefore patentable (26).

Intellectual property, then, is a critical resource of the biotechnology industry, and much of this knowledge derives from federally funded projects at university and nonprofit research institution laboratories (85). In fact, however, universities and research institutions themselves can realize financial gain from federally funded research. For example, in 1980 Stanford University and the University of California received the so-called Cohen-Boyer patent, which grants exclusive use of a genetic engineering method. To date the Cohen-Boyer patent is one of the most lucrative patents, accruing royalty revenues of $14,660,699 in FY 1992 alone (52). However, is this experience unique?

OTA's survey of universities and academic research institutions focused on NIH and DOE life sciences research (charged by Congress to undertake the Human Genome Project) and, for comparative purposes, all U.S. government-supported research at the same institutions. OTA queried technology transfer officials about qualitative aspects of technology transfer at academic research institutions—e.g., the goals of the technology transfer function; the effectiveness of different methods of technology transfer; the nature and impact of obstacles to technology transfer at these institutions; and several other issues related to academic-based technology transfer. Additional-

[1] To address questions related to technology transfer at universities and academic research institutions, OTA sought data related to the experiences and perspectives of technology transfer officials at these entities. Questionnaires were mailed to institutions that fell within the top 45 in funds (representing a majority of extramural funding for both NIH and DOE) received from either NIH or DOE life sciences or both. For this survey, respondents were asked to provide data based on their institution's fiscal year.

To assess industry's perspectives, OTA surveyed 100 biotechnology firms by telephone to assess their experiences with Cooperative Research and Development Agreements (CRADAs). Firms involved in NIH or DOE life sciences CRADAs were contacted and compared to a sample of firms not involved in CRADAs.

One of the most vocal sectors opposed to the NIH's patent filing was the academic-based researcher. To gauge the attitudes of scientists toward the NIH applications specifically, as well as intellectual property and technology transfer issues generally, OTA surveyed by telephone 253 randomly selected recipients of NIH grants awarded through study sections principally funding grants in human molecular biology. OTA also sought information to assess the impact, if any, of these patents and technology transfer on research practices.

Finally, publication counts and citation analysis are part of the field of bibliometrics, an indicator of research productivity, although it does have limitations (84,86). To explore relationships between publications, citations, patenting, and federal technology transfer activities, OTA conducted a bibliometric and patent analysis of intramural NIH scientists participating in one or more CRADAs compared to NIH scientists not involved in CRADAs. Appendix B contains details of OTA survey methods.

ly, OTA sought quantifiable measures such as income, numbers of patents, and types of licenses.

Goals

OTA's survey sought respondents' views of the purpose of federal technology transfer. Technology transfer officials were asked to score eight primary factors according to relative importance. These goals, listed below in no particular order, were:

- to promote local or regional economic development;
- to augment the research budget of the institution;
- to augment the discretionary income of the institution;
- to fulfill laws obligating the transfer of federally supported technology to the public;
- to stimulate more commercially applicable research at the institution;
- to help create innovative spinoff companies based on the institution's research;
- to assist staff at the institution in establishing industrial research arrangements; and
- other (list).

Twenty-four institutions cited fulfilling federal technology transfer laws as the most important goal. Eighteen institutions chose "other" as the most important, and all but one wrote in a goal best summarized as "to benefit society through the commercialization of research." One respondent said "to protect faculty inventions" was the chief goal, calling attention to the patenting function in the technology transfer process.

Although subjective, OTA's survey results clearly indicate that federal technology transfer statutes are taken seriously by technology transfer officials at universities and nonprofit research institutions. This finding is consistent with the sampling method for this survey—i.e., the survey population was drawn from institutions where a significant amount of research was funded by the U.S. government and therefore subject to federal law. Interestingly, 43 percent of technology transfer officials (18 of 42) viewed their technology transfer function as part of a university or research institution's larger social mission; such a view is consistent with what nontechnology transfer university officials have stated is the purpose of academic technology transfer function (100). Of the remaining goals, survey respondents said creating innovative spinoff companies based on research performed at the institution was the least important purpose of technology transfer.

Effectiveness of Different Mechanisms

OTA asked respondents about the effectiveness of common methods of technology transfer, that is: exclusive licensing, nonexclusive licensing, industry-sponsored research agreements, technical assistance, direct investment in licensees, setting up spinoff companies, exchange of personnel, and site visits. Institutions were asked to characterize the methods as not effective, effective, or very effective. All but two institutions responded to this question.

Data reveal that survey respondents view exclusive licensing as the most effective method of transferring technology at these institutions, with all but four institutions responding that it was very effective and only one of those four claiming it was not effective. Industry-sponsored research agreements (see box 3-1) were judged the second most effective mechanism overall: 20 institutions claimed sponsored research was very effective, with two believing it ineffective. Nonexclusive licensing and setting up spinoff companies were both viewed as the next most effective means of transferring technology. And finally, OTA found that 32 institutions viewed direct investment in licensees to be an ineffective technology transfer method (though two institutions judged it to be very effective).

With respect to this last mechanism—direct investment in licensees—opportunities for investing in such licensees, or receiving equity in a small startup as part of a licensing arrangement, are likely to increase in the future if universities continue attempts to set up venture capital funds or incubators to commercialize academic science. Current-

BOX 3-1: Washington University-Monsanto Sponsored Research Agreement

Sponsored research agreements present both the corporate sponsor and the research institution with an opportunity to benefit. The key to taking advantage of this opportunity is ensuring that care is taken in the process of reconciling the profit-maximizing goals of the corporation with the academic mission of the nonprofit research institution or university. Moreover, the concerns of the U.S. government must be considered as well because of significant federal support for biomedical research at these institutions, Reconciling disparate institutional goals, sometimes in tension, must be negotiated in advance—especially if the proposed agreement involves large sums of money. Most sponsored research agreements, however, are small and easily managed by all parties involved.

Some agreements, however, are broader, occur for longer periods of time, and involve a significant amount of money. For example, at Washington University, Monsanto is providing about $9 million each year on topics chosen by the research faculty, but that are of interest to Monsanto as well (23). Monsanto funding represents 5 percent of the annual research budget at Washington University, and Monsanto is restricted to research on bioactive proteins and peptides under the agreement (23). Monsanto issues requests for proposals (RFPs) each year, describing areas of specific interest that faculty members may submit proposals for. A joint committee of five senior scientists from Monsanto and five from Washington University review the proposals. Every two years, an independent audit of scientific quality is conducted; several members of the National Academy of Sciences conducted a recent audit (23).

Under the agreement, faculty members receiving Monsanto funds agree to assign their patents to the company and to keep confidential any proprietary information they receive from Monsanto. Manuscripts are reviewed and then released for publication in 30 days or less. No restrictions on collaboration with faculty at other Institutions exist, and the agreement provides a mechanism for sharing research materials based on Monsanto-funded work (23). On occasion, a patentable discovery has been developed with funding from Monsanto and the U.S. government. In such cases, the provisions of federal law are applied to the discovery, Including the Bayh-Dole Act (Public Law 96-517)(23).

Some experts express concerns about sponsored research agreements, particularly those that are large in scale or scope. Among the concerns: agreements excluding rival firms from access to unused R&D, deals allowing companies to excessively control the direction of research and its results, and provisions that restrict the freedom of researchers to publish their work. In the wake of the controversy over a proposed agreement between Scripps Research Institute and Sandoz Pharmaceutical, the National Institutes of Health (NIH) conducted a survey of 375 sponsored research agreements at 100 U.S. research institutions in 1993. The NIH survey revealed that most agreements are small and so presumably raise less concern. Indeed, according to NIH officials, there were no agreements similar to the Scripps-Sandoz agreement (57). Nevertheless, in response to a congressional directive, NIH has drafted guidelines to resolve concerns about the potential for sponsored research agreements and perceived abuse of federal funding at nonprofit research institutions.

SOURCE Office of Technology Assessment, 1995

ly, however, U.S. universities pursue this avenue cautiously because of the controversy it generates (53).

■ Barriers

OTA also sought to determine technology transfer officials' perceptions of the most serious obstacles to technology transfer at their institutions. Three institutions did not respond to the question, which asked respondents to rank from one (most significant) to 10 (least significant) the following list of potential obstacles (here, in no particular order):

- cost of patenting discoveries;
- appearance of conflict of interest;

- lack of industry interest;
- lack of researcher or faculty interest;
- compliance with U.S. government technology transfer laws;
- difficulty of attracting skilled technology transfer personnel;
- conflicts between local government and U.S. government requirements;
- industry reluctance to accept nonexclusive licenses;
- industry reluctance to meet royalty demands;
- unproven state of academic technology; and
- other (list).

Twenty-eight institutions believed the unproven state of academic technology was the most significant barrier; another 11 institutions ranked it as the second most significant barrier. On the other hand, three institutions ranked it among the least significant barriers to effective technology transfer.

OTA data reveal that a lack of industry interest was viewed by survey respondents as the second greatest barrier to technology transfer: Twelve institutions ranked the lack of industry interest as the most significant barrier to technology transfer, and 18 claimed lack of industry interest as the second greatest barrier to technology transfer. Four institutions did not view low industry interest as a significant barrier. Patenting costs are viewed as the third most significant barrier, according to survey respondents. Eight institutions claimed patenting costs as their first or second most significant barrier.

Interestingly, one institution claimed conflict of interest issues are the second most significant obstacle, and three others cited conflict of interest as the third most significant obstacle to technology transfer. Three institutions cited "other" and offered that decreased federally funding of research is the most significant obstacle to technology transfer. For three institutions, industry dislike of royalty demands is perceived as an obstacle. One respondent felt the U.S. tax code creates disincentives that amount to the most serious obstacle to technology transfer. Along that vein, university officials propose that the federal government establish a permanent R&D tax credit to encourage greater support by industry of university research (102). OTA's data reveal that for all but two institutions, industry aversion to nonexclusive licensing terms is not viewed as a significant obstacle.

Federal technology transfer laws and regulations, and conflicts between local and federal requirements regarding technology transfer, are viewed as the least significant barriers to technology transfer. Nevertheless, one respondent felt conflicts between federal and local governments impede technology transfer, another respondent viewed federal technology transfer laws as the second most significant obstacle, and four respondents felt federal laws were the third most severe obstacle.

Overall, OTA data concerning obstacles to technology transfer indicate that respondents believe federal laws and regulations do not interfere with technology transfer. The most serious obstacle stems from the (expected) uncertainty about the value of new discoveries and technologies derived from basic academic research. Hence, neither industry nor institutions surveyed are at fault per se for this obstacle: Industry might be tentative about an area of basic research, but the respondents' interface with industry does not appear to be a serious barrier, according to academic technology transfer officials.

With respect to the possibility that specific federal regulations related to technology transfer present a burden, OTA also sought comments on federal regulations that require reporting of invention disclosures for federally funded research. For 26 institutions, the regulations, on balance, had no effect. For 18 institutions, the reporting requirement was burdensome to some degree. However, six institutions commented that the reporting requirements aided the technology transfer process.

Other Issues

In addition to inquiring about the goals, barriers, and effective mechanisms of federal technology transfer, OTA gathered information about academic institutions' policies and practices in implementing their technology transfer function.

Flexibility

OTA probed the flexibility of certain negotiated issues or provisions of standard licensing agreements. Areas explored included controls on data access, restrictions on the release of data, payment schedules, structure of royalties and licensing fees, ownership of patent rights, liability issues, dispute resolution, and allocation of patenting costs. Institutions reported themselves as not flexible, flexible, or very flexible for each provision. The level of flexibility carried a numeric weight on the questionnaire that was used to calculate population results.

According to OTA's data, the institutions surveyed are more flexible regarding issues such as royalties, fees, and payment schedules. Somewhat less flexible, but still subject to negotiation, are issues relating to patent cost distribution, dispute resolution, and control over access to scientific data. According to respondents, licensing provisions relating to patent ownership and liability issues are generally not subject to negotiation for companies wishing to license discoveries at academic research institutions. Moreover, seven institutions said they are generally less flexible if the invention in question derived from federally funded research.

Royalty Distribution

With respect to the distribution of net income from royalties and fees, OTA found a range of practices among the surveyed institutions. Respondents had licensing royalty distribution policies that allocated income to the inventor(s), sometimes to the inventor's laboratory, the inventor's academic department or school, to the institution itself, and sometimes to the office responsible for technology transfer. The proportion of royalty income received by the inventor(s) ranged from 15 to 50 percent. At 13 institutions, the inventor's laboratory received from 10 to 47.5 percent of net income from royalties and fees. The institutions themselves received royalty income ranging from 7.5 to 75 percent. On average, inventor(s) received 32 percent of royalty income, and institutions received an equal share of 32 percent.

Overall, respondents viewed income from royalties or fees as discretionary. One institution reported having no formula for distributing royalty income because it had no licenses or other activities from which any income could accrue. Many institutions claimed that income went into a research or patent fund; in fact, most researchers do not view royalty income to supplement their research or salaries as an important aspect of technology transfer (table 3-1; box 3-2). No differ-

TABLE 3-1: Researchers' Expectations of the Effectiveness of Technology Transfer for Molecular Biological and Biomedical Research (in percent)

	A lot of effect	Some effect	A little effect	No effect	Not sure[a]
Promoting public health and helping cure disease	79%	17~0	2%	o %	2%
Promoting U S economic competitweness abroad	65	25	6	o	4
Creating Innovative spinoff companies	51	37	6	12	4
Advancing the frontiers of science	45	40	13	1	0.8
Making new discoveries public without losing rights to commercialize them	21	32	20	10	17
Creating opportunities for "hands-on" student learning	17	35	33	12	4
Augmenting funds for one's research	15	39	34	9	4
Augmenting one's salary	2	8	26	64	1

[a]percentages may not add to 100 due to rounding

SOURCE Off Ice of Technology Assessment, 1995, based on a 1993 OTA telephone survey of 253 biomedical researchers receiving extramural NIH funds from study sections awarding grants in molecular biology and genetics, broadly defined

BOX 3-2: Researchers' Attitudes Towards Technology Transfer

To assess the attitudes and practices of academic researchers regarding the commercializatlon of biomedical research, OTA conducted a telephone survey in 1994 of 253 U.S. academic molecular biology researchers receiving grants from the National Institutes of Health. Several questions specifically dealt with the topic of technology transfer in academic institutions.

Ninety-one percent of researchers surveyed by OTA (230 respondents) approved or strongly approved of academic research collaboration with industry in the life sciences. Forty-six percent of these researchers (106 individuals) were personally involved in industry-sponsored collaborations, and 53 percent (122 respondents) were not personally involved in industry-sponsored collaborations

Researchers were generally aware and supportive of technology transfer processes. Eighty-seven percent of researchers (219 respondents) were aware their university had technology transfer policies Sixty-two percent (156 respondents) of researchers surveyed stated that they "are required to disclose possibly patentable inventions to (their) university, " but 28 percent (71 respondents) said they were not required to do so. Seventy percent of researchers who stated that their university had technology transfer policies (153 respondents) also said that these policies had not "frustrated (them) with more paperwork burdens that (they) would rather not deal with. "

OTA found that not only were scientists aware, but a majority had been involved in technology transfer at their institution. Sixty-three percent (159 respondents) of researchers surveyed reported that they or members of their research team had conferred with officials at their institution about technology transfer issues arising from their research Of those who had conferred with officials, 38 percent conferred with them once a year, 20 percent conferred with them once every six months, 18 percent conferred with them once every three months, 16 percent conferred with them once a month, and 3 percent conferred with them once a week or more. Thirty-six percent (91 respondents) claimed that they had not conferred with officials about technology transfer.

OTA also asked researchers about how strongly they expected technology transfer in the life sciences to affect some of the frequently-cited goals of technology transfer (table 3-1) In general, OTA found molecular geneticists receiving NIH funding appear to view technology transfer positively in the context of the societal goals intended by lawmakers.

Seventy-nine percent (199 respondents) expect technology transfer to have "a lot of effect on promoting public health and helping cure disease. " Sixty-five percent (165 respondents) expect technology transfer to have "a lot of effect on promoting U.S. economic competitiveness abroad " Fifty-one percent (130 respondents) expect technology transfer to have "a lot of effect on creating innovative spin-off companies. " Forty-five percent (114 respondents) expect technology transfer to have a lot of effect on "advanclng the frontiers of science. " Researchers felt that technology transfer would have some effect on "making new discoveries public without losing rights to commercialize it, " "creating opportunities for 'hands-on' student learning, " and "augmenting funds for [their] research. " Additionally, a majority of scientists—64 percent (161 respondents)—do not expect technology transfer to augment their salary.

SOURCE Office of Technology Assessment, 1995

ences existed in the distribution of royalty income from federally funded versus that from privately funded research.

Timing of Patenting

Under the premise that it is easier to justify the expense of pursuing patent protection (which, as noted earlier was viewed as a barrier to technology transfer by some respondents) on a discovery if a company interested in licensing has already been identified, OTA's survey explored the timing of the patenting function as part of the technology transfer process at academic institutions. Specifically, questions addressed the proportion of cases where a licensing agreement with a company was sought before pursuing a patent on a discovery, and how often the institution was successful with this approach.

On average, institutions participating in OTA's survey seek potential licensees before pursuing patent protection 53 percent of the time, and they are successful 22 percent of the time. For NIH-funded research in particular, universities and research institutions seek potential licensees prior to patenting in 50 percent of cases and are successful 21 percent of the time. For DOE-funded research, potential licensees are sought before pursuing a patent 29 percent of the time and institutions succeed for 12 percent of cases. Thus, respondents report it is generally easier to find prospective licensees for NIH-funded discoveries than for DOE-funded discoveries.

Marketing

OTA also asked how respondents conduct marketing of new inventions. For an average 48 percent of cases, 47 institutions have the researcher identify potentially interested companies. At 46 institutions, technology transfer officials offered technologies to key firms that the officials know are commercializing related technologies approximately 61 percent of the time. Thirty-seven institutions canvass by mail, telephone, or site visit, local or regional firms for 31 percent of their new inventions. Thirty-three institutions turned to companies already engaged in research at their institutions in an average 16 percent of cases. At 27 institutions, an average 25 percent of technologies are published in a database frequently examined by interested parties. And finally, 20 respondents relinquish the marketing of their technologies to an outside party about 10 percent of the time.

Licensing without Patenting

Another series of questions examined licensing of discoveries without applying for patents. OTA asked institutions if they had ever licensed a discovery (other than software), without ever intending to file for a patent, and whether the research leading up to the discovery was funded by NIH or DOE. In FY 1992, 37 institutions had licensed without patenting for a total of 80 discoveries. An average of 53 percent of those were based on research funded by NIH, and one discovery in FY 1992 was based on research funded by DOE. According to data OTA gathered from follow-up questions, most of these discoveries were biological materials or reagents commonly used for research purposes without filing for a patent.

Domestic Manufacturing Preference Clause

Finally, OTA asked if any potential licensees had declined to license a discovery because the firm objected to a domestic manufacturing preference clause as required by law. Five institutions reported turning away an interested company for this reason, for a total of six scuttled deals in FY 1992. Four of those potential deals involved research funding from NIH, and none involved DOE-funded research. Nearly all the institutions commented that they never had a need to end licensing discussions with a company over the issue of manufacturing in the United States, primarily because licensees' approached had domestic manufacturing operations.

Income

Income from exclusive and nonexclusive licenses is the main financial indicator of the productivity of NIH- and DOE-funded research at academic institutions. Nevertheless, income is a crude indicator of productivity, lagging behind research re-

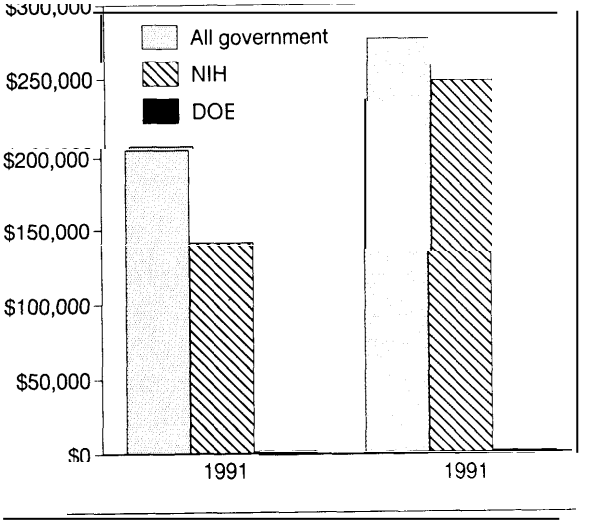
suits that emerge before commercial applications are even found. Income from licensing usually takes months, or even years, to accrue. After years of research, and what can be a time-consuming process to obtain a patent, it can take months or years to find a party interested in licensing the technology. Moreover, even after a licensee is aboard, several years often can elapse, since most biomedical technologies require regulatory approval to reach the marketplace. All of these factors increase the time it takes (in most cases) to realize a financial return on biomedical research and probably account for what some might perceive as a low rate of return from licenses related to NIH- and DOE-supported life sciences research.

Still, analyzing income data can prove instructive. Exclusive licensing income is examined separately from nonexclusive licensing income. OTA's income data (figure 3-1) allow an approximate characterization of both licensing strategies, which could prove useful in assessing the merits of proposals to mandate nonexclusive licensing of federally funded research.

Licensing income, from NIH- and DOE-supported life sciences research at the institutions responding to OTA's survey, ranged from zero to nearly $13 million. For example, 1992 income from exclusive licenses based on NIH-supported research was $12.9 million at the institution reporting the most income, with approximately $3.3 million the next highest response. In 1992, OTA survey respondents had a median income of $102,5OO from exclusive licenses.

OTA found an even greater range for income from nonexclusive licenses. The 1992 income from nonexclusive licenses based on NIH-supported research ranged from zero to nearly $15 million, with five institutions accounting for more than 90 percent of the income reported by survey respondents. The median income in 1992 from nonexclusive licenses based on NIH-supported research was $21,200. The 1992 median total income—from both exclusive and nonexclusive licenses based on NIH supported research-was $248,325.

FIGURE 3-1: Median Income Earned from Licenses to U.S. Government, NIH, and DOE Supported Research for 1991 and 1992



SOURCE: Off Ice of Technology Assessment, 1994

For life sciences research supported by DOE, 1992 income from exclusive licenses ranged from zero to $837,000, with only seven institutions reporting any exclusive licensing income that year. The survey found 1992 income from nonexclusive licenses based on DOE-supported life science research at 46 institutions ranged from zero to just over $90,000, with the other three institutions receiving income of about $11,000 or less. In 1992, only 10 institutions reported some income from licenses based on DOE supported research.

OTA's survey respondents reported a cumulative total for FY 1992 of $87.74 million of income from NIH licenses and almost $1.65 million from DOE licenses. Interestingly, in only one case did an institution receiving significant income from nonexclusive licenses also receive significant income from exclusive licensing agreements. In all other cases, institutions reporting higher than average income from exclusive licenses reported relatively little or no income from nonexclusive licenses.

TABLE 3-2: Summary of Data from OTA Survey of Academic Research Institutions

Institutional Fiscal Year	All U.S. government	National Institutes of Health	U.S. Department of Energy
Reported Inventions 1991	1373	822	52
Reported Inventions 1992	1549	889	55
Patent filings 1991	688	496	21
Patent filings 1992	723	518	19
Exclusive licenses 1991	181	135	3
Exclusive licenses 1992	222	169	2
Nonexclusive licenses 1991	186	104	2
Nonexclusive licenses 1992	174	135	4
Exclusive license income 1991	$28,364,646	$24,081,480	$ 594,767
Exclusive license income 1992	$45,197,909	$32,002,457	$1,528,105
Nonexclusive license income 1991	$55,031,692	$51,318,994	$ 31,748
Nonexclusive license income 1992	$60,777278	$55,738,223	$ 114,492

SOURCE, Off Ice of Technology Assessment, 1995

A few institutions appear to have received significantly more income from exclusive licensing agreements than their peer institutions. Although the Bayh-Dole Act was passed in 1980, it has taken almost a decade for most academic institutions to begin to see royalties emerge from patents on their federally funded discoveries. Even at institutions with mature programs, the technology transfer function is barely self-supporting; as noted earlier, accruing income from licensing usually takes years.

Based on the income data, DOE-supported life sciences research appears significantly less productive for extramural academic research institutions. However, DOE research in the life sciences is more commonly conducted at large, contractor-operated federal laboratories, which were not part of the survey population.

Based on OTA's survey data, a handful of institutions clearly have exploited nonexclusive licensing to yield significant income; the Cohen-Boyer patent, a breakthrough technology, illustrates this point. (OTA's data, however, do not allow for conclusions concerning the nature of research more likely to yield significant income through nonexclusive licensing.) Nevertheless, experts generally agree that however rare they may be, enabling breakthrough technologies are usually appropriate for nonexclusive licensing because they promote broad diffusion. Again, as the Cohen-Boyer patent illustrates, both industry and the patentholder benefited from the many nonexclusive licenses permited. Table 3-2 summarizes data related to income and other quantitative results obtained from the OTA survey of technology transfer officials at universities and nonprofit research institutions.

■ Additional Data Analysis

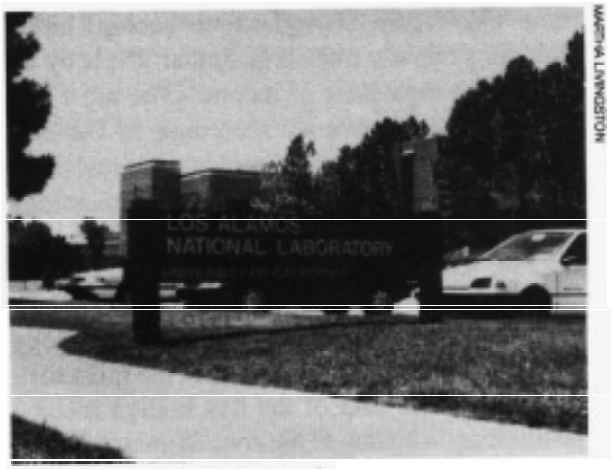
As part of the data analysis, OTA analyzed a few bivariate cross tabulations and performed some ordinary least squares (OLS) regression analyses and associated statistical tests. OTA did not investigate relationships between more than the two variables noted in each case, although there may be such causal relationships or links among more than the variables explored in each cross tabulation. It is important to recognize these correlations say nothing about the likelihood of other, possibly confounding, variables affecting the outcomes of the analyses reported by OTA in this section. Moreover, the sample sizes for some of these analyses were small.

To examine whether a correlation exists between "high" income (defined by OTA as greater than $1 million) and seeking licenses before filing for patents, licensing income data for both NIH and DOE were compared with data from questions

about seeking licenses on discoveries prior to filing a patent application. OTA found no significant difference in behavior between institutions, regardless of income. Some institutions with no license income always attempted to find licensees 'before patent filing. As well, no differences emerge when examining rates for successful licensing prior to patent filing. For NIH-funded research, all but one of the five institutions with high licensing income sought licensees before patent filing 50 percent or more of the time. However, of those institutions, one claimed success 50 percent of the time and four said they were successful 10 percent of the time or less. For DOE, 10 institutions had income; the two institutions with more than $200,000 reported success in licensing discoveries prior to patenting 20 percent of the time or less. OTA analyses, including t-tests of the coefficients, indicated that a causal relationship was extremely unlikely.

Licensing income data for both NIH and DOE research were also crosstabulated with data from questions about the methods used to find potential licensees. Based on this analysis, OTA found no marketing technique unique to institutions that had high licensing income. All respondents use all marketing approaches to about the same extent, regardless of licensing income received. All but one institution reporting high income turned to key companies in the relevant field to try to license discoveries 75 percent or more of the time. Conversely, less than 20 percent of the time, all but one respondent reporting high income published discoveries in an electronic database to which potential licensees have access. For institutions reporting high income, all remaining methods of finding potential licensees tend to be used less than 50 percent of the time. Regression analysis and associated t-tests for this sample showed that any causal bivariate relationship was very unlikely between the level of income and any of the methods used to market inventions.

In addition, licensing income data were compared with data from questions probing the effectiveness of certain methods of technology transfer to determine if any correlation exists between levels of income at the institutions and the perceived effectiveness of those methods. Again, all methods of technology transfer are viewed as effective or not effective to the same extent by the institutions, regardless of income. All high income institutions viewed exclusive licensing as very effective, including the institutions reporting the highest income from nonexclusive licenses. The high income institutions were split on the effectiveness of nonexclusive licensing, just over half viewing it as effective and the remainder claiming it as very effective. One of the high income institutions felt that sponsored research agreements are an ineffective method of technology transfer. Direct investment in licensees was viewed as not effective by all but two of the high income institutions, which viewed it as a moderately effective method of technology transfer. Technical assistance, personnel exchange, site visits, and setting up spinoff companies were all claimed to be generally effective by institutions with high income. Institutions reporting little or no licensing income shared no coherent viewpoint on the effectiveness of these methods of transferring technology. When regression analysis and associated statistical tests are conducted for this survey, no causal relationship appeared between any of the methods and any level of income reported.



The same income data were compared with data from questions examining obstacles to technology transfer at these institutions to determine if a simple correlation exists between the perceived obstacles at the institutions and their in-

come. Once again, obstacles to technology transfer were generally ranked at similar levels by all institutions regardless of income. The most significant obstacle overall according to the survey—unproven state of technology—is ranked as the second most severe obstacle to technology transfer by four of five institutions reporting high income, with one high income institution claiming it as the most significant obstacle. Conversely, a general lack of industry interest in technology transfer at academic institutions is the most serious obstacle for four of the five highest income institutions, with one of the five claiming it as the second most severe obstacle. For all obstacles however, the rankings tended to be similar regardless of income from licenses. Regression analysis and associated statistical tests showed that, among the various reported obstacles to technology transfer, no unique causal relationships to income reported exist for this sample.

Finally, income data from the institutions were crosstabulated with patent filing and licensing data to determine whether a correlation exists between those institutions filing for and licensing patented discoveries and income. One of the five institutions reporting high income filed over 40 patent applications. However two institutions with little or no income also filed for at least 40 patents. On the other hand, one institution reporting about $13 million in licensing income, filed fewer than five patent applications. The number of licenses granted to companies followed the same pattern. In this survey, OTA found no correlation between filing for patents or entering into licensing agreements and income from licenses. It is critical to note, however, that patents and licenses do not immediately yield income, usually not even in the same year that the patent issues or the licensing agreement is signed. Patents and licenses are among the first steps toward building a stream of royalty income derived from sales of a good or service that incorporates the technology invented at an academic research institution. Hence, the income reported by the institutions in this survey is primarily derived from patents and licenses in prior years. Not surprisingly, OLS regression analysis on OTA's data, and associated statistical tests of this bivariate relationship, confirms this conclusion.

BIOTECHNOLOGY COMPANIES' PERSPECTIVES ON FEDERAL TECHNOLOGY TRANSFER

As defined and authorized by the Federal Technology Transfer Act (FTTA) of 1986 (Public Law 99-502), a Cooperative Research and Development Agreement (CRADA) is an agreement between one or more federal laboratories and one or more nonfederal parties, under which the government provides personnel, services, facilities, equipment, or other resources (but not funds), and the nonfederal parties provide funds, personnel, services, facilities, equipment, or other resources toward the conduct of specific research or development efforts. Under a CRADA, these resources are provided toward the conduct of specified research or development efforts consistent with the missions of the laboratory.

Hence, CRADAs are a key mechanism for federal laboratories to share research materials and data and to collaborate on research with industry. CRADAs are intended to be agreements negotiated between individual laboratories or institutes and nonfederal parties, although there is oversight from federal agencies. This section presents results from an OTA survey of selected biotechnology companies' perspectives and experiences with CRADAs they have negotiated with NIH and DOE.

Profile of Companies Surveyed

Appendix B describes the sample population selection in detail. Briefly, OTA conducted a survey of 100 biotechnology companies in late 1993 and early 1994. A sample of firms, with and without life science CRADAs at DOE or NIH, was drawn and survey questions focused on the value to companies of CRADA collaborations, as well as the nature of the collaboration between the companies and federal laboratories. A total of 75 companies qualified following initial screening and responded to both written questionnaires and telephone interviews. The survey questions were

asked of the vice president for R&D, or other comparable executive for each company.

The demographic characteristics of the survey sample emphasize the scale and scope of the types of companies that the FTTA legislation was intended to assist. Of the 75 responding companies, eight were subsidiaries of other companies, and five are divisions of larger companies; these companies responded with data drawn from the parent company. The median estimated gross revenue for their current fiscal year (1993 or 1994) was $810 million; the median projected life sciences R&D budget was $9 million. The 75 respondents together employ approximately 1,005,000 full-time workers. Over the past five years, respondents reported receiving a total of 1,514 patents from the U.S. Patent and Trademark Office. The 75 companies currently have a combined total of 2,269 health care products on the market, 420 (19 percent) of which required regulatory approval. Interestingly, 23 firms reported not having any product on the market at the time the survey was conducted.

■ Experience with and Value of CRADAs

OTA's data provide some general indicators of the value to respondents of research performed under CRADAs. For the 75 companies, 23 reported having CRADAs with NIH and 10 reported having CRADAs with DOE. Three companies had both NIH and DOE CRADAs, and 27 companies had CRADAs with either NIH or DOE, but not both. CRADAs undertaken by these 30 firms, at NIH and DOE, led to 21 patent filings and 15 issued patents over the five-year period 1989 to 1994, though to date only three patented inventions are used in products that have reached the market. The companies reported to OTA that, on average for the 30 firms, 1.9 percent of gross revenues for the five-year period resulted from research performed under CRADAs, totaling approximately $31 million over the past five years. For these companies, royalty income from licenses to which the CRADA contributed were insignificant. These data imply that CRADAs have yet to generate much income for the firms that enter into life science CRADA partnerships with NIH and DOE.

The survey also probed the experiences of the companies with life science CRADAs at NIH and DOE. Of 75 companies, 23 reported having experience with a total of 43 CRADAs at NIH, including ongoing and terminated CRADAs. The 10 companies with DOE CRADAs reported having 14 life science CRADAs, including ongoing and terminated projects. The three companies with both NIH and DOE life science CRADAs were asked if there was any difference between CRADAs at NIH and DOE. One company claimed there was no difference and the two others claimed there was a significant difference. Of these, one claimed that the DOE CRADA application process was too bureaucratic, while the other company stated they have had problems with the pricing provision that was then a part of NIH's CRADAs.

To further examine companies' experiences with CRADAs, one CRADA was randomly selected from a list the respondent provided. Among the issues explored for the specific CRADA were the extent of the companies' and NIH or DOE laboratories' contributions. For the 30 companies with CRADAs at either NIH or DOE:

- 19 companies reported that federal researchers were provided to explore topics of interest to the companies;
- 18 companies reported that their laboratories were provided with U.S. government materials and equipment;
- 10 companies had access to equipment in federal laboratories;
- 16 companies had exclusive licensing provisions in the CRADA agreement;
- 4 companies received exclusive licensing privileges to research that was not conducted under the CRADA;
- 8 companies provided researchers to work in federal laboratories;
- 23 companies provided materials and equipment;
- 9 companies provided access to their equipment for federal researchers;
- 14 companies provided compensation for federal researchers;
- 16 companies provided other funding for federal researchers; and
- 13 companies provided funding for, or otherwise conducted the patent application process.

Clearly, federal laboratories contribute a share of resources to CRADAs, but OTA data reveal that a company's contribution to the CRADA is significant as well. To the extent that companies share the burden of CRADAs, it becomes more difficult to argue they are getting a free ride from the U.S. government (see Box 3-3).

OTA's survey results demonstrate that for the companies willing to invest in life science CRADAs at NIH or DOE, in most cases U.S. government contributions (other than funds) likely will match those of the companies. Overall, six companies felt that the benefits greatly outweigh the risks and expenses of CRADAs, seven felt the benefits somewhat outweighed the risks, and 12 thought the benefits equaled the risks and expenses. There were four companies that felt the risks and expenses of CRADAs exceeded the benefits.

From a qualitative viewpoint, the data from the 30 companies' tend to endorse the general value of CRADAs to the biotechnology industry. For example, 8 companies said that the intellectual contributions of federal researchers were very important, another 15 claimed the contributions to be somewhat important. Fifteen companies felt that government researchers had contributed original research ideas unavailable without the CRADA. Moreover, 18 companies reported that the researchers' technical know-how also would have been unavailable without the CRADA, and 17 companies expect an ongoing working relationship with government CRADA scientists. Nine of these companies intend to pursue another CRADA, and the remaining seven companies expect informal working relationships. A total of 15 companies felt that use of biological materials provided by the federal laboratory was somewhat or very important, and 10 felt that the use of such materials and expenses would be unavailable outside the CRADA. When asked if they would do it over again for all of their CRADAs, 8 companies said that they would do so for all their CRADAs, 8 said they would for most of their CRADAs, 7 said they would for some of their CRADAs, and 6 companies said they would be willing to repeat the experience for only a few or none of their CRADAs.

Concerns

OTA's survey identified concerns that trouble some companies participating in the survey. Seven companies reported that these concerns caused them to forgo or retreat from a CRADA with NIH or DOE. Eleven companies expressed no concern over the possibility of disclosure of information that they had intended to keep secret. Nine companies felt it was a major concern, and nine felt it was a minor concern. Only three companies reported major concern about government scientists, involved under their CRADA, going to work for a competitor; for 14 other companies this issue was a minor concern.

Fourteen companies had major concerns that the reasonable pricing clause in their NIH CRADA at that time would restrict profitability of products resulting from the CRADA. This result mirrors

BOX 3-3: Patenting, Publishing, and CRADAs for NIH Scientists

Cooperative Research and Development Agreements (CRADAs) are the mechanism by which industry effects technology transfer with federal scientists. Because of their exposure to industry and its sensitivity to the Importance of intellectual property protection, federal scientists involved in CRADAs might be expected to hold more patents than National Institutes of Health scientists not involved m CRADAs. However, the extent to which CRADA involvement affects the degree to which NIH scientists seek patents is unknown. Similarly, some have raised concern that commercialization of research could lead to Increased secrecy. Hence what effect, if any, do CRADAs have on publication by NIH intramural scientists? To address these issues, OTA performed a bibliometric analysis of possible relationships between CRADAs with patent and publishing characteristics of NIH intramural scientists.

The patents of 199 NIH scientists who participated in CRADAs (before and after they received their CRADAs) were analyzed and compared with a matched control group set of 199 NIH scientists. CRADA scientists get more than five times as many patents (136 in 1986-1993) as the non-CRADA scientists (25 in 1986-1993). In addition, patents from CRADA scientists were considerably more frequently cited than patents of control group scientists—i.e., the impact of the CRADA scientists' patents was higher (1,1 O v. 0.79) for the years examined. The patent rates of the CRADA scientists before and after receiving their CRADAS (defined as more than two years after the CRADA) increased at the same rate as their rate of patenting. From the point of view of patenting, while the CRADA itself does not seem to have a substantial effect on the patenting behavior of scientists, those scientists who enter into CRADAs are more prolific patenters (by almost a factor of 5), than scientists who are not involved in CRADAs That is, CRADA scientists appear to have a different orientation toward patentable biomedical research than non-CRADA researchers.

A second analysis examined the publications of a set of 116 CRADA and 116 non-CRADA researchers, separating the CRADA scientists who received their first CRADA In each of the three years 1988 1989, and 1990, so that "before CRADA" and "after CRADA" publications could be analyzed Based on this analysis, OTA found that researchers involved in CRADAs publish twice as many papers as non-CRADA scientists. Those scientists whose first CRADA was in 1988 were the most prolific, coauthoring more than 12 papers per year.

The bibliometric analysis revealed a slight, but statistically significant, decline in publication rate after an NIH scientist receives a CRADA. How to account for this result, however, is not entirely clear because of the time limitations required to track CRADA scientists over many years. Conversely, the non-CRADA scientists show absolutely no decline in publication pattern. Another comparison between the two populations revealed that the degree of "basicness" of journals in which articles were published was virtually identical between the CRADA and non-CRADA researchers. Finally, CRADA and non-CRADA scientists at NIH also published in equally influential journals.

SOURCES Office of Technology Assessment, 1995, based on F, Narin and K S Hamilton, CHI Research, Inc., Haddon Heights, NJ "Patenting for CRADA and Control Scientists," contract document prepared for D. Blumenthal and N. Causino, Massachusetts General Hospital, Boston, MA, under a contract for the Office of Technology Assessment, U S Congress, Washington, DC, 1994, and F Narin and K S Hamilton, "Publishing for CRADA and Control Scientists, " CHI Research, Inc. , Haddon Heights, NJ, "Publishing for CRADA and Control Scientists," contract document prepared for D Blumenthal and N Causino, Massachusetts General Hospital Boston, MA, under a contract for the Off Ice of Technology Assessment, U S Congress, Washington, DC, 1994

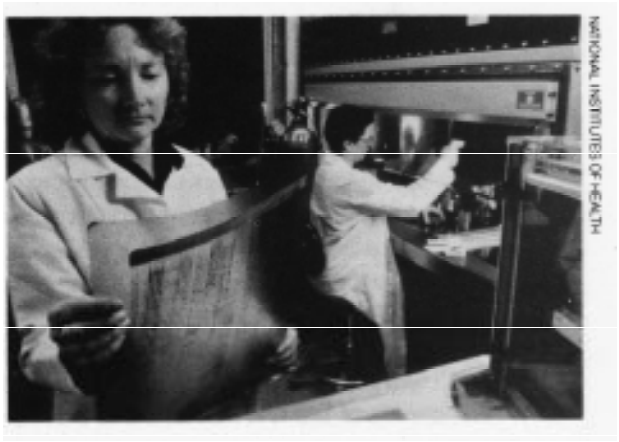
the finding of a 1994 OTA workshop involving a broad range of biotechnology and genome industry representatives, where executives pointed out that their interest in CRADAs was significantly retarded by potential price controls on pharmaceuticals (74).[2] On the other hand, eight companies felt the reasonable pricing clause was a minor concern, and seven others had no such concerns.

Eight of the companies felt it was a major concern that the CRADA language had no guarantee of an exclusive license for unanticipated products developed under the CRADA, and 14 others felt it to be a minor concern. Of the 30 CRADA firms, seven companies had major worries that the government would not honor the terms of the CRADA regarding exclusivity, and 10 other firms had minor concerns over this issue.

In general, OTA's survey results related to concerns of the biotechnology industry with CRADAs echo the findings of a 1993 report by the U.S. Department of Health and Human Services' Inspector General. This report also noted that industry considers the process of establishing CRADAs to be lengthy and complex, thus either discouraging formation or serving as a disincentive to further participation (98). As described in the next section, OTA's survey data show some evidence of this issue as a concern to some in the biotechnology industry, but the data also demonstrate the process is not a concern to others. ,

■ Executing CRADAs with NIH and DOE

Another set of questions probed the CRADA formation process from the companies' perspective. Out of 30 firms with NIH and DOE CRADA experience, 22 discovered CRADAs via personal contacts, one reported reading a journal article, one firm was made aware of CRADAs at a professional meeting, four companies reported receiving promotional materials from the U.S. government. According to these data, personal contacts are most effective for forming life science CRADAs at NIH or DOE. Four companies claim



that initial discussions toward forming CRADAs were begun by company officials, and eight report that the discussions were begun by government officials. Sixteen companies claim that discussions began by both federal and company officials equally. Within 20 companies, the research scientists themselves are the most enthusiastic advocates of CRADAs, and in five firms it was the vice president for R&D. Efforts to make industry more aware of CRADAs are seen as very effective by five companies, somewhat effective by 13 companies, somewhat ineffective by nine companies, and very ineffective by two companies. These data suggest that outreach to industry could be improved on the part of federal laboratories.

Relative to applying for life science CRADAs at NIH and DOE, 20 companies said they used a model CRADA application. Of these 20 companies, eight thought it was helpful, five said it was neither helpful nor obstructive, and six firms felt it was obstructive. Nine companies felt that the government's involvement in writing the CRADA application was very helpful, and seven other firms felt it was somewhat helpful. Six companies claimed that federal involvement is neither helpful nor obstructive, and seven companies felt it was obstructive. Twenty-five of the companies said there was a federal official responsible for coordinating the CRADA application process. For those five firms that said there was no such of-

2 In spring 1995, NIH dropped its insistence on a reasonable pricing clause (97).

ficial, they all claimed it would have been helpful if there was a government coordinator. Only six companies felt that such an official neither helped nor obstructed; 19 firms felt that a coordinating official in the application process helped them. Nineteen companies reported that their application was reviewed by a committee, and nine firms claimed that the committee's review took longer than was reasonable. Four companies felt that the committee pointed out ambiguities or problems important to resolve.

Licensing Provisions

Companies tend to focus on exclusive licensing of results to their CRADAs. A total of 21 companies sought exclusive licensing in the CRADA application for patents that might result from the CRADAs. Concerning the scope of exclusive licenses in the application, 16 companies reported that it was an issue for negotiation. Five companies sought exclusive licenses to government held patents on material used under the CRADA, but not a result of it. However, 22 companies did not actually receive exclusive licenses from the government, despite 16 companies having exclusive licensing provisions in their agreements. Seven companies did obtain exclusive licenses to their CRADA results. It is possible that some of the CRADAs did not result in anything to license exclusively from the 22 companies' perspective, or less likely, the federal laboratory did not honor its agreements.

Additional Issues

For those companies with no experience with CRADAs, OTA asked about their attitudes and awareness relative to CRADAs. Fourteen of 34 companies had never heard of CRADAs. For the 20 firms that were aware of CRADAs, 17 said they would consider entering into one. Ten of the 20 firms aware of CRADAs had some contact with federal officials or scientists concerning CRADAs, and for two of these companies the contacts were ongoing. Five companies said it would be very likely they would apply for life science CRADAs in the future, eight said it would be somewhat likely they would do so. Seventeen companies said they probably would not be interested in life science CRADAs with NIH or DOE laboratories.

As part of the survey, OTA took the opportunity to inquire about relations between the survey respondents and foreign nonprofit research institutions, with a focus on intellectual property rights resulting from international R&D collaborations. According to the survey, 31 of the 75 companies claimed to participate in collaborative R&D agreements with foreign nonprofit research institutions complete with rights to intellectual property licensed or otherwise obtained from foreign research institutions. These data show the openness of at least 41 percent of the companies to international research collaboration. Only one firm claimed to have licensed technology from a U.S. party that had such rights originally based on an international research collaboration.

In summary, OTA's data show an unevenness of companies experiences with CRADAs. Although most of the companies with CRADA experiences felt the federal laboratory helped them, the fact that most firms did not obtain exclusive licenses to CRADA results belies the more basic or enabling nature of the research collaboration common to CRADAs in the life sciences. In many cases, such a result is not necessarily a problem, but it does point to a possibility of companies' expectations going unfulfilled.

From the U.S. government's perspective, CRADAs can assist federal investigators in many cases, according to an analysis of OTA survey data. This is consistent with the findings from the DHHS Inspector General's investigation (98). A recent report by the U. S. General Accounting Office also found that CRADAs can provide a useful opportunity for federal research agencies to benefit from collaboration with industry, while pursuing research goals consistent with their statutory missions (80).

SUMMARY AND CONCLUSIONS

Over the past 15 years, Congress enacted legislation to address technology transfer of federally funded research performed at universities and re-

search institutions, as well as technology transfer of intramural research performed at federal facilities. Given the time necessary to implement the laws, however, only now are efforts to evaluate their impacts being undertaken.

Data from OTA's survey indicate that universities and research institutions do not believe federal laws and regulations interfere with technology transfer in most cases. Overall, OTA's survey found that academic technology transfer officials view the Bayh-Dole Act as vital to federal technology transfer. Clearly, academic research institutions successfully transfer some federally supported research to the private sector for commercial development. Significant barriers to academic technology transfer apparently are not a function of U.S. government laws or regulations.

With respect to the biotechnology industry's view of NIH and DOE (life sciences) technology transfer, CRADAs in particular, OTA's survey data found most respondents held positive views—despite the finding that life science CRADAs have yet to become commercially productive for most companies that have them. For companies willing to invest in life science CRADAs with NIH or DOE, U.S. government contributions (other than funds) match those of the companies in most cases. Moreover, six companies felt the benefits greatly outweigh the risks and expenses of CRADAs, seven felt the benefits somewhat outweighed the risks, and 12 thought the benefits equaled the risks and expenses. In contrast, four companies felt the risks and expenses of CRADAs exceeded the benefits.

Thus, beginning in 1980, Congress provided incentives for nonprofit research institutions and universities to license federally funded research, simply by changing the rules of intellectual property ownership. Congress appears to have achieved the intended effect of moving federally supported research to the marketplace without appropriating taxpayer funds for a new R&D program. On the other hand, because the increase in number of products mirrors a period of rapid growth in federal funding for life sciences research, it is impossible to unlink technology transfer from strong federal support for basic biomedical research. Nor did OTA assess the relative contribution of each to the unequaled development growth of the U.S. of the biotechnology sector.