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Technology Transfer at U.S. Universities

The time has come for a closer and more intimate relation between industry and academia.

—Edward E. David, President of the Exxon Research and Engineering Company and former Science Advisor to President Richard Nixon in 1979[1]

What is ultimately most striking about today's academic industrial complex is not that large amounts of private capital are flowing into universities. It is that universities themselves are beginning to look and behave like for-profit companies, I believe that if we value unfettered basic research as the prime function of the academic setting, then it is fair to ask if the extent of current commercial interactions distorts that mission and promotes the public interest.

—Nobel Prize-winning Chemist Paul Berg of Stanford University in testimony at hearings of the Committee on Science, Engineering, and Public Policy of the National Academies in 2001[2]

Universities account for roughly 50% of all basic research in the United States.[3] According to economists, this research has a measurable impact on the national economy via knowledge spillover effects, such as academic publications and faculty consulting, and university licensing agreements with private industry. Historically, knowledge spillover effects have been the primary means by which university research, i.e., university technologies, has been transferred to industry. That was still the case in 2006. However, university licensing was a growing and sometimes very rewarding phenomenon for universities, although its impact on both industry and the academy was a source of intensifying debate.

This note focuses on the transfer of university-based technologies into the private sector. By virtually any measure, technology transfer from U.S. universities increased dramatically in the 25 years leading up to 2006. Between 1995 and 2004, for example, the number of executed licenses yielding income nearly doubled; the number of filed and issued patents each more than doubled; and gross license income more than tripled, from less than $300 million in 1995 to $1.1 billion in 2004. See **Exhibit 1** for details on these and other measures. The U.S. Patent and Trademark office granted 3,800 patents to universities in 2004 (2% of the total); fewer than 250 patents were granted to universities in 1980 (less than 1% of the total).[4] While universities varied widely in their technology transfer activity, many experienced tremendous growth in their technology transfer activity during this period. Harvard University's FY 2004 licensing revenues ($23.7 million), for example, were nearly 1000 times larger than its licensing revenues in 1980 ($24,000).[5]

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Some successful licensing deals delivered spectacular results and generated national publicity. Notable examples of high profile licenses involved the University of Florida, which earned $93 million from Gatorade-related patents (over a 20-year period); Stanford University which earned more than $220 million from a gene-splicing patent (recombinant DNA) and reaped $336 million from stock it received in a licensing arrangement with Google for a patent on page-ranking technology; and, Emory University, which received $540 million for its equity stake in the HIV-drug Emtriva. Local politicians were beginning to take notice of these financial windfalls and increasingly looked to universities to spur regional economic development.

Despite the publicity surrounding these success stories, multi-million dollar licensing deals were relatively rare, and tended to occur among a handful of universities. Less than 1% of active licenses generated royalties in excess of $1 million (e.g., only .6% of almost 21,000 active licenses in 2000 generated royalties in excess of $1 million).[6] Truly valuable licenses were rare, according to Mark G. Edwards, an industry expert.[7] And many technology transfer offices based in U.S. universities failed to cover operating costs related to licensing activities.[8]

Many factors influenced a university's ability to transfer and successfully commercialize its research. Internal factors included the strength and focus of the university research base: leadership, incentives, and rewards: history and strength of corporate relations with the university and research units; and the entrepreneurial climate. External factors included the availability of angel and seed capital, laboratory and incubation space, legal assistance, management capacity building resources, and networking opportunities.[9]

The ultimate aim of university licensing, at least for the university, was the delivery of some public benefit. This aim was typically stated explicitly in mission statements connected with a university's technology transfer office. Phillip Pizzo, Dean of Stanford Medical School, noted that technology transfer at U.S. universities had made great strides in achieving public benefits of various kinds, especially in the biotech sector:

> Some 1,000 therapies and technologies are based on university-licensed discoveries. Many of these are in the life-sciences products and processes for diagnosing disease, reducing pain and suffering and prolonging lives. They include the development of recombinant DNA technology, the nicotine patch, the PSA test for prostate cancer, the cochlear implant, which provides a sense of sound to people who are deaf.[10]

A Brief History of Technology Transfer

University research received a big boost in the post-World War II era. In November 1944, as World War II was winding down, President Franklin Delano Roosevelt asked the head of the wartime Office of Scientific Research and Development, Vannevar Bush, to answer the question: "What can the Government do now and in the future to aid research activities by public and private organizations?"[11]

Bush's brief report, *Science: The Endless Frontier*, urged the federal government to become much more involved in funding university research, especially in areas related to military applications and basic research.[12] Widely acclaimed, Bush's report led to the establishment of the National Science Foundation[13] and became an influential policy guide for several decades. Throughout the 1950s and 1960s, federal research dollars flowed into universities, which in turn expanded graduate departments and built new facilities. During the early part of this period, most federal research dollars came from the military or mission-oriented organizations, such as the Atomic Energy

Commission. In 1957, 84% of federal research funds were directed for military purposes.[14] By the early 1960s, however, the National Institutes of Health had overtaken the Department of Defense as the largest single funder of university research.[15]

Throughout the 1950s and 1960s, federally funded, university-based research was seldom commercialized.[16] One reason was that federal research funds came with certain conditions: any university discovery or patent based on federally-funded research became property of the United States, unless the university pursued a cumbersome exemption process. From the standpoint of industry, few companies wanted to invest in university technologies to which they did not own the patents. From the standpoint of academia, many universities avoided the patenting process, as a prevailing attitude in the academy at the time was that patents might corrupt the intellectual commons and impede the free exchange of ideas.

Of course, some universities had been patenting and licensing their discoveries for many years, since at least 1912 when faculty at the University of California, Berkeley set up the Research Corporation, an independent nonprofit organization that filed patents and licensed patents on behalf of faculty and universities. Frederick Cottrell, a founder of the Research Corporation, believed that an organization independent of the university would help avoid the "danger" of "secrecy in scientific work" at universities.[17] Some universities created internal organizations to oversee licensing activity, with varying degrees of restrictions over what could be licensed.[18] While most universities lacked patent policies prior to World War II, many universities had some kind of policy that restricted the pursuit of medical-related patents. Harvard University, for instance, prohibited its faculty from pursuing patents for health-care inventions. According to a Harvard policy adopted in 1934, "No patents primarily concerned with therapeutics or public health may be taken out by any member of the University, except with the consent of the President and Fellows; nor will such patents be taken out by the University itself except for dedication to the public."[19]

During the 1970s, federal funding for basic research at universities dropped off, as federal monies were channeled into the Vietnam War and Germany and Japan emerged as economic threats. "The old Cold War view that U.S. scientific and technological supremacy depended on a strong federal commitment to *basic* (emphasis added) science and advanced education gradually lost its vitality," wrote one observer. The decline in federal funding led to more aggressive patenting efforts among universities.[20] At the same time, federal officials began seeking ways to promote industrial applications of university research. Under the auspices of the NSF, the government supported a series of industry-university alliances, including the University-Industry Cooperative Research Program, which offered grants to faculty that received funding from corporations. The hope was that this kind of sponsored research would promote development of inventions more relevant to the economy. According to some, government officials had serious doubts about the economic productivity of government investment in basic research. One observer noted:

> A 1979 audit of government-held patents showed that fewer than 5% of some 28,000 discoveries—all of them made with the help of taxpayer money—had been developed, because no company was willing to risk the capital to commercialize them without owning title. "Discoveries were lying there, gathering dust," says [Senator Birch] Bayh today [1995], from his office at the Washington law firm Venable LLP. "So the taxpayers weren't being protected. We'd spent $30 billion in research for ideas that weren't helping anybody."[21]

By 1980, several factors were delivering a new boost to university research. Jennifer Washburn, author of *University Inc.*, a book critical of commercialization at U.S. universities, remarked:

> By the late 1970s, several concurrent developments—the leveling off of federal science and technology spending, the birth of biotechnology, the emergence of a new knowledge-driven

economy—had converged to align the interests of universities and industry as never before. To consummate this marriage, however, more than overlapping interests were needed. A legal and political mandate from Washington was also required. It came, in 1980, in the form of an obscure yet profoundly influential piece of legislation called the University Small Business Patent Procedures Act, later known as the Bayh-Dole Act.[22]

In a single stroke, the Bayh-Dole Act transformed the ability of universities to commercialize faculty inventions. It gave universities ownership rights to discoveries made with federal funding, and allowed universities to grant exclusive licenses to business for use of these discoveries. To enable the movement of technology into the commercial realm, the government also urged universities to create technology transfer offices to manage the commercialization of federally-funded, university-based research (via the Stevenson-Wydler Act).

At the time, the Bayh-Dole Act was controversial. Proponents argued that exclusive licensing was critical to advancing U.S. competitiveness on the global stage. Opponents charged that the bill amounted to a give away of tax-payer funded research, or worse that it was tantamount to charging tax-payers twice, once for funding the creation of the research and then for the higher prices that come from the company's monopoly control over the good. Other critics were concerned that the law would have a deleterious impact on the public domain of knowledge.[23] The Bayh-Dole Act was ultimately passed on congress's last day in session.

There is little doubt that Bayh-Dole had an impact on both university licensing practices and, more broadly, the relationship between industry and the university (though the extent of this impact remains a matter of some debate). In 1980 only 25 universities had technology transfer offices; a decade later 200 such offices existed.[24] Startups based on university inventions jumped five-fold between 1980 and 2000: from an average of .54 per institution in 1980 to 2.39 per institution in 2000.[25] The number of patents assigned to universities and number of licensing agreements between firms and universities also jumped.

Technology Transfer after Bayh-Dole

Several trends supported the growth of university-based technology transfer. Some universities invested their own funds in start-ups that utilized their own home grown technologies. This approach had mixed results. Carnegie Mellon University for example made $25 million from its successful investment in Lycos, while Boston University lost $100 million in the failed biotech venture, Seragen.[26]

Some universities, such as MIT, encouraged spin-off companies but did not invest their own funds. MIT spin-offs tended to begin as modest enterprises, often overseen on a part-time basis by university faculty. Some failed outright and are all but forgotten. Others did not live up to their initial promise but spawned a host of follow-on firms. A substantial number, however, including Raytheon (whose co-founder was Vannevar Bush), Thermo Electron and Bolt, Beranek and Newman, proved to be enduring sources of job growth. At MIT, officials presented promising technology to venture capitalists with whom they had informal working relationships. Relying on venture capitalists allowed MIT to avoid the costly mistakes that occurred at other schools when university officials, isolated from market forces, made repeated rounds of investment in firms developing unfeasible technologies.[27]

Another trend was the expansion of industry-based sponsored research, led by investments from the biotech sector. Industry often funded university research in exchange for the rights to license commercially useful discoveries that were made using targeted research funds. Between 1991 and 2005, industry research at U.S. universities tripled from $1 billion to nearly $3 billion. Some universities explored long-term global agreements with single corporate entities. These helped finance new facilities and diminished conflict between laboratories with different corporate sponsors. Many of these multi-year agreements were worth more than $20 million. See **Exhibit 2** for selected 2004 data on universities with the highest sponsored research expenditures. Several examples are notable. In 1981, Germany-based Hoechst, then one of the largest chemical companies in the world, reached a $70 million, 12-year agreement to fund molecular biology research at Massachusetts General Hospital, a teaching hospital affiliated with Harvard University. In 1982, Monsanto reached a $24 million five-year agreement to fund biomedical research at Washington University. The arrangement was renewed repeatedly, and by 1994, Monsanto had contributed $100 million to biomedical research at Washington University. In 1985, Georgetown University signed a $65 million agreement with an affiliate of the Italian pharmaceutical maker Fidia S.p.A.[28]

These large, long-term agreements were by no means restricted to the biotech sector. In 2002, Stanford signed a 10-year, $225 million agreement with Exxon Mobil, General Electric, Schlumberger and Toyota to create and finance the Global Climate and Energy Project, an initiative to research low-greenhouse-gas emission technology. In 2000, Princeton University signed a 10-year, $20 million agreement with Ford and BP to research climate change and reduce/capture carbon dioxide emissions via the Carbon Mitigation Initiative. Clemson University received its largest cash donation ever—$10 million—from BMW to jumpstart a $1.5 billion automotive research center.[29]

A third trend, patent pools, occurred primarily in engineering-related sectors unrelated to healthcare. One of the more successful university-industry patent pools was formed in 1997, when Columbia joined industry partners such as Sony to form a patent pool related to MPEG-2 technology.

Many businesses, of course, did not license technology from universities. A 2002 survey examined 182 companies that had not licensed technology from any university between 1993 and 2000.[30] While many companies in the survey preferred to develop their own technologies, the survey also indicated that these firms had issues with both available university technology and technology transfer offices:

> The company deems university technologies to be too early and too underdeveloped; or the company rarely found university research that was relevant to their lines of business. Some firms not licensing from universities also indicate a discomfort with imposed limitations on the degree of control they would be able to acquire over a university technology. They cite policies limiting firms to license rather than acquire outright ownership of patents and point to professors' tendencies to publish related research results without delay. Other firms report that they feel university negotiators hold unreasonable expectations over the value of their inventions, underestimate the cost of further R&D required, and as a result, hold out for too much on licenses. Most fundamentally perhaps, firms feel the clash of cultures, not fully understanding or tolerating the university's lack of business culture. They report that university technology transfer is overly complex, cumbersome and bureaucratic, or that OTT [Office of Technology Transfer] staff seem inexperienced and unprofessional, failing to treat them as valued customers.[31]

University Licensing Infrastructure

Universities and affiliated medical schools often created departments specifically devoted to the complex issues surrounding sponsored research and technology transfer. In many universities, the so-called Office of Sponsored Research (OSR) became a close working partner with the university's

Technology Licensing Office (TLO). The OSR was an internal university-based watchdog that monitored industry-university partnerships. The statement below, from the Harvard TLO website, describes one of the main issues that face OSRs and TLOs when they negotiate an Industry Sponsored Research Agreement (ISRA or SRA):

> Negotiation of an ISRA is a balancing act. Industry and academia in the long-run are at cross-purposes; academia champions the free and open exchange of ideas, results and data, while industry, concerned with competitive advantage, prefers to protect its information. Yet, in the short-term, the interests of both parties may overlap in a certain area of research, and a company may agree to fund such research in return for certain rights.[32]

Representatives from both the university and industry sought equitable intellectual property arrangements in a sponsored research agreement. The statement below—also from Harvard's TLO website—discusses the main areas of negotiation covered in a sponsored research agreement (SRA):

> Typically, a university retains ownership of an invention arising from the funded research and offers the sponsor company an option to negotiate for an appropriate commercial license to those inventions. Ownership by the University is an important issue that is sometimes contested by companies (i.e., the company would like to own any inventions arising from the funded research). Relinquishing ownership also relinquishes any control the University may be able to exert to ensure that the Harvard inventions are developed and introduced into public use as quickly as possible. It also means that the inventor may not be able to use his/her own invention in his/her own research without the permission of the company. Other points of negotiation include the length of the option period, terms for the license agreement and what non-royalty-bearing rights a company may have to use inventions deriving from research they have funded. Although some of these negotiations may be protracted, the University and the company are almost always able to reach acceptable intellectual property terms.[33]

The Modern Office of Technology Transfer[1]

The modern Technology Transfer Office (TLO) served several functions: It set policy for acceptable relationships between university researchers and the private sector. It was responsible for negotiating technology licensing arrangements, SRAs and material transfer agreements (MTAs), which allowed researchers at one institution to use materials, such as stem cell lines, from another institution. TLOs became the main point of contact with university inventors. These offices offered guidelines to faculty on how to submit their reports of invention, and managed the entire patent process, a time-consuming, labor-intensive, and expensive activity that involved numerous parties and several stages. See **Table A** for a brief description of the patent process and the **Appendix** for a description of the entire technology transfer process. Finally, these offices monitored the progress of licensing agreements; including, monitoring royalty and other fee payments, watching for patent infringements, and ensuring that licensees developed the intellectual property that they had licensed.

TLOs ranged in size and expertise; at some of the larger universities, technology business directors or licensing associates had expertise in the technologies they managed. On average, a technology transfer office generated $8 million in revenues, though 79% earned less than $5 million. And half reported income less than $824,000.[34] TLOs below the median had, on average, four employees.[35]

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[1] Universities have various names for their respective technology transfer offices. We adopt the convention of referring to Technology Transfer Offices as Technology Licensing Offices, or TLOs.

Table A Patent Process

Activity	Description
1. Report of Invention	When an inventor or creator submits a "disclosure" form describing the innovation to the Technology Licensing Office (TLO). The disclosure briefly describes what it does, what platform(s) it has been developed to run on etc.
2. Decision to File for Patent	The TLO investigates the invention to determine whether to invest funds to patent it. U.S. patents cost from $10,000-30,000 each and filing for equivalent foreign protection can increase the ultimate cost several-fold
3. Patent Application	If decision is made to file an application, the TLO engages a patent attorney to work with the inventor(s) to write the patent application, file it in the U.S. Patent and Trademark Office, and follow it through the patenting process.

Source: Harvard Office of Technology Development.

All universities split income with inventors. Typically, the allocation of revenues was split between the technology transfer office, the inventor, and the inventor's school. Universities were comprised of a number of schools, and each had overhead that was covered by licensing revenues. Technology transfer offices incurred significant legal fees for patents, and licensing revenues were often used to cover these fees and the overall operations of the departments. According to one study:

> Universities gave an average of 40% of net income to the inventors and 16% to the inventor's department or school. Departments and schools often return their portion to the inventor's lab. For some universities, it is possible for as much as 75% of net income to be under the control of an inventor. On average, central administrations and TTOs take 26% and 11% respectively, of the income from licensing. Nearly 30% of administrations received no royalty income. Proceeds from the liquidation of equity are distributed differently from other revenue streams. 90% of universities allowed faculty to establish and operate businesses based on technology owned by the university but developed in the course of the faculty's own research.[36]

Substantial variation existed across universities in how royalties from license agreements were distributed to the inventor, the inventor's department and college, the inventor's laboratory, and to the university.[37] One report indicated that:

> The majority of inventions are at an early stage of development when they are licensed, and that inventor involvement in the process is important, not only for finding licensees, but also for further development once licenses are executed. Indeed, almost half of the inventions licensed are only a proof of concept at the time of license. It is not surprising then that the licenses executed include payment schemes that induce inventor involvement in development and do not obligate the licensees to large up-front payments. That is, agreements almost always include running royalties and small up-front fees, often include sponsored research and less frequently include equity positions in the licensee. Royalties generate the lion's share of revenue generated by university licenses.[38]

Technology Transfer Offices (MIT, Stanford & Harvard)

Massachusetts Institute of Technology (MIT)

From the time MIT opened its doors in 1865, its mission was to prepare students for "useful work." An orientation toward industry collaborations was embedded in MIT culture. The original mission of the school was to enable "the advancement, development and practical application in connection with arts, agriculture, manufacturers and commerce."[39] "It's a way of life here," said Lita Nelsen, the director of MIT's TLO. "The extent of MIT's entrepreneurial philosophy and culture is seen in few other universities except Stanford," one report observed.[40]

The MIT TLO was frequently cited as one of the most productive technology transfer offices of any U.S. university. According to the Milken Institute University Technology Transfer and Commercialization Index, for instance, MIT occupied the top spot, among all universities in North America (See **Exhibit 3a** and **3b** for selected details from the Milken Commercialization Index).[41] MIT was also one of the leading sources of new technology spin-offs in the greater Boston area. MIT faculty included co-founders of some of the earliest biotech companies (e.g., Genzyme, Repligen, Biogen, Amgen). Through 2004, MIT students, alumni and faculty had founded over 5,000 companies. Approximately 150 new MIT-related companies were founded each year. In total, MIT-related companies employed more than 1.1 million people and collected annual revenues of $230 billion.[42] Within the biotech sector, at least 45 U.S. biotechnology companies were founded or co-founded by MIT graduates or faculty, or had licensed important technology from MIT. These firms employed nearly 10,000 people and produced aggregate annual revenues of $3 billion, almost a quarter of the total annual revenues ($12.7 billion) of all U.S. biotechnology companies.[43]

MIT's success in technology transfer was attributed to a number of factors. According to Nelsen, "The most important factor in (MIT's) success is its strong research base. The pipeline for our technology transfer has primarily been basic research funded by the federal government."[44] MIT had had great success in obtaining government funding. In FY 2003, MIT's R&D expenditures totaled $472 million, of which 75% came from federally funds.[45] Success with obtaining government grants depended on the quality of MIT faculty, which included 10 Nobel Prize winners.

MIT's organization and infrastructure promoted collaborations among researchers and industry. MIT's Entrepreneurship Center in the Sloan School of Management offered a wide range of courses and initiatives such as the $50K Competition—a business competition that involved business plan workshops and mentoring, and student internships with start-up and venture capital firms. The MIT Enterprise Forum, an affiliated nonprofit organization, provided training and forums that linked MIT entrepreneurs with potential investors in areas all over the globe. The Deshpande Center, with a $20 million endowment, provided faculty with grants that advanced research from the idea to innovation stage. MIT's Office of Corporate Relations provided an entry point for industries that wanted to sponsor and gain access to research. Its Industrial Liaison Program enabled member firms to draw upon MIT faculty and researchers to enhance their technology strategies, and also helped faculty members stay abreast of the latest developments in industry.[46]

In the 1970s, MIT began creating a technology park, developing an abandoned factory adjacent to its main campus in East Cambridge. Later, it added six additional buildings to form the Tech Square complex, which it leased to various businesses, many with ties to MIT. "When you look at the reason many companies are here in Massachusetts, it's because of MIT," said Scott D. Sarazen, senior vice president for MassDevelopment, the state's economic development authority. "It's a direct result of technology that started at MIT."[47]

MIT TLO MIT first hired someone part-time in 1940 to work on technology transfer in what was then called the Patent Office. In 1983, the office became the TLO. Nelsen arrived three year later, and became its director in 1993.

In 2004, the MIT tech transfer office had a 30-member staff, and handled 450 invention disclosures from the main MIT campus.[48] Staffing included 11 Technology Licensing Officers and Associate Technology Licensing Officers, four Technology Licensing Associates who assisted the Officers, four financial operations staff, seven information and operations staff, and four administrative staff. Many of the Officers had worked with TLO for 10 or more years. The department hired outside counsel to file patents.

MIT TLO Officers had a close working relationship university researchers, and were able to help identify commercial opportunities at an early stage. Nelsen and her Officers also had ongoing, close, informal relationships with many venture capitalists. These relationships were a key element in forging partnerships with industry. "What Lita's really great at is matchmaking," said Irene Abrams a licensing officer who had worked with Nelsen for 13 years.[49] Nelsen agreed with the match-making description:

> People come by—VCs, entrepreneurs, people looking for technology. And she'll introduce them to the inventors and get them talking." We do have people beating on our doors saying, "What have you got that we might be interested in? And that can be existing companies or venture capitalists looking to invest in the next new thing. . . ." We say "You ought to go talk to Professor X, because he has a technology on which we have a patent. If you fall in love, then we'll negotiate a license agreement." Sometimes we call ourselves a high-tech dating service.[50]

Other success factors included: clear straightforward policies and an open door; smart people and good delegation; top-notch basic research; a rich entrepreneurial environment; money as a bi-product, not the focus; articulated support from the President and academic leadership. In fact, during his tenure as MIT president (1990–2004), former MIT President Charles Vest was outspoken in his support of university-industry linkages:

> [W]hen companies provide large financial support, the university gains effective access and working relationships with their leaders and best thinkers; that interdisciplinary and inter-school programs can be successful; that knowledge transfer from academia to industry can be accelerated; and that academicians can contribute directly and effectively to solving problems posed by today's industry that are stimulating, challenging, and important.[51]

Stanford University

Like MIT, Stanford University had a long history of collaborations with industry. Discoveries made at Stanford contributed to the creation of nearby Silicon Valley. Hewlett Packard, Genentech, Cisco and Google were just some of the many high profile companies associated with Stanford University technologies.

Stanford University's TLO was established in 1969 by Niels Reimers, then-associate director of Stanford Sponsored Projects Office. Like many other universities at the time, Stanford relied on the New York-based Research Corporation to license university-based inventions. Reimers discovered early on that licensing revenues from Stanford technologies between 1954 and 1967 totaled less than $5,000.[52] Reimers believed he could do "better," and proposed a technology licensing program.[53] In its first (partial) year, Reimers's office took in roughly $55,000.[54] Under Reimers, the Stanford TLO pioneered the marketing approach to technology transfer. This approach encouraged faculty to promptly disclose inventions, the TLO evaluated their market value, obtained intellectual property protections, and pro-actively identified licensees for those inventions. Stanford Provost William Miller provided key support to the TLO during the 1970s, an era in which many academics questioned the deepening connections between industry and university. One of the many successful outcomes of the Stanford TLO was the Cohen-Boyer recombinant DNA patent, which the office licensed to many parties. This license became the largest source of licensing revenue at the Stanford TLO over the term of the patent's life. During this period, it was also one of the most lucrative licensing deals by any university.

Stanford TLO In its 2005-2006 annual report, the Stanford TLO reported that it grossed $61.3 million in licensing royalties (2005-2006), executed 109 new licenses, and had 470 income-generating technologies.[55] It spent $5.7 million on legal expenses. The Stanford TLO comprised a Director and 28 staff members, including licensing associates, liaisons, a full-time compliance expert, accounting staff, and several industrial contract officers. Licensing associates had specific science or technology backgrounds and business experience, and were dedicated to particular disciplines. The Stanford TLO Director reported to the Stanford Dean of Research.

The success of Stanford University's technology transfer program was supported by an entrepreneurial culture that accommodated and supported faculty involvement with industry.[56] Beginning in the 1990s, faculty with, and without, tenure were allowed to take leaves of absence to start businesses or work in a company. The entrepreneurial culture even extended to the students. In 1996, Stanford launched a privately-funded Stanford Technology Ventures Program (STVP) that offered courses, seminars, mentoring and internships for engineering and science students. Its Mayfield Fellows Program provided a nine-month work-study program, in which a dozen undergraduate students attended courses on managing technology ventures; performed a paid internship at a start-up company and received mentoring and participated in networking activities. Also begun in 1996 was the Business Association for Stanford Engineering Students, one of the largest entrepreneurship organizations in the nation with over 5,000 members; half were students and Stanford faculty; the other half were alumni, entrepreneurs, executives, venture capitalist and service providers in the community. The Association sponsored not only three student-run business plan competitions, but also networking opportunities within the University and surrounding areas. "Most technology transfer activities focus on faculty. The STVP focuses on students—we are teaching students to have an entrepreneurial mindset that will help them at some point later on when they go to start a business or work with someone else who has started a business," said Tina Seelig, Director of STVP.[57]

Unlike MIT, Stanford had a medical school at which faculty conducted biomedical research. The Stanford TLO coordinated all licensing activity at its medical school. Stanford had clear conflict of interest guidelines regarding medical faculty relations with industry. The Stanford School of Medicine website listed tips for researchers on how to avoid conflicts of interest involving: consulting, advisory boards, board of directors, stock or stock options, licensing arrangement, company founder, loans, talks, and gifts.[58] A selection from the school's industry interactions policy is presented in **Table B** below. Enacted in October 1, 2006, this policy followed the lead of several other schools, and was one of the most far reaching of its kind by any medical school.

Table B Stanford University: Industry Interactions Policy

If you are a Founder

- It is assumed that you have both an intellectual and financial commitment to the company, however, your primary commitment is to the University and your commitment to the company should not conflict with that obligation or conflict with any other university rules or regulations.
- **You cannot serve in a management capacity for the company while a Stanford employee.**
- You must not provide the company with early or exclusive access to the results of your research, unless those results come from a sponsored research project with the company.

Your relationship to the company should not interfere with your primary obligations as a faculty member or University employee or conflict with any other university rules or regulations.

You must keep your financial interests separate from your research and University obligations in order to:

- Protect your students, trainees, and others whom you are responsible for directing, from undue influences or the compromise of academic freedoms;
- Preserve the integrity of the research;
- Cause no harm to human subjects used in your research; and
- See that any creations or discoveries that arise during the course of your research or scholarly activities are not pipelined to the company, and are disclosed in a timely fashion to the Office of Technology Licensing; and not allow your relationship to compromise the free exchange of ideas or delay or prohibit publications arising from your University activities.
- You must disclose this relationship in publications and public discussions of any of your research that is sponsored by the company or related to the company.

Source: Stanford University website. http://med.stanford.edu/coi/founder.html, accessed January 12, 2007.

Harvard University

Like MIT and Stanford, Harvard had many faculty with a record of success obtaining funding from federal sources and publishing in the academy's most highly-regarded publications. However, Harvard's overall ranking (18th) in the Milken Commercialization Index was much lower than the ranking of either MIT (1st) or Stanford (4th), and Harvard ranked 24th out of the top 25 universities in terms of developing start-ups (see **Exhibit 3a** and **3b**).

From an institutional perspective, Harvard had few formal systems that linked its scientific faculty with industry. For instance, Harvard had no institution comparable to the Deshpande Center (MIT) or the Business Association for Stanford Engineering Students. From a cultural perspective, Harvard was continuing to define its relationship with market forces. "Harvard, if you go way back, was quite ambivalent about whether they should be doing this kind of stuff—soiling the ivory tower with the grubby fingerprints of industry," said Lita Nelsen, MIT TLO director.[59] In fact, during the late 1970s and early 1980s when Harvard was trying to develop a formal technology transfer program, the university had difficulty cultivating faculty interest in filing reports of invention. Joyce Brinton who was the full-time director of Harvard's TLO from 1984 to 2005, explained:

> A majority of faculty did not even think about the commercialization process. There was also a contingent that felt that commercialization was wrong: that patents were monopolies and that monopolies were bad and against the public interest. That antipathy lasted until the

> late '80s. In the 1980s, many conversations with faculty followed the same script. A licensing associate from our office would go to meet with a faculty and the first thing the faculty would say is: "I don't invent. I do basic research. So, what do you want to talk to me about?" It took quite a bit of time to get to the point where there were faculty who were not only interested in making the kinds of discoveries that would bring a Nobel, but were also interested in seeing that those discoveries turned into something that would make a difference in the "real world." Harvard prided itself on being an ivory tower, and the faculty reflected that. A lot of the work in those early years, from the late 1970s until the late 1980s, was nurturing that change in view; letting people know that there was a channel.[60]

Harvard TLO Harvard established its TLO in 1976. The office was originally staffed with three part-time employees. The initial goal of the office was to organize knowledge about ongoing research; evaluate opportunities for commercialization; and, "more importantly, to assess whether faculty could be convinced that commercialization was worth devoting some time and effort to," said Brinton.[61] (See **Exhibits 4** and **5** for details on selected Harvard technology transfer activities through 2004.)

With the emergence of the biotech sector, faculty attitudes toward commercialization began to change and Harvard expanded its technology transfer program. However, several issues dogged Harvard's technology transfer activities throughout the 1980s and 1990s. One issue was conflicts of interest, both real and perceived, that emerged between Harvard researchers and their financial stakes in companies that supported their research—several incidents made headlines in papers across the country. One particularly noteworthy example concerned Harvard Professor Walter Gilbert, who founded Biogen to commercialize the cancer-fighting drug, interferon, and a host of other biotech products.[62] He was openly criticized for his commercial focus by other academics, inside and outside of Harvard. The Harvard administration saw a conflict of interest between Gilbert leading a company and being a Harvard professor, and offered Gilbert a choice: keep his tenured position at Harvard or resign his position as CEO of Biogen.[63] Gilbert decided to leave Harvard. Two years later, Gilbert won the Nobel Prize for biology (1980). Four years later, he resigned from Biogen and returned to Harvard.

Another issue was intellectual property protection, an issue that also challenged many other schools. In one instance, Harvard agreed to a sponsored research arrangement with the biotech firm Cambridge BioSciences, which intended to sponsor research in Professor Max Essex's Harvard School of Public Health laboratory, and license AIDS-related inventions from Essex's lab. Soon after, Cambridge BioSciences went into bankruptcy, and the AIDS technology became ensnarled in a legal battle. Brinton described what happened:

> After discussions with the inventors, the then-Dean, the then-General Counsel, and the then-President, it was ultimately decided that Harvard would bring a suit [against a company to whom Cambridge Biosciences had sublicensed the technology]. It became a very complex legal business. There is nothing as awful as having a technology from a university tied up in a bankruptcy. Nothing. Ultimately the suit was settled in Harvard's favor, but it had several long-term impacts. First, it colored a number of peoples' attitudes toward working with business and Harvard at the same time. Second, the school learned that it sometimes had to be aggressive in its dealings with industry to protect development of its intellectual property. Third, sometimes creative solutions don't work as expected if the business partner is not chosen well. The stakes tend to be very high with School of Public Health discoveries that have great potential for alleviating suffering in the Third World. That's why the demise of Cambridge BioSciences was so difficult: a significant public good was tied up in a bankruptcy for years. No one was happy about that.[64]

By the 1990s, it was apparent that Harvard's approach to technology transfer differed in several respects from that of other leading universities. For instance, unlike other universities with successful TLOs, Harvard had a relatively fragmented technology transfer organization. Harvard had (until 2005) two main technology transfer offices: one was associated with Harvard Medical School and the other managed technical transfer activities at all of the other schools comprising Harvard University. In addition, each Harvard-affiliated teaching hospital had its own technology transfer office. It was more common for a university to have a single office coordinating technology transfer activities.

Another difference between Harvard and other universities was its lingering cultural attitudes toward commercialization. Former Harvard University president, Derek Bok, professed a concern that resonated with some elements of Harvard's faculty body in his 2003 book *Universities in the Marketplace,* "I worry that commercialization may be changing the nature of academic institutions in ways we will come to regret. By trying so hard to acquire more money for their work, universities may compromise values that are essential to the continued confidence and loyalty of faculty, students, alumni, and even the general public."[65]

In 2005, then President Larry Summers and Provost Steven Hyman made technology transfer a priority, and Harvard hired Isaac Kohlberg, then the CEO of Tel Aviv University's Economic Corporation and its Technology Transfer Organization. The focus on technology development—not simply technology transfer—meant that the organization had several new areas of emphasis. Kohlberg explained:

> I want my staff to be much more involved in the technology; understand at a basic level what professors are doing in their labs and help them form collaborations with other researchers, either within the institution or at other institutions. Another way to become more involved in the technology is to become better at putting technologies together internally. One of my business directors may have some chemical technologies from FAS [Faculty of Arts and Sciences] that really fit well with the technology of another business director who covers the medical school. If we are better at bundling the patents and technologies, we can add value either by starting up a company or by creating a more valuable package of technologies to license to some pharmaceutical company.[66]

Under Kohlberg, the Harvard Medical School TLO was merged with the main campus TLO, the name of the department was changed to the Office of Technology Development to reflect the department's focus on identifying, nurturing, and guiding technologies to market. Kohlberg also increased outreach to faculty and industry, created a multi-million dollar accelerator fund to help inventors develop basic research into technologies that could draw commercial interest, and hired new staff with business and sector expertise backgrounds. Despite his belief that the Harvard OTD was on its way to joining MIT and Stanford as an elite TLO, Kohlberg described several obstacles that remained in his path:

> Anyone who wants to achieve success in the technology transfer business has to manage faculty or principal investigators that do not report to him or her. So, my success is measured in part on licensing revenues that come from inventions that are patented by my office, but those revenues ultimately depend in a significant way on people over whom I have no authority. Obviously, that is a situation that will not and should not change. However, it is a serious constraint, especially at Harvard where we are continuing to change the attitude toward commercialization among our faculty researchers.[67]

The Bayh-Dole Debate (in 2006)

The increasing role of technology transfer activities was generating widespread debate over the impact of Bayh-Dole. Was Bayh-Dole interfering with technology transfer? Were technology transfer offices becoming profit centers? Was Bayh-Dole abetting a corrosion of the intellectual commons? And finally, were financial incentives from licensing diverting faculty from basic science?

Some opponents of Bayh-Dole pointed out that the legislation had failed to increase technology transfers into certain sectors, such as semi-conductors, where it was relatively easy to innovate around patent constraints[68] and interfered with the development of new technologies in the life sciences. In 2004, leaders of medical schools and industry from across the country met at a conference hosted by the Federal Drug Administration and agreed that increased patenting activity among universities in the life sciences had become a "roadblock to the drug development process."[69] Moreover, a *New England Journal of Medicine* survey of 210 biotechnology company executives found that 34% had "disputes with their academic partners over intellectual property."[70] By 2004, overall industry research spending at U.S. universities had become volatile and leveled off, as increasingly complex products requiring multiple licenses and the potential for lengthy negotiations with universities appeared to be diminishing overall industry interest in sponsored research.[71]

While technology transfer centers had yet to become profit centers on many campuses, critics alleged that TLOs were aiming to become profit centers. "Universities have evolved from public trusts into something closer to venture capital firms. What used to be a scientific community of free and open debate now often seems like a litigious scrum of data hoarding and suspicion," wrote Fortune magazine.[72] Within the academy, some faculty were refusing to share research results with one another, sometimes due to restrictions explicit in the sponsored research agreements that financed their findings or because of their own personal interests in companies that might benefit from their research. In one study, a Harvard Medical School professor, Eric Campbell, found that 21% of geneticists who withheld information from other researchers cited the "need to protect the commercial value of results."[73] Another study indicated that 27% of university licenses include clauses that allow deletion of information from papers before submission and 44% ask for publication delay.[74] A growing body of literature suggested that faculty with industry ties were more likely to report research results favorable to their corporate sponsor, were more likely to conduct lower quality research, and were less likely to disseminate their results to the scientific community.[75]

Financial incentives had a mixed impact on faculty-related commercial activity. On one hand, there was little evidence that financial incentives from licensing altered faculty research agendas. Authors Jerry and Marie Thursby, academic experts on technology transfer, discussed their research on the topic in a 2003 article in *Science*: "Studies of technology transfer from the University of California, Stanford, and Columbia find little evidence of either changes in research direction or financial return as a major motive for the research. A study of over 3400 faculty at six research universities from 1983 to 1999 suggests that the portion of research that was basic has not changed even though licensing increased by a factor greater than 10."[76] Another study offered a different perspective on financial incentives: Lach and Schankerman found that universities that granted higher royalty shares to academic faculty generated more inventions and higher levels of license income.[77]

By 2006, the impact of Bayh-Dole on U.S. universities and industry remained an open question and a growing source of debate. It was not clear what if anything could or should be done to change the law, which merely permitted (and did not require) exclusive licensing by U.S. universities. One possibility concerned a little noticed provision in the law that granted the federal government royalty-free use of any invention or discovery made with federal funds.

Conclusion

University-based technology transfer activities were often associated with commercialization. This was due, in part, to the increased focus by universities on moving their discoveries into the marketplace, but it also reflected the lack of participation of nonprofits in university-based technology transfer. “We have yet to see technology transfer organizations embrace non-profits as partners in technology transfer, said Usha Balakrishnan, of the Centre for the Management of Intellectual Property in Health Research and Development.[78]

While technology transfer offices had solidified their roles as the main engine behind technology transfer activity at U.S. universities, these offices had had uneven success within various economic sectors. In the software industry, some software licenses, such as Stanford’s page-ranking technology license with Google, led to public benefit and delivered significant financial reward to Stanford, inventors and Google, but blockbusters license deals in the software sector were few and far between. In the semi-conductor industry, there were few if any blockbuster license arrangements since products that incorporated semi-conductors had become so complex and required so many different technologies that the value of any individual semi-conductor related patent was low. Within the biotech sector, which encompassed a wider range and higher probability of high-value licenses, there was a growing concern that university licensing practices were actually interfering with drug development.

At a January 2004 meeting hosted by the FDA, leaders of medical schools and industry agreed to take steps to better define, and find ways to share, “precompetitive” research findings. They also promised to explore ‘pooled’ patents, already used by the information-technology industry, which grant broad access to entire suites of them at once. “We’ve grown up expecting a certain return on investment in pharmaceuticals, and it isn’t happening,” says Frank Douglas, director of the newly established Center for Biomedical Innovation at MIT. “People are beginning to question whether we’re using the right model. Douglas wanted more precompetitive ideas and research tools to be shared freely, without the need for licensing. “If we could get people to agree on what is considered precompetitive,” he says, “we might have a more rational approach to licensing fees and royalties.”[79]

According to former MIT president Vest:

> A common concern is whether such major interactions [with industry] and support distort the mission of the university. Good people may well disagree on this. My own view is that they expand the intellectual opportunity space in which some faculty and students engage in a very positive way, and that faculty will not permit anything they consider to be distortion. A faculty-wide survey and study of the partnerships was conducted in 2002, and it concluded that while many people worried that such distortion might occur, no one could cite an instance in which they believed it actually had. . . .
>
> Despite my enthusiasm for meeting academia’s responsibilities as part of our national innovation system, I also believe that we must take great care as we develop new relations with industry so that universities do not assume a posture that is too utilitarian. In time this would erode their intellectual independence and their ability to serve as objective critics of society. Indeed, there is a paradox in that it is this very independence and objectivity that usually attracts industry to work jointly with academia. The right balance must be struck. As we work together in areas that have policy implications, such as the environment, energy, telecommunications, and productivity, we must maintain our independence and objectivity. Thus, it is in the best interests of both parties that these matters be addressed carefully and resolved.[80]

Exhibit 1 AUTM Licensing Survey Data: Aggregate Totals for Respondents in Each Year for Fiscal Years 1995–2004.

	Aggregate Totals									
U.S. Universities	**FY 2004 (N=164)**	**FY 2003 (N=165)**	**FY 2002 (N-156)**	**FY 2001 (N=142)**	**FY 2000 (N=141)**	**FY 1999 (N=138)**	**FY 1998 (N=131)**	**FY 1997 (N=131)**	**FY 1996 (N=130)**	**FY 1995 (N-126)**
Research Expenditures:										
Industrial Sources	$2,554,419,927	$2,538,760,737	$2,404,907,940	$2,246,204,230	$2,190,058,178	$2,220,382,848	$1,965,009,289	$1,780,184,084	$1,528,547,770	$1,354,926,040
Federal Government	25,159,914,841	23,062,609,472	20,202,036,829	17,658,541,447	15,899,295,875	15,011,952,207	13,659,954,553	13,026,416,130	12,311,036,157	11,335,384,435
Total Sponsored Research Expenditures	37,162,153,394	34,826,920,266	31,695,704,942	27,560,264,488	25,494,275,323	23,638,068,068	21,386,650,472	19,815,622,401	18,670,168,150	17,132,239,225
Licenses/Options Executed	4,087	3,855	3,739	3,300	3,585	3,304	3,078	2,696	2,203	2,119
Gross License Income Received	1,088,469,003	1,033,609,726	997,830,761	868,283,344	1,099,886,997	675,957,625	613,554,537	480,822,470	364,941,642	298,472,310
License Income Paid to Other Institutions	54,413,897	65,489,154	38,803,307	41,021,592	32,715,054	34,488,252	36,664,999	36,123,046	28,591,054	25,590,346
Licenses/Options Yielding License Income	9,543	8,976	8,490	7,715	7,518	6,683	6,006	5,635	4,949	4,241
Legal Fees Expended	189,190,568	176,278,483	158,835,514	133,005,995	117,927,842	100,528,535	100,722,531	90,769,499	74,580,021	58,865,922
Legal Fees Reimbursed	79,977,790	74,971,227	68,760,518	59,518,476	53,685,716	42,498,294	41,075,589	35,676,882	28,476,628	25,312,652
Invention Disclosures Received	15,002	13,718	12,638	11,259	10,701	10,062	9,555	9,003	8,099	7,317
Total U.S. Patent Applications Filed	12,347	11,755	10,632	9,454	8,534	7,618	6,518	5,557	3,858	5,026
New U.S. Patent Applications Filed	9,462	7,203	6,509	5,784	5,561	4,877	4,140	3,627	2,723	2,347
U.S. Patents Issued	3,268	3,450	3,109	3,179	3,222	3,082	2,681	2,225	1,767	1,518

Source: Compiled from the Association of University Technology Managers® (AUTM): U.S. Licensing Survey FY 2004.

Exhibit 2 Selected Data on University Technology Licensing, Sorted by Total Sponsored Research Expenditures

U.S. Universities	Year O.5 Prof. FTE Devoted to Tech. Transfer	Total Sponsored Research Expenditures	Invention Disclosures Received	New U.S. Patent Applications Filed	Licenses and Options Executed	Adjusted Gross License Income Received	Licenses and Options Yielding License Income	Legal Fees Expended	Legal Fees Reimbursed	U.S. Patents Issued	Startup Companies Formed
Univ. of California System	1979	$2,791,777,000	1,196	515	273	$74,275,000	906	$18,771,893	$9,678,734	270	5
Johns Hopkins Univ.	1973	1,594,724,410	367	402	100	6,321,110	197	5,592,103	3,652,988	89	5
Massachusetts Inst. of Technology	1940	1,027,000,000	515	287	134	25,781,923	410	9,743,678	5,103,258	159	20
Univ. of Washington/Wash. Res. Fdn.	1983	833,907,430	233	104	70	22,808,483	322	1,682,274	568,260	38	7
Univ. of Illinois, Chicago, Urbana	1981	813,740,000	262	108	88	5,793,914	164	3,182,745	590,526	59	16
Univ. of Wisconsin at Madison	1925	763,875,000	405	163	203	47,689,165	261	5,874,261	355,402	93	2
Univ. of Michigan	1982	752,527,056	285	149	73	10,633,528	172	4,778,991	3,175,810	74	13
SUNY Research Fdn.	1979	710,175,177	257	124	50	13,363,714	157	2,302,633	681,909	43	7
Stanford Univ.	1970	693,529,925	350	428	89	47,272,397	474	6,032,806	3,480,000	87	9
Univ. of Pennsylvania	1986	654,457,805	392	536	87	8,653,042	54	5,124,464	2,547,407	45	6
Penn State Univ.	1989	606,521,000	167	125	23	1,916,613	70	1,931,353	1,341,437	46	4
Harvard University	1977	590,592,500	160	73	50	16,654,975	253	4,048,714	2,678,605	35	4

Source: Compiled from The Association of University Technology Managers (AUTM) 2005 University Licensing Survey.

Exhibit 3a Milken Institute University Technology Transfer and Commercialization Index (2000–2004)

Rank	University	Patents Issued Score	Licenses Executed Score	Licensing Income Score	Startups Score	Overall Score
1	Massachusetts Institute of Technology (MIT)	95.17	79.89	90.64	100.00	**100.00**
2	University of California System	97.26	85.25	95.156	83.24	**96.59**
3	California Institute of Technology	100.00	70.00	87.12	86.60	**92.94**
4	Stanford University	91.56	84.28	93.76	77.02	**92.65**
5	University of Florida	84.82	71.41	92.57	69.26	**86.11**
6	University of Minnesota	78.92	77.46	91.02	69.24	**85.65**
7	Brigham Young University	66.87	80.60	86.13	77.57	**85.41**
8	University of British Columbia	74.36	74.09	82.73	77.42	**84.23**
9	University of Michigan	82.70	72.25	77.98	74.89	**82.54**
10	New York University	73.68	63.30	100.00	58.16	**81.63**
11	Georgia Institute of Technology	76.80	60.51	72.79	83.41	**80.95**
12	University of Pennsylvania	76.41	72.05	83.95	67.15	**80.83**
13	University of Illinois, Chicago, Urbana-Champaign	72.80	74.55	77.60	72.72	**80.35**
14	University of Utah	77.08	70.80	81.56	66.01	**79.40**
15	University of Southern California	70.77	79.81	70.37	75.72	**79.28**
16	Cornell Research Foundation, Inc.	86.31	75.99	77.99	61.51	**78.69**
17	University of Virginia Patent Foundation	66.53	75.11	79.41	68.48	**78.52**
18	Harvard University	78.82	76.06	87.54	52.45	**77.68**
19	University of California, San Francisco	88.60	11.63	99.73	62.39	**77.19**
20	North Carolina State University	78.41	73.80	74.40	64.77	**76.94**
21	SUNY Research Foundation	79.51	64.36	84.63	58.01	**76.90**
22	W.A.R.F./University of Wisconsin	87.59	86.65	90.52	38.99	**76.86**
23	McGill University	77.47	68.76	72.12	69.24	**76.80**
24	University of Washington/Washington Research Foundation	75.11	76.10	88.49	50.03	**76.54**
25	University of North Carolina, Chapel Hill	78.48	76.86	71.14	64.21	**76.00**

Source: Ross DeVol and Armen Bedroussian, "Mind to Market: A Global Analysis of University Biotechnology Transfer and Commercialization," Milken Institute, September 2006, p. 14.

Exhibit 3b Milken Institute University Biotechnology Publication Ranking, Top 50 (1998–2002)

Rank	University	Country	Biotech Publication by University Score	Activity Score	Impact Score	Overall Score
1	Harvard University, Cambridge	United States	100.0	74.7	63.3	**100.0**
2	University of Tokyo	Japan	84.9	77.5	43.5	**83.3**
3	University of London	United Kingdom	86.8	60.0	50.0	**83.1**
4	University of California, San Francisco	United States	54.5	83.0	63.8	**79.6**
5	University of Pennsylvania, Philadelphia	United States	51.8	77.2	55.9	**72.9**
6	University of California, San Diego	United States	42.0	72.8	64.5	**71.2**
7	Johns Hopkins University, Baltimore	United States	47.5	70.8	59.1	**70.8**
8	Washington University, St. Louis	United States	37.9	85.4	58.6	**69.4**
9	University of Washington, Seattle	United States	47.1	69.7	55.4	**68.4**
10	University of California, Los Angeles	United States	47.0	66.2	54.3	**67.0**
11	Yale University, New Haven	United States	37.5	74.5	59.0	**66.7**
12	Stanford University	United States	37.9	68.3	59.8	**65.7**
13	Rockefeller University, New York	United States	14.1	100.0	67.0	**65.3**
14	University of Wisconsin at Madison	United States	36.9	76.6	53.3	**64.0**
15	University of Cambridge	United Kingdom	34.6	67.4	58.2	**63.1**
16	Baylor College of Medicine, Houston	United States	30.5	80.9	55.3	**62.9**
17	University of Oxford	United Kingdom	31.8	72.6	58.1	**62.9**
18	Duke University, Durham	United States	31.5	72.4	55.8	**61.5**
19	Osaka University	Japan	43.4	69.2	45.2	**61.4**
20	Kyoto University	Japan	41.7	71.1	45.7	**61.2**
21	Massachusetts Institute of Technology (MIT), Cambridge	United States	27.4	60.2	64.2	**60.6**
22	University of Texas at Dallas	United States	25.8	77.5	56.8	**60.5**
23	Universités de Paris (I-XIII)	France	48.4	59.3	41.7	**59.7**
24	Columbia University, New York	United States	32.0	58.3	58.3	**59.5**
25	University of California, Berkeley	United States	32.4	54.1	59.8	**59.4**

Source: Ross DeVol and Armen Bedroussian, "Mind to Market: A Global Analysis of University Biotechnology Transfer and Commercialization," Milken Institute, September 2006, p. 11.

Exhibit 4 Harvard Technology Transfer Activities

Summary of Technology Transfer Activity

(Fiscal Year 1999 through Fiscal Year 2004)

Reports of Invention

	1999	2000	2001	2002	2003	2004
FAS	40	41	52	59	49	86
HMS & HSDM	54	64	81	55	50	58
HSPH	13	21	17	18	15	13
Other	2	7	8	8	4	3
Total	109	133	158	140	118	160

Cases Licensed or Optioned

	1999	2000	2001	2002	2003	2004
FAS	17	30	35	51	45	19
HMS & HSDM	34	31	43	26	23	14
HSPH	7	8	15	8	5	12
Other	2	2	2	2	1	2
Total	60	71	95	87	74	47

U.S. Patent Applications Filed

	1999	2000	2001	2002	2003	2004
FAS	30	23	42	28	24	39
HMS & HSDM	32	29	39	28	26	32
HSPH	10	12	6	0	4	3
Other	0	0	2	3	0	0
Total	72	64	89	59	54	74

Licenses & Options Granted

	1999	2000	2001	2002	2003	2004
FAS	16	37	35	50	30	18
HMS & HSDM	28	31	38	26	25	16
HSPH	7	8	18	11	12	12
Other	3	2	3	2	1	2
Total	54	78	94	89	68	48

U.S. Patents Issued

	1999	2000	2001	2002	2003	2004
FAS	18	18	18	19	24	19
HMS & HSDM	39	30	12	29	21	13
HSPH	13	7	8	9	12	2
Other	0	0	0	0	0	0
Total	70	55	38	57	57	34

Revenues (Thousands of Dollars)

	1999	2000	2001	2002	2003	2004
FAS	1,593	1,440	4,243	2,664	2,540	2,760
HMS & HSDM	11,288	14,494	19,499	16,421	20,728	19,958
HSPH	635	617	1,066	685	1,035	919
Other	93	52	71	147	41	45
Total	13,609	16,603	24,879	19,917	24,344	23,682

Summary of Trademark Licensing Activity

(Fiscal Year 1999 through Fiscal Year 2004)

Active Licenses

	1999	2000	2001	2002	2003	2004
U.S.	173	142	139	139	119	127
Foreign	20	11	14	20	14	17
Total	193	153	153	159	133	144

Revenues (Thousands of Dollars)

	1999	2000	2001	2002	2003	2004
U.S.	484	522	493	514	567	567
Foreign	139	127	108	179	142	247
Total	623	649	601	693	709	814

Source: Harvard Office of Technology and Trademark Licensing 2004 Annual Report.

Key: FAS = Faculty of Arts and Sciences; HMS = Harvard Medical School; HSDM = Harvard School of Dental Medicine; HSPH = Harvard School of Public Health

Exhibit 5 Harvard Equity Holdings

Harvard Equity Holdings Summary

Chart summarizes all license-derived equity currently held by the University.
No equity was liquidated during Fiscal Year 2004.

Licensee	Year License Signed	Harvard's Equity Position	Harvard Case Number	Remarks
Zycos, Inc. (Lexington, MA)	1993	Equity Accepted	Urban 847	(Formerly Hex and Pangaea Pharmaceuticals, Inc.) Shares received in 1996.
Ariad Gene Therapeutics (Cambridge, MA)	1994	Equity Accepted	Schreiber 902	Shares received in 1995.
Theravance, Inc. (San Francisco, CA)	1997	Equity Accepted	Whitesides 1349	(Formerly Advanced Medicine) Shares were received in 1999. Additional shares were received in 2000.
Enanta Pharmaceuticals, Inc. (Cambridge, MA)	1998	Equity Accepted	Verdine 1472	(Formerly NOVIRx, Inc.) Shares received in 1998.
Modular Genetics, Inc. (Lincoln, MA)	2001	Equity Accepted	Jarrell 897 Shair 1594 Jarrell 1819	Shares received in 2001.
BioMimetic Pharmaceuticals (Setauket, NY)	2001	Equity Accepted	Antoniades Cases: 439, 536, 537, 538, 614, 814; Williams 1013	Shares received in 2001.
Fluidigm Corporation (South San Francisco, CA)	2001	Equity Accepted	Whitesides Cases: 967, 1196, 1361, 1484, 1728, 1734, 1759, 1762, 1764; Prentiss 1623	(Formerly Mycometrix Corp.) Shares received in 2001.
Nantero, Inc. (Waban, MA)	2001	Equity Accepted	Lieber 1641, 1923	Shares received in 2001. Additional shares received in 2003.
NanoSys, Inc. (New York, NY)	2002	Equity Accepted	Lieber Cases: 1137, 1243, 1352, 1489, 1641, 1678, 1765, 1852, 1923, 1924; Park 1935	Shares received in 2002. Additional shares received in 2003. Additional shares received in 2004.
Reaction Biology Corp. (Pittsburgh, PA)	2002	Equity Accepted	Schreiber 1513	(Formerly Morewood Molecular Sciences) Shares received in 2002.
Minerva Biotechnologies Corporation (Newton, MA)	2002	Equity Accepted	Whitesides 967, 1406, 1703	Shares received in 2003.
Concurrent Pharmaceuticals, Inc. (Cambridge, MA)	2002	Equity Accepted	Shakhnovich 1260 Shakhnovich 1460	Shares received in 2002.
Infinity Pharmaceuticals, Inc. (Boston, MA)	2003	Equity Accepted	Shair 1537, Schreiber 1633	Shares received in 2003.
Storage Matrix, Inc. (Newton, MA)	2003	Equity Accepted	Rabin 421	Shares received in 2003.
Peptimmune, Inc. (Cambridge, MA)	2003	Equity Accepted	Strominger 1931	Shares received in 2003.
Curis, Inc. (Cambridge, MA)	2004	Equity Accepted	Melton 956 Tabin 963 McMahon 1565	Shares received in 2004.
Agencourt Bioscience Corp. (Beverly, MA)	2004	Equity Accepted	Church 1438	Shares received in 2004.

Source: Harvard Office of Technology and Trademark Licensing 2004 Annual Report.

Appendix

Technology Transfer: How the Process Works[81]

The technology transfer process begins in the university when the research investigator or creator identifies a discovery or innovation or completes a copyrightable work that he or she believes may have potential for commercial development.

Submitting the Disclosure The first formal step in the process occurs when an inventor or creator submits a "disclosure" form describing the innovation to the university office that has responsibility for university licensing activities (usually called the Technology Licensing Office or "TLO"). The disclosure briefly describes the idea of the new discovery or invention or, if software, multimedia or other informational product, describes the product, what it does, what platform(s) it has been developed to run on and so forth.

Evaluating a Disclosure for Patenting If the disclosure is an invention, the TLO will further investigate the invention to determine whether it seems advisable to invest funds in patenting it. U.S. patents cost from $10,000-30,000 each and filing for equivalent foreign protection can increase the ultimate cost several-fold.

The decision whether to file a patent application generally is based on the answers to at least three questions:

1. Based on the state of publicly known information about the elements of the discovery (called "prior art"), is the invention likely to be patentable, and is the patent likely to be broad enough in scope to have commercial value? The first question is answered by a search of the literature and the past patents, often with the help of a professional search librarian, and sometimes by consulting a patent attorney and asking for a patentability opinion based on the patent attorney's search of all resources.

2. If it were patented, would the invention be likely to attract the commercial investment needed for development through a license? The second question is far more difficult to answer. It depends on the potential market for the product; the likely technological success of developing the invention into a practical product; the type of technology—and whether investors are currently interested in investing in such fields; what are the competitive technologies; and even the current state of the economy. The more innovative the technology, the more difficult it is to conduct market research in an efficient, meaningful manner, since the potential investors and customers may never have envisioned such a product.

3. Are there funds available within the institution or from a prospective licensee to pay for the patenting costs? The answer to this question is one of practicality. Since a university TLO may receive a significant number of invention disclosures each year, it will not have the financial resources to investigate the commercial potential in detail for each invention or to invest in the costs of patenting for each invention. Consequently, all TLOs must make choices.

These questions, as well as numerous other factors, contribute to making the decision on patenting one of the most difficult a TLO must make.

Filing the Patent Application If the decision is made to file an application, the TLO engages a patent attorney to work with the inventor(s) to write the patent application, file it in the U.S. Patent and Trademark Office, and follow it through the patenting process. In order to comply with the procedural requirements imposed under U.S. Patent Law, licensing or staff professionals in the TLO must have a good understanding of the patenting process as well as an understanding of the various strategies under current patent law for filing provisional and utility patents.

Under most university technology transfer policies, if the university decides it will not file, there is an opportunity for the inventors to decide whether they would like ownership waived to them. The process for requesting a waiver, or endorsing an inventor's request for waiver to the funding agency in the case of a federally-funded invention, is often well established within the university.

Marketing the Patent (finding a licensee)

(a) The challenge of licensing university inventions. A university will file a patent application on an invention only if it intends to license the invention for commercial development. The challenging basic premise with respect to university inventions is that most often they are of unproven market potential. Often additional research must be undertaken before the real work of product development can even begin. Few companies are willing to take the risk university inventions require, particularly where, as in the case of many medically-related inventions, it may take many years of research and development before it is known whether the product will be successful. A company or investor must have a long product-planning horizon before it will consider investing in university patents. For this reason, traditional methods of technology marketing, such as advertising the invention, publishing lists of technologies available for licensing, or using Internet listing services, often meet with limited success in finding licensees for university patents.

(b) When licensing begins. Potentially, a license to the patent—particularly if it is exclusive or partially exclusive—increases the incentive for the company to make the risky investment in development, since the patent can protect the company ("the licensee") from competition in the marketplace if the product is successfully developed. Universities typically seek licensees as soon as the patent application is filed, rather than wait the 2-5 years until the patent is issued. The motivation for early licensing is to get industry investing in the technology as soon as possible.

(c) Identifying potential licensees. Most universities with successful licensing programs find that it is important to know a variety of companies in fields where the university is prolifically inventing and to focus on the technology plans and the unmet needs of those companies. At the same time, efforts are made to encourage companies and potential investors to get to know the university and its researchers. Then, when a new invention arises, the potential for a "customized" introduction is already in place.

(d) Selecting the licensee. In those rare cases where more than one qualified licensee has requested a license, the university will consider co-licensees, or may divide the license by field of use (see below). If neither of these alternatives is commercially practical, the university will make a judgment as to which is the better prospect for licensing, taking into consideration the financial and technical capabilities of the candidates to develop and market the technology and the commitments each is willing to make to reach the marketplace.

Negotiating the License

(a) Field of the License. Some inventions cover multiple products in a number of different fields. A biological invention, for example, may have applications in research, in diagnostics, in vaccines, and in therapeutics. If the licensee is a large multi-divisional company with businesses in all fields of the invention and is willing to commit to product development in all fields, the license granted may be broad; if the company's business is limited to a single field, then a field of use may be specified in the license, and the company's rights to exploit the invention limited to that field. This will leave the invention licensable to companies working in other fields.

(b) Exclusive or Nonexclusive within a field (or in all fields). A license may be nonexclusive (that is, similar licenses may be granted to a number of companies) or exclusive (one company only). In the case of federally funded inventions, under Bayh-Dole all licenses must acknowledge that the federal government also has a license for government purposes. Exclusive licenses are generally desirable when the licensee must make a large, high-risk investment to bring the product to market. Few companies will be willing to undertake such an investment if licensing rights are available to other companies once the original company's development is successful.

Nonexclusive licenses are generally desirable when the invention is a broadly applicable process or has self-evident technological advantages which will be useful to many companies and so it is not necessary to "induce" investment. Nonexclusive licenses are highly preferable where the invention is a research tool, useful to both the commercial and academic communities and a high degree of access is important.

(c) Diligence requirements. If an exclusive license is granted to a company, the university must assure that the company is working diligently to develop the invention. Consequently, an important part of any license negotiation is the diligence provisions. These requirements may include, for example, specifying the number of people assigned to develop the invention within the company, the amount of funding a company will commit to development, or in the case of a small company the amount of investment capital that will be raised to fund development. If diligence provisions are not met, the university may cancel the license or, if the license was exclusive, rather than terminating the license altogether, the university may make it nonexclusive, thereby regaining the option to grant licenses to others.

(d) Royalties and other financial considerations. The financial considerations for a license involve a balancing of risks and rewards. Since many university inventions tend to be at an early stage of development at the time of licensing, royalty rates and license fees are typically lower than those between commercial companies licensing one another. At the same time, universities are usually unwilling to "cap" royalties at a pre-determined dollar value in the license. Since the university is sharing the "downside" with lower license fees and royalty percentages, it is reasonable to share in the "upside" if the product is very successful and value received by the licensee is greater than anticipated. The financial components of the deal are negotiated between the university and the licensee and typically include:

(i) *Reimbursement of the university's patent costs:* This is required, almost without exception, for exclusive licenses.

(ii) *License issue fee:* This fee may range from a very few thousand dollars to a quarter of a million or more. It is usually a fact-specific determination depending upon the stage of development of the invention, the size and breadth of the patent package, whether any patents have issued or whether all are still pending, the size of the potential market and so forth. These are factors contributing to the "value" of the invention.

(iii) *Annual license maintenance fees:* Many universities use these as a way of sharing the risk with the licensee. An annual license maintenance fee allows the university to charge a lower license issue fee upfront, and assures that the company shows an active interest in retaining the license as evidenced by its willingness to make a financial commitment to renew the license annually.

(iv) *Running royalties:* These are usually specified as a percent of sales of the product or service covered by the patent. The rate depends on many factors, including the profitability (margin) of the class of product covered by the invention; the size of the market; the stage of development of the technology when licensed; whether the product also falls under patents owned by others; and whether the university's technology is the key enabling technology for the product or just a minor component. Typically, university patents command royalties in the range of 1 to 6 percent of product sales; occasional licenses include royalties outside that range based on specific factors.

(v) *Equity shares:* When a license is granted to a young privately held company, shares of stock in the company may be offered to the university as a form of royalty under the license. Often, other license fees and/or running royalty percentages may be lowered in consideration of the equity shares. Not all universities have policies allowing them to accept equity in lieu of royalties and some State institutions do not have the requisite legal authority to accept equity.

(e) Additional License Terms. Licenses also commonly include activity reporting requirements for the licensee; agreement (in the case of an exclusive license) as to which party will prosecute patent infringers and how damages will be shared; agreement on which party will have responsibility for prosecuting and maintaining patents and in which countries; circumstances under which, and procedures for, terminating the license; and the administrative and legal processes for handling disputes between the parties.

Finally, and very important for the university, provisions are placed in licenses for protecting the university as licensor. To protect the university's ongoing research and educational programs, under any exclusive license grant, the university usually retains the right to use the licensed technology for those purposes.

Distribution of Patent Licensing Revenues All U.S. research universities have instituted policies governing the disposition of revenues earned from technology transfer activities. Most commonly, the first revenues received from a license are used to repay the university for the patenting costs of the invention if the license does not hold the licensee accountable for these costs. Thereafter, revenues are generally distributed according to a formula that has been adopted by the university. In most cases, inventors will receive approximately one-third of revenues earned from the licensing of their patents ("inventors' share"), although the percentage various among institutions. Some universities implement a sliding scale, with the inventor's share higher in the early years of a license when the royalty return tends to be lower.

The remaining revenues are distributed within the institution ("institutional share") in proportions that vary widely from university to university between the inventor(s)' laboratories, the inventor(s)' departments, and the university's general fund. In some universities, a portion of the institutional share will be used to "seed" inventions or new technology developments that will benefit from some maturation in the university before they are ready for licensing.

Source: Adapted from unpublished Harvard Business School manuscript, Note on Technology Transfer at U.S. Universities and Colleges, 2004. Vik Agrawal, Daveen Chopra, Danny Lewis prepared this unpublished note under the supervision of Professors Richard G. Hamermesh and Robert F. Higgins.

Endnotes

[1] Jennifer Washburn, *University Inc.: The Corporate Corruption of Higher Education* (Basic Book, 2005). Quote is from p. 59.

[2] Quote is cited in James J. Duderstadt, "Commercialization of the Academy: Seeking a Balance between the Marketplace and Public Interest," April 6, 2002. Transcript of Talk given at Emory University. Accessed from http://milproj.ummu.umich.edu/publications/academy_comercialization/download/academic_commercialization.pdf,

[3] Saul Lach and Mark Schankerman, "Royalty Sharing and Technology Licensing in Universities," *Journal of European Economic Association*, 2(2–3) April–May 2004: 252–264.

[4] Association of University Technology Managers 2004 Licensing Survey, p. 2.

[5] Information in this paragraph is based on Stephen Heuser, "Harvard woos firms to fund research," *Boston Globe*, November 9, 2005; and "Universities Across U.S. Invent a way to bring in more money cashing in on research," *Omaha World-Herald*, May 30, 1995.

[6] Mark G. Edwards, Fiona Murray and Robert Yu, "Value creation and sharing among universities, biotechnology and pharma," *Nature Biotechnology*, June 2003, pp. 618–624.

[7] Ibid.

[8] Jerry G. Thursby and Marie C. Thursby, " University Licensing and the Bayh-Dole Act," *Science* (vol. 301), August 22, 2003. p. 1052. Thursbys' reported data from a 2000 AUTM [Association of University Technology Managers] report that was itself based on a survey of 156 universities. Within this data set, the average income per respondent was about $8 million, 79% earned less than $5 million and half reported income less than $825,000. The average income per license was $66,645, but only 43% earned any royalties.

[9] Diane Palmintera, et al., "Accelerating Economic Development through University Technology Transfer," based on Innovation Associates Inc. Report to the Connecticut Technology Transfer and Commercialization Advisory Board of the Governor's Competitiveness Council, February 2005.

[10] Phillip A. Pizzo, "Stanford manages its industry interactions with utmost integrity," *San Jose Mercury News*, July 14, 2006.

[11] http://www1.umn.edu/scitech/assign/vb/vannevar_bush_letter.htm. FDR asked Bush to answer three other questions as well: a) What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?; (b) With particular reference to the war of science against disease, what can be done now to organize a program for continuing in the future the work which has been done in medicine and related sciences?; (c) Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?

[12] The entire report was 192 pages. The text part, omitting appendices, was just 40 pages.

[13] The establishment of the NSF was delayed until 1950 due to political wrangling over who the NSF should be accountable to. This meant that the main federal funders were mission oriented agencies, such as the Atomic Energy Commission, the Army, Navy and Air Force.

[14] Alice P. Gast, "The Impact of Restricting Information Access on Science and Technology" http://www.aau.edu/research/Gast.pdf.

[15] Washburn, University Inc.: The Corporate Corruption of Higher education, p. 44.

[16] This paragraph is based on Josh Lerner and Edgar Davis, "The Scripps Research Institute: November 1993 (Abridged)," HBS Case No. 296-068 (Boston: Harvard Business School Publishing, 1996), p. 6.

[17] See p. 51 in Washburn.

[18] In 1925, for example, the University of Wisconsin at Madison set up the Wisconsin Alumni Research Foundation (WARF) to coordinate the school's patenting and licensing activities. WARF delivered revenues, but the government sued WARF several times in succeeding years for its restrictive licensing practices of basic scientific advances related to health care.

[19] University IP Policies and Access to Medicines, Yale Aids Network, http://www.yale.edu/aidsnetwork/Spring%202003%20Univ%20IP%20History.ppt, accessed January 4, 2007

[20] Yale AIDS Network, "History of University IP Policies: Changing Objectives?" April 19, 2003.

[21] Clifton Leaf and Doris Burke, "The law of unintended consequences," *Fortune*, September 19, 2005.

[22] Washburn, p. 59.

[23] Because it made no distinction between nonrival and rival goods. Explain clearly, sentence that follows doesn't. inventions that could be used simultaneously by many people without taking anything away from someone else, such as gene-splicing technology that any biologist might have an interest in using and inventions that required protection in order for it to be shepherded to the marketplace, such as an ingredient in a particular confection.

[24] Gregory Graff, Amir Heiman, and David Zilberman, "University Research and Offices of Technology Transfer," *California Management Review*, 45/1 (Fall 2002): 88–115. This sentence is adapted from this article.

[25] Ibid.

[26] Richard Florida, op. cit. and Paul Gompers and Josh Lerner, *Money of Invention* (Harvard Business School Press, 2001).

[27] This paragraph is based on Lerner and Davis, "The Scripps Research Institute: November 1993 (Abridged)," p. 8.

[28] Ibid., p. 7.

[29] Lynnley Browning, "BMW's Custom-Made University," *New York Times*, August 29, 2006.

[30] Graff, Heiman, and Zilberman, "University Research and Offices of Technology Transfer," p. 90.

[31] Ibid.

[32] http://www.techtransfer.harvard.edu/ISRA.html, accessed June 28, 2006.

[33] Quoted passage is excerpted from http://www.techtransfer.harvard.edu/ISRA.html, accessed June 28, 2006.

[34] Thursby and Thursby, " University Licensing and the Bayh-Dole Act," p. 1052.

[35] Ibid.

[36] Jerry G. Thursby, Richard Jensen, and Marie C. Thursby, "Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities," *Journal of Technology Transfer*, 26, 2001, pp. 59–71. Quote is from p. 61.

[37] Joseph Friedman and Jonathan Silberman, "University Technology Transfer: Do Incentives Management, and Location Matter," *Journal of Technology Transfer*, 28, 17–30, 2003, p. 22.

[38] Thursby, Jensen, and Thursby, "Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities," pp. 59–71. Quote is from p. 59.

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41 Milken Institute Mind matters doc., "U.S. Universities lead in biotechnology research, tech transfer and commercialization of intellectual property," September 20, 2006.

42 MIT Entrepreneurship Center, 2004. cited in Palimtera, p. 46.

43 "Study Traces Impact of Government-Funded MIT Research on biotechnology and Drugs, MIT News Release, January 22, 1996. http://web.mit.edu/newsoffice/www/bioStudy.html, accessed January 2, 2007.

44 Palimtera

45 MIT total R&D expenditures were even higher when expenditures ($500 million) included the Lincoln Laboratory, a federally funded research and development organization based in Lexington, MA operated by MIT.

46 This paragraph draws heavily from Palimtera p. 46.

47 Robert Weisman, "Firm hand steers MIT Technology Patent Licensing has wide impact," *Boston Globe*, January 26, 2004.

48 The Lincoln Laboratory was a federally funded R&D center operated by MIT. (It later became part of the Broad Institute a Harvard-MIT collaboration). The Whitehead Institute received $XX million of federal funding

49 Robert Weisman, "Firm hand steers MIT Technology Patent Licensing has wide impact."

50 Ibid.

51 Charles Vest, "Industry, Philanthropy and Universities: the Roles and Influences of the Private Sector in Higher Education," September 2005, Clark Kerr lecture series at University of California at Berkeley.

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53 Ibid.

54 Ibid.

55 http://otl.stanford.edu/about/resources/otlar06.pdf, accessed February 25, 2007.

56 Palmintera

57 Palmintera

58 See http://med.stanford.edu/coi/tips.html.

59 Stephen Heuser, "Harvard woos firms to fund research," *The Boston Globe*, November 9, 2005.

60 From Richard G. Hamermesh, Josh Lerner and David Kiron, "Syndexa: Technology Transfer at Harvard University," HBS Case No. 806-117 (Boston: Harvard Business School Publishing, 2006).

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63 Fox Butterfield, "Colleges are uneasy over faculties' outside jobs," *The New York Times*, November 16, 1981.

64 Hamermesh, Lerner and Kiron, "Syndexa: Technology Transfer at Harvard University."

65 Derek Bok, *Universities in the Marketplace: The Commercialization of Higher Education*, (Princeton and Oxford: Princeton University Press, 2003. Quote is from the preface, p. X.

[66] Ibid.

[67] Ibid.

[68] Virginia Gerwin, "The technology trap," *Nature*, 2005, pp. 948–949.

[69] Ibid., pp. 948–949. Quote is from p. 949.

[70] Jock Friedly, "New anticoagulant prompts bad blood between partners**,"** *Science,* March 29, 1996.

[71] Gerwin, "The technology trap," *Nature*, 2005, pp. 948–949.

[72] Clifton Leaf, "The law of unintended consequences: Twenty five years ago a law known as the Bayh-Dole Act spawned the biotech industry," *Fortune*, September 19, 2005.

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[74] Cited in Thursby and Thursby, "University Licensing and the Bayh-Dole Act," p. 1052.

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[76] Thursby and Thursby, "University Licensing and the Bayh-Dole Act," p. 1052.

[77] Lach and Schankman, "Incentives and Invention in Universities," NBER Working paper, 2003.

[78] Intellectual Asset Management April/May 2006.

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