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Accelerating Economic Development Through University Technology Transfer

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Accelerating Economic Development Through University Technology Transfer

**Based on:
Report to the Connecticut Technology Transfer
and Commercialization Advisory Board
of the Governor's Competitiveness Council**

**Prepared by:
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M. JODI RELL
GOVERNOR

STATE OF CONNECTICUT
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HARTFORD, CONNECTICUT 06106

FOREWORD

Connecticut's prosperity, quality of life and economic future depend upon its ability to make the most of its technology assets and ability to innovate. Connecticut has some of the finest academic and research facilities in the world, and one of the most educated and productive workforces in the nation. We are leveraging these resources to advance our technology industries, and to create new science and technology businesses and jobs.

The Report to the Connecticut Technology Transfer and Commercialization Advisory Board of the Governor's Competitiveness Council has far-reaching implications for job growth, economic development and education - three of my top priorities. Jobs in the 21st century will be grown, not merely filled, and the companies that create them must be nurtured, not merely attracted to our state. Yankee Ingenuity is still our ace in the hole. It has been a key to our success for 300 years. Our challenge now is to turn that ingenuity toward creating the underpinnings of a 21st century economy.

Connecticut is very fortunate to have institutions such as Yale University and the University of Connecticut (UCONN) as well as 45 other universities and colleges. In 2003, Yale and UCONN together spent more than \$600 million in research and development. The Yale School of Medicine, widely recognized as an international leader in life sciences research, spent more than \$270 million for research and training and is one of the top recipients of funding from the National Institutes of Health. UCONN's Centers for Regenerative Biology, Global Fuel Cell Center, Institute for Materials Sciences, Center for Marine Sciences, and School of Engineering also are conducting cutting-edge research.

Connecticut is home to hundreds of world-renowned corporations, many of which have their research headquarters in the state. Corporations such as Pitney Bowes, Pfizer, United Technologies, U.S. Surgical Corporation, Boehringer Ingelheim, General Electric and Bristol-Myers Squibb are leading research and development in their fields. In a five-year period, the top five corporations alone in Connecticut produced 1,700 patents. This rich corporate research base provides the pipeline for future innovation and jobs in industries such as pharmaceuticals, nanotechnology, aerospace and defense, information technology and software, finance and insurance, and manufacturing.

Composed of CEOs from a cross-section of industries, legislative leaders, heads of key educational institutions, labor representatives, officials of industry associations and several state commissioners, the Governor's Competitiveness Council was established to oversee cluster based economic development efforts in Connecticut. In November 2003 the Council created the Connecticut Technology Transfer and Commercialization Advisory Board to examine and evaluate technology transfer and commercialization processes. The Board includes prominent business, university, venture capital and public sector leaders.

In early 2004, the Board sought an assessment of national and international best practices in university technology transfer and commercialization and recommendations for steps Connecticut should take. The report to the Board targets factors that help state position their universities as centers of innovation and business growth, including strong academic leadership and research capabilities, availability of early stage capital, commitment to and support of entrepreneurship programs, and the existence of infrastructure such as innovation centers, incubators and research parks.

As Governor of the State of Connecticut, I am pleased to share parts of this report with other state, academic and corporate leaders across the country. These are competitive times, and the competition is increasingly global. More than ever it is important for states to work toward the common goals of strengthening the nation's scientific and technological research and building its technological workforce. Connecticut will be doing its part to help lead the way.


M. Jodi Rell
Governor



PREFACE

In 2003-2004, the Connecticut Governor's Competitiveness Council began forging a path toward national science and technology leadership. It formed the Connecticut Technology Transfer and Commercialization Advisory Board composed of leaders from the State's top universities, corporations, venture capital firms, and economic development organizations. As one step toward building a State agenda for science and technology leadership, the Advisory Board contracted with Innovation Associates Inc. to examine national models of university-based initiatives and provide recommendations that would leverage the State's university resources and enhance its economic competitiveness.

This report – *Accelerating Economic Development Through University Technology Transfer* – is excerpted from Innovation Associates' *Report to the Connecticut Technology Transfer and Commercialization Advisory Board of the Governor's Competitiveness Council*. It highlights models of university technology transfer and commercialization, related efforts such as entrepreneurship programs, and the infrastructure and environment needed to support commercialization efforts. The Connecticut Technology Transfer and Commercialization Advisory Board generously allowed the release of major portions of the original report as a contribution to the knowledge base in university technology transfer and technology-based economic development. This report does not include the recommendations to the State of Connecticut or discussion about Connecticut institutions found in the original report. It does provide case studies of university-based technology transfer and related economic development initiatives that lay the groundwork for state, university, and corporate actions to leverage university resources. It also informs state and national policy leaders about the importance of funding research and development in universities and supporting the infrastructure – seed capital, networking, entrepreneurial development, incubation, specialized laboratories and other tools – necessary for innovation, technology transfer and commercialization to flourish.

We hope that the report will promote state, university, and corporate leaders throughout the nation to collectively take action that will leverage and build upon our nation's unparalleled research base.

Diane Palmintera
President, Innovation Associates Inc.

ACKNOWLEDGEMENTS

Innovation Associates Inc. (IA) would like to thank the members of the Connecticut Technology Transfer and Commercialization Advisory Board of the Governor's Competitiveness Council, its expert panel, and cluster representatives for their active input to this report. This report could not have been completed without the contributions of this distinguished group of executives representing universities, business, and government. We would particularly like to thank Louis Hernandez Jr., Chairman of the Advisory Board, who provided direction and leadership. A list of the members of the Advisory Board is found in Appendix A.

We also would like to recognize the U.S. Economic Development Administration's support of this effort through a grant to the State of Connecticut. We especially appreciate William Kaufmann's valuable input and feedback throughout the project. Alissa DeJonge, Economist, Connecticut Economic Resource Center also provided extensive assistance.

IA appreciates the advice of its National Advisory Group on the selection of university models for case studies and additional advice. A list of the Group appears in Appendix B. We want to particularly acknowledge Louis Tornatzky, Select University Technologies and Paul Waugaman, Technology Commercialization Group (TCG) who provided valuable input to this report. TCG also provided the technology transfer data that appear in Appendix D and are referenced in case studies. In addition, the State Science and Technology Institute through their extensive knowledge base contributed valuable assistance.

We are most grateful to the numerous individuals from universities and community/state programs who shared their valuable time and knowledge. Although too many to name here, some of those individuals are (arranged in alphabetical order by university): *Carnegie Mellon University*: Doros Platika, President & CEO, Pittsburgh Life Sciences Greenhouse; Donald F. Smith Jr., Vice President for Economic Development for the Mellon Pitt Carnegie Corporation; Patrick Stewart, Partner, Idea Foundry; Robert Wooldridge, Director, Innovation Transfer Center. *Georgia Institute of Technology*: Joel "Rick" Duke, Director, Economic Development Institute; George Harker, Director, Office of Technology Licensing; Wayne Hodges, Vice Provost for Economic Development & Technology Ventures. *Massachusetts Institute of Technology*: Robert Ayan, Program Manager, Entrepreneurship Center; Krisztina Holly, Director, Deshpande Center; Kenneth Morse, Managing Director, Entrepreneurship Center; Lita Nelsen, Director, Technology Licensing Office. *Purdue University*: Sam Florance, Director, Gateways Program; Simran Trana, Acting Director, Office of Technology Commercialization. *Stanford University*: Katharine Ku, Director, Office of Technology Licensing; Tina Seelig, Executive Director, Stanford Technology Ventures Program. *University of California, San Diego*: Alan Paau, Assistant Vice Chancellor, Technology Transfer and Intellectual Property Services. *University of Pennsylvania (Penn)*: Richard Bendis, CEO & President, Innovation Philadelphia; Louis Berneman, Managing Director, Center for Technology Transfer, Penn; Barbara Schilberg, Managing Director & CEO, BioAdvance. *University of Wisconsin-Madison*

(UW-M): Mark Bugher, Director, University Research Park; Charles Hoslet, Managing Director, Office of Corporate Research, (UW-M); Bryan Renk, Director, Wisconsin Alumni Research Foundation. *Washington University (WU, St. Louis)*: Robert Calcaterra, Director, Nidus Center; Michael Douglas, Director, Office of Technology Management, WU; Duke Leahy, former Director, Office of Technology Management, WU; Marcia Mellitz, Director, Center for Emerging Technologies; Patricia Snider, President & CEO, BioGenerator.

EXECUTIVE SUMMARY

“Silicon Valley”, “Rt. 128” and “Research Triangle” have become familiar terms throughout the country and the world. For as long as these terms have been recognized, states and communities have been trying to replicate them. Universities have been at the center of these models and have provided a pipeline for science and technology innovation, generating thousands of technology licenses and spinning off new technology enterprises.

There is no doubt that university technology transfer and commercialization activities are impacting local, state, and national economies. In FY 2003, Stanford alone filed more than 300 patents and some familiar companies such as Google, Sun Microsystems, Silicon Graphics, Netscape, Cisco Systems, and Yahoo have spun off from the University. Approximately 150 new MIT-related companies are founded each year, with at least 10 percent of those directly resulting from university technology transfer activities. Other universities such as Washington University in St. Louis, Georgia Institute of Technology in Atlanta, University of Wisconsin in Madison, and Carnegie Mellon University in Pittsburgh also are making impressive strides and contributing to the diversification and growth of their regional economies.

University technology transfer and commercialization are complex processes. They involve licensing inventions or starting up enterprises based on the universities’ research. Research and development (R&D) resources, infrastructure, seed capital, entrepreneurial incentives and culture, university-industry enablers, intermediary facilitators, and leadership – political, academic and corporate – are just some of the inputs involved in shaping effective processes. Moreover, a successful practice in one environment may not be a successful practice in another since resources, cultures, environments and priorities vary from university to university, community to community, and state to state.

In 2004, the Connecticut Technology Transfer and Commercialization Advisory Board of the Governor’s Competitiveness Council contracted Innovation Associates Inc. (IA) to examine exemplary technology transfer practices and to provide recommendations for enhancing state initiatives that leverage its university R&D resources. IA examined practices at 10 universities: Carnegie Mellon University (CMU), Georgia Institute of Technology (Georgia Tech), Massachusetts Institute of Technology (MIT), Purdue University (Purdue), Stanford University (Stanford), University of California, San Diego (UCSD), University of Pennsylvania (Penn), University of Wisconsin-Madison (UWM), Washington University (WU), and Cambridge University, United Kingdom (Cambridge). In addition to examining university technology transfer and commercialization activities, IA also examined related university and/or community entrepreneurship programs, incubators, research parks, seed capital programs, and cluster-driven innovation centers. The highlights and lessons that follow are based on these successful university and related practices.

HIGHLIGHTS AND LESSONS FROM EXEMPLARY UNIVERSITIES

The exemplary universities and the environments in which they operate provide some consistent and strong lessons to guide public and private decision makers:

- **A Strong and Focused University Research Base Feeds the Pipeline for Commercialization** – Excellent university technology transfer is built on excellent research. This research provides the pipeline for commercialization of research results. Moreover, just as important as the absolute magnitude of a university’s research portfolio is its strategic focus. In order for some model universities to build strong and focused research bases, they assessed core competencies and developed strategic plans around those core competencies. These efforts provided direction for: (a) hiring “stars” in targeted fields, (b) targeting federal R&D funds, (c) increasing corporate sponsored research, and (d) promoting state initiatives that leverage federal and corporate funds.
- **Federal R&D Funding Provides a Critical Base for Technology Transfer and Commercialization Efforts** – In most universities successful in technology transfer, there is substantial research funding from the federal government. Federal funding, particularly from the U.S. Department of Defense and the National Institutes of Health, normally accounts for the majority of the universities’ research expenditures. The National Science Foundation also plays a significant role through its programs.
- **Champions Catalyze Most Successful Technology-Based Economic Development** – In virtually every region in which a major research university has played a strong role in fostering regional economic development, one can point to a champion, often a strong university president or chancellor. These university heads, such as UCSD’s former Chancellor Atkinson and Washington University’s former Chancellor Danforth, have the experience, vision, and will to move their institutions into new roles as well as the leadership to rally the community’s corporate leaders and public decision makers.
- **Private Corporations and Foundations Can Play a Major Role** – In many communities and states, private corporations and foundations have played a major role in stimulating science and technology research and promoting regional economic outcomes. Corporations play a role not only by endowing university chairs and sponsoring collaborative R&D, but also by participating in entrepreneurial activities and funding technology-based initiatives in the community. In St. Louis, for example, the Danforth Foundation, Monsanto, and the McDonnell Family have funded substantial initiatives and, in Pittsburgh, the Heinz Endowments and other corporate contributors have provided the majority of funding for the Pittsburgh Life Sciences Greenhouse.

- **Early-Stage Capital is a Critical Ingredient in Launching University Start-Ups** – Entrepreneurs from universities successful in generating start-ups have access to seed capital. In addition, universities and intermediary organizations assist entrepreneurs with business plan development and offer entrepreneurs opportunities to showcase and network with potential investors. Where early-stage capital does not exist, universities, public and private sectors step in to create it, often seeding private funds that leverage additional monies. Angel networks also play an increasingly important role in spawning early-stage firms.
- **Innovation Centers Can Provide a Focal Point for Technology-Based Activities** – In some communities and states, innovation centers serve as focal points for technology-based activities. Innovation centers often are directly or indirectly linked to universities, involve corporate participation and provide a variety of services and linkages including pre-seed/seed capital, Executive-in-Residence programs, and mentoring for technology start-ups.
- **The Entrepreneurial Culture of a University is Key to its Technology Transfer Success** – The entrepreneurial culture of a university is perhaps the strongest and most pervasive influence on its technology transfer and commercialization performance. Creating an entrepreneurial culture is both “bottom up” and “top down”, requiring a combination of leadership from the top and entrepreneurial drive from the bottom. Universities successful in transferring technologies often provide implicit or explicit rewards and incentives for faculty who participate in technology transfer and commercialization activities, and have hiring practices that favor industry and entrepreneurial experience.
- **Networking is Key** – Part of the entrepreneurial culture inside and outside the university is networking. A critical ingredient well known to students and faculty at MIT, Stanford, and Cambridge are opportunities for entrepreneurs to network with potential investors, corporate clients, partners, service providers, and other entrepreneurs. Often the university technology transfer and licensing offices also encourage and facilitate interaction with venture capitalists, law firms, and corporations, early in the technology transfer process.
- **Entrepreneurship Programs Can Add Value to Technology Transfer Efforts** – Often model universities have strong entrepreneurship programs that offer entrepreneurial courses and activities for engineering and science students as well as business students. These activities include business plan competitions, practicum with start-ups, and mentoring by successful entrepreneurs.

- **Incubators and Research Parks Provide a Visible Technology Presence** – Many exemplary universities have incubators and research parks. This is particularly important for universities that have had to build an entrepreneurial presence such as UWM and Purdue. Their research parks are now quite successful, each employing several thousand high-tech workers and adding a technology presence where there once was none.
- **No Quick Fixes** – Most technology transfer and commercialization efforts at successful universities, and the resulting entrepreneurial and economic development phenomena that have grown around those universities have taken decades to accomplish. Moreover, the technology transfer field is still relatively new and evolving. Often results, particularly short-term results, are difficult to demonstrate and to quantify. Academic, public and private decision makers should be cognizant of these facts and accordingly build into programs the flexibility to experiment and the time to mature and evolve.

These lessons, and others found throughout this report, represent the experiences of some of the nation's most successful university technology transfer and commercialization programs. These models had academic, corporate, and political leaders willing to champion R&D and technology-based economic development over the long haul. They recognized that by leveraging R&D and entrepreneurial resources in one's university, community and state, it created new opportunities for both academic excellence and economic growth. Universities benefit from technology transfer and commercialization activities by attracting and retaining top entrepreneurial-minded academicians as well as gaining from license income. Communities and states that provide the entrepreneurial infrastructure in which university technology transfer and commercialization can flourish, benefit from the technology start-ups and business expansions that result. Not every community has a Stanford and can create a Silicon Valley, but public and private leaders can work together to identify, strengthen and leverage their own resources to enhance innovation-based economic opportunities.

ABBREVIATIONS

ATP	Advanced Technology Program, National Institutes for Standards & Technology
ATDC	Advanced Technology Development Center (Georgia Institute of Technology)
AUTM	Association of University Technology Managers
BASES	Business Association for Stanford Engineering Students
BFIP	Ben Franklin Investment Partners (Pennsylvania)
BFTP	Ben Franklin Technology Partners (Pennsylvania)
BFTDA	Ben Franklin Technology Development Authority (Pennsylvania)
CEL	Center for Experiential Learning (Washington University)
CDBG	Community Development Block Grant, U.S. Department of Housing & Urban Development
CDC	Center for Disease Control
CES	Center for Entrepreneurial Studies (Stanford University)
CET	Center for Emerging Technologies (St. Louis, Missouri)
CI	Connecticut Innovations
CMU	Carnegie Mellon University
CSTC	Center for Science and Technology Commercialization (University of Connecticut)
CTT	Center for Technology Transfer (University of Pennsylvania)
EDA	Economic Development Administration, U.S. Department of Commerce
EDI	Economic Development Institute (Georgia Institute of Technology)
EDP	Entrepreneurship Development Program (Massachusetts Institute of Technology)
EDTV	Economic Development and Technology Ventures (Georgia Institute of Technology)
ERC	Engineering Research Center, National Science Foundation
GCATT	Georgia Center for Advanced Telecommunications Technology
GRA	Georgia Research Alliance
GTARC	Georgia Tech Applied Research Corporation
GTRC	Georgia Tech Research Corporation
GTRI	Georgia Tech Research Institute
I&EDR	Industrial and Economic Development Research Program (University of Wisconsin-Madison)
ICAPP	Intellectual Capital Partnership Program (Georgia Institute of Technology)
IP	Intellectual property
IUCRC	Industry-University Cooperative Research Centers, National Science Foundation
MEP	Manufacturing Extension Partnership, National Institute of Standards & Technology
MFP	Mayfield Fellows Program (Stanford University)
MIT	Massachusetts Institute of Technology

MTC	Massachusetts Technology Collaborative
NIST	National Institute of Standards & Technology
NSF	National Science Foundation
OCR	Office of Corporate Relations (University of Wisconsin-Madison)
OIR	Office of Industrial Relations (Georgia Institute of Technology)
OSI	Office for Strategic Initiatives (University of Pennsylvania)
OTC	Office of Technology Commercialization (Purdue University)
OTL	Office of Technology Licensing (Stanford University)
OTM	Office of Technology Management (Washington University)
PACSCI	Pennsylvania Cyber Security Commercialization Initiative
PRF	Purdue Research Foundation
PRP	Purdue Research Park
R&D	Research and development
RAM	Research Alliance of Missouri
RCGA	Regional Chamber and Growth Association
S&T	Science and Technology
SBIR	Small Business Innovation Research
SCPD	Stanford Center for Professional Development
SEP	Skandalaris Entrepreneurship Program (Washington University)
SITN	Stanford Instructional Television Network
SPAN	Southwestern Pennsylvania Angel Network
SSTI	State Science and Technology Institute
STVP	Stanford Technology Ventures Program
TAP	Technical Assistance Program (Purdue University)
TCG	Technology Commercialization Group
TCN	Technology Commercialization Network
TIS	Technical Information Service (Purdue University)
TLO	Technology Licensing Office (Massachusetts Institute of Technology)
UCSD	University of California, San Diego
UPMC	University of Pittsburgh Medical Center
URP	University Research Park (University of Wisconsin-Madison)
URPI	University Research Park, Inc. (University of Wisconsin-Madison)
UWM	University of Wisconsin-Madison
WARF	Wisconsin Alumni Research Foundation
WAVE	Weinert Applied Ventures in Entrepreneurship (University of Wisconsin-Madison)
WIBR	Whitehead Institute for Biomedical Research
WIN	Wisconsin Innovation Network
WTC	Wisconsin Technology Council
WTN	Wisconsin Technology Network
WTS	Wisconsin TechSearch

I. INTRODUCTION

In the past 20 years, technology-based economic development has expanded from a few models in Silicon Valley, Rt. 128 and Research Triangle to numerous examples found throughout the United States, Europe and Asia. Research universities have been at the center of many of these efforts. After the passage of federal legislation in 1980 that permitted universities to own inventions developed with federal funding, technology transfer and commercialization efforts grew rapidly. These efforts mainly involved patenting and licensing academic inventions, and sometimes launching start-ups based on university research. Today, technology transfer and commercialization activities encompass a wide range of activities in universities as well as related technology and entrepreneurial initiatives by state and local governments and intermediary organizations. These initiatives are aimed at leveraging university inventions to achieve the economic development goals of diversification, growth and enhanced competitiveness.

University technology transfer and commercialization are complex processes. They operate as part of the culture and environment within the university and as part of the larger external environment surrounding the university. There are many factors that affect the university's ability to transfer and commercialize its research. Internal factors include 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 entrepreneurial climate. Other factors external to the university such as the availability of angel and seed capital, laboratory and incubation space, legal assistance, management capacity building resources, and networking opportunities are just some of the elements that form the infrastructure that supports university technology transfer efforts.

In order to better understand how to leverage its university resources, the Connecticut Technology Transfer and Commercialization Advisory Board of the Governor's Competitiveness Council contracted Innovation Associates (IA) to identify exemplary practices employed by universities, and to provide recommended actions for consideration by the private, public and academic sectors. IA identified 10 university-based models and examined technology transfer, commercialization and related activities in the universities and in the surrounding communities. This national report is excerpted from the original report to the Connecticut Technology Transfer and Commercialization Advisory Board.¹

¹ The original report can be found under "Technology Transfer Report" at:
<http://www.youbelonginct.com/user-cgi/pages.cgi?dbkey=387&level=3&category=about>.

UNIVERSITIES AS A PIPELINE FOR TECHNOLOGY-BASED ECONOMIC DEVELOPMENT

Starting in the late 1970's and early 1980's, technology transfer and commercialization of university and federal laboratory research gained increasing attention and led to new federal legislation.² In 1980, the Bayh-Dole Act accelerated technology transfer from universities to the private sector. This statute established a uniform federal invention policy that permitted universities to retain title to inventions developed through federally-funded research; it encouraged universities to collaborate with industry in promoting commercialization of inventions and retained federal government "march-in" rights to insure diligence in commercialization by patent licensees. Subsequent acts provided additional incentives for university-industry collaboration. The National Cooperative Research Act of 1984 relaxed antitrust restrictions on jointly funded R&D to permit collaborative R&D ventures with universities and federal laboratories. In 1988, the Technology Transfer Act additionally authorized federal laboratories to enter into cooperative R&D agreements with third parties, including private firms and universities.

Since the passage of the Bayh-Dole Act, universities have been an increasing resource for technology-based economic development through the transfer and commercialization of university inventions. When one examines the collective outcome of university technology transfer efforts in the U.S., there can be little doubt about the impact on local, state and national economies. The Association of University Technology Managers compiled results from 236 institutional respondents to the AUTM Licensing Survey™: FY 2003.³ It found that reporting institutions:

- Filed almost 8,000 new U.S. patent applications in FY 2003;
- Established 4,100 new companies based on a license from an academic institution since 1980, two-thirds of which were still operating at the end of FY 2003;
- Executed more than 4,500 new licenses and options in FY 2003, and almost 26,000 licenses and options were active in that year;
- Launched more than 2,200 new commercial products between FY 1998 and FY 2003; and
- Generated \$1.3 billion of license income in FY 2003.

Many publicly supported universities particularly state land grant universities, traditionally view economic development as one of their missions. They consider technology transfer and commercialization as part of that economic development mission as well as a university mission to disseminate knowledge. Private universities, even those actively engaged in technology transfer, often have a more tenuous link to economic development goals. Moreover, within some universities there still remain issues about the role of technology transfer vis-a-vis the university's primary academic mission of teaching and education. In addition, academic

² For more information on federal laboratory-based economic development see *Partners on a Mission: Federal Laboratory Practices Contributing to Economic Development* (OTP, November 2004) at: www.InnovationAssoc.com or www.Technology.gov.

³ For more information on the AUTM Licensing Survey™ go to: www.autm.net.

institutions and corporations that commercialize the university's technologies, represent two very different environments with contrasting values and cultures. Issues concerning the use of faculty time to pursue commercial goals based on their university research, conflict between the academic need for unrestricted publishing versus the corporate need for commercial confidentiality, and concerns about conflict-of-interest are still being worked through in many institutions. But some institutions such as Massachusetts Institute of Technology, Stanford University, Carnegie Mellon University, and Georgia Institute of Technology appear to have found a balance between achieving academic excellence and pursuing technology transfer and commercialization goals. They have found that by licensing and spinning off new technology enterprises it has enriched their environments, making them more attractive for "star" faculty and innovative-minded faculty and students. As a younger generation of faculty increasingly desires entrepreneurial opportunities, universities have had to embrace a more open entrepreneurial spirit. This has benefited the universities and the economies surrounding them.

THE ROLE OF STATE GOVERNMENT IN BUILDING A TECHNOLOGY-BASED INFRASTRUCTURE

Most states have implemented technology-based economic development programs to fill the gaps in federal programs and to capitalize on their state's technology resources, mainly research universities. States with declining industrial economies such as Ohio, Pennsylvania, Massachusetts, and New York implemented programs earlier than most and were particularly aggressive in implementing a range of incentives and initiatives designed to replace old industrial jobs with high-wage employment in emerging fields. In the 1990's, many other states developed comprehensive, technology-based strategies often aimed at catalyzing specific clusters, most frequently in life sciences and information technology/software clusters. In the early 2000's, because of state budgetary pressures, some states began to reduce technology-related budgets. But other, more visionary states during this period actually stepped up their investments, mainly in life sciences, by using tobacco settlement monies, pension funds and bond authority to support R&D institutes, seed and venture capital funds and related initiatives. These efforts included Florida's commitment of more than \$300 million to recruit the Scripps Florida Biotechnology Research Institute and Pennsylvania's \$100 million investment to seed three Life Sciences Greenhouses. In 2004, some states additionally committed major funding to stimulate specific types of research, most notably California's 10-year, \$3 billion commitment to fund stem cell research.

The State Science and Technology Institute (SSTI) reported that from January 2002 to October 2003, states committed more than \$2 billion in new funding for initiatives designed to build technology-based economies. In addition to the more than \$2 billion in new funding, the states provided more than \$480 million during FY 2003 in ongoing financial support to technology-based economic development programs. State initiatives particularly focused on building life science

clusters and improving the research capacities of universities. The following examples show the range of state initiatives created since January 2002:⁴

- Florida – In 2003, the Florida State Legislature made a \$310 million commitment to Scripps Research Institute as part of an agreement for Scripps to locate its first branch or satellite office in the state. The state’s pension fund managers also decided to invest up to \$400 million in venture capital funds.
- Indiana – In 2003, the State Legislature approved a key portion of the *Energize Indiana* plan including \$75 million for the 21st Century Research and Technology Fund to bolster the commercialization of university research and improve the state’s research capabilities at its universities; \$50 million for tax credits to promote Indiana venture capital initiatives; and \$9 million for certified technology parks.
- New York – In 2002, the Governor committed \$475 million for two technology-based economic development programs. The budget provided \$250 million for Centers of Excellence to upgrade research facilities at the state’s colleges, universities and research institutions. The budget also provided \$255 million for “Generating Employment through NY State Science” created to maximize the R&D potential of life sciences research conducted by academic research institutions.
- Pennsylvania – In 2002, the State Legislature designated \$100 million of tobacco settlement funds for three Life Sciences Greenhouses in Pittsburgh, Philadelphia and Central Pennsylvania. In 2003, the Commonwealth committed an additional \$60 million in tobacco settlement funds for biotech venture capital. Three funds have received up to \$20 million each and are required to leverage that funding at least 3:1 resulting in at least \$180 million.
- Utah – In 2003, the State Legislature passed the Utah Venture Capital Enhancement Act that created the Utah Capital Investment Board and a \$100 million five-year fund of funds. The Act authorized the Utah Capital Investment Corporation and provides for the issuance of contingent tax credits to investors in the Utah fund of funds. The Act is intended to attract investment in technology firms in the fields of life sciences, advanced manufacturing and information technology sectors.
- Wisconsin – In early 2004, the Wisconsin Assembly approved legislation intended to create \$62 million in new funding for start-ups through assistance in three areas: (a) an angel investment tax credit; (b) an early-stage seed investment tax credit in “certified” start-ups; and (c) grants and loans for the technology and commercialization program. In November 2004, Wisconsin additionally committed \$50 million for various initiatives aimed at stem cell research.

Additional discussion on the role of individual states and communities is incorporated in the “History and Environment” sections of the case studies.

⁴ Examples were extracted from “Building Tech-based Economies: State Actions in 2002 and 2003”, SSTI and compiled from SSTI “Biweekly Digests”. For more information on state actions go to: www.ssti.org.

METHODOLOGY

In order to examine the exemplary practices employed by universities for technology transfer and commercialization, and to provide recommended state actions, IA identified and selected 10 university models. The Connecticut Technology Transfer and Commercialization Advisory Board provided oversight of this selection process. Members of the Advisory Board are listed in Appendix A. IA also assembled a National Advisory Group that provided input, and members of this Group are listed in Appendix B.

IA selected university-based models that: (1) demonstrated significant technology transfer outcomes, (2) exhibited qualities and operated in environments similar to Connecticut's universities, and (3) focused on life sciences and information technology (IT)/software clusters. In addition, IA sought some models that were particularly innovative or had exemplary qualities tied to commercialization such as strong university-industry collaboration, entrepreneurship programs, incubators or research parks, seed/pre-seed initiatives, and affiliated innovation centers. Models also were selected to achieve a balance between public and private universities. A graph depicting evaluation criteria and selected models appears in Appendix C.

In order to assess technology transfer outcomes, IA used the following measures: (a) number of new U.S. patents filed, (b) number of new licenses executed, (c) number of active licenses, (d) total license income, and (e) number of start-ups launched. IA, working with the Technology Commercialization Group (TCG) "normalized" outcome measures by calculating the ratio of each outcome to total R&D expenditures. This allowed IA to view comparable data across U.S. universities. IA/TCG used outcome data from the Association of University Technology Managers' (AUTM) Licensing Survey™ of universities, and data on R&D expenditures from the National Science Foundation (NSF). In early 2004, the most recent data available from these sources was FY 2001. (Individual case studies show more recent data that was provided by university technology transfer offices for this report.) Based on "normalized data", IA targeted universities in the first or second quartile nationally in each outcome category. Technology transfer metrics for selected models appears in Appendix D. Graphs on R&D expenditures by science and engineering field and by source of funding appear in Appendix E. FY 2003 awards to selected universities by the National Institutes of Health (NIH) and NSF are shown in Appendix F.

IA staff and consultants conducted on-site and telephone interviews with key actors in the selected 10 universities and in the surrounding communities. Interviews were conducted with directors of all university technology transfer and licensing offices. Depending on the model, interviews also were conducted with related (a) university and/or community entrepreneurship programs, (b) incubators and research parks, (c) seed capital programs, and (d) innovation centers. The results of these interviews are summarized in the case studies found later in this report.

University models selected were:

- Cambridge University (Cambridge) – Cambridge University in the United Kingdom was selected because of its exceptional record of technology start-ups that have grown around the University, and the innovative role of its private sector consultancies. This model was the only international one selected. The case study on Cambridge does not appear in this national report.
- Carnegie Mellon University (CMU) – CMU is a medium-sized, private university with a strong record of high R&D expenditures, a significant percentage coming from the federal government and private industry, and top quartile showings in start-ups and new licenses. The region’s initiatives such as the Digital and Life Sciences Greenhouses are linked to CMU and add an innovative dimension.
- Georgia Institute of Technology (Georgia Tech) – Georgia Tech is a public university with strong industry relationships. Although this university shows unexceptional technology transfer outcomes, its affiliated programs such as the Advanced Technology Development Center exhibit impressive outcomes, and its Economic Development Institute has a strong record of related accomplishments.
- Massachusetts Institute of Technology (MIT) – MIT is consistently one of the top universities in all technology transfer metrics. Moreover, exceptional activities at the Entrepreneurship Center in the Sloan School of Management and other activities at the Engineering School add value to MIT’s exceptional technology transfer.
- Purdue University (Purdue) – Purdue ranks in the top national quartile in new licenses, active licenses, and start-ups. In addition, its research park and Gateways Program add a strong entrepreneurial dimension to its technology transfer activities.
- Stanford University (Stanford) – Like MIT, Stanford’s stellar performance in technology transfer is well known. Stanford consistently ranks in the top quartile in every category and is particularly strong in licensing. The majority of Stanford’s R&D expenditures are in life sciences, and a significant portion is devoted to engineering and computer sciences.
- University of California, San Diego (UCSD) – UCSD is a major factor in the build-up of the San Diego region’s life science and information technology/software companies. UCSD conducts exceptional technology transfer activities and pro-active networking involving entrepreneurs and business leaders.
- University of Pennsylvania (Penn) – Penn exhibits strong licensing activity. Its R&D focus is on life sciences including pharmaceuticals. The University takes a pro-active role in the community to promote technology-based development.

- University of Wisconsin-Madison (UWM) – UWM is in the first quartile in new licenses, active licenses and license income. *Forbes* rated the small college town of Madison as the “Best Place for Businesses and Careers” (2004) citing spin-offs around the University.
- Washington University – Within a five-year period, Washington University in St. Louis came from obscurity to rank nationally in the first quartile for new and active licenses. Also noteworthy are the exemplary incubators and related initiatives that add value to the University’s technology transfer activities.

In Chapter II, we present an overview of lessons learned. In-depth case studies on university models and related initiatives are presented in Chapter III.

II. SUMMARY OF LESSONS LEARNED

In this chapter, we summarize the lessons from case studies to guide academic, business, and government leaders. For academic leaders, the lessons are intended to enhance technology transfer and commercialization activities and build an entrepreneurial culture. For business leaders, the lessons are intended to increase their understanding of university technology transfer and to demonstrate the corporate role in supporting university R&D and in commercializing the results. For government leaders and public decision makers, the lessons are intended to offer guidance on developing and enhancing an infrastructure that leverages university research for economic goals. These lessons also demonstrate to federal policy makers the importance of federal government funding for university research. This research provides the pipeline for inventions that are transferred to and commercialized by the private sector. The lessons show that together, academic, business, and government decision makers can make a difference in stimulating and sustaining science- and technology-based economies.

We present lessons in three sections: Lessons for Government and Business Leaders, Lessons for Academic Leaders, and Cross Cutting Lessons. In Chapter III, case studies offer additional lessons learned as well as detailed explanation of the lessons referenced here.

LESSONS FOR GOVERNMENT AND BUSINESS LEADERS

CHAMPIONS ARE CRITICAL TO THE SUCCESS OF TECHNOLOGY TRANSFER EFFORTS

I believe that it is part of the University's mission, as a State-funded institution, to give something back to the State, by creating a more favorable environment for attracting and developing technology industries.

- Richard C. Atkinson, former President, University of California⁵

In many communities in which there is successful technology transfer and commercialization from universities, we see champions. These champions are often presidents or chancellors of universities. In some cases, the university presidents or chancellors who became champions were successful entrepreneurs or corporate heads. In the San Diego region, the former Chancellor of UCSD, Richard Atkinson championed the University as a source for technology start-ups. Dr. Atkinson used his position and influence to reach out to San Diego's corporate leaders to build R&D capacity at the University by endowing chairs, sponsoring research, and constructing laboratories and other facilities. He also encouraged the creation of CONNECT to network the region's corporations and entrepreneurs. In St. Louis, Washington University's former Chancellor William Danforth championed life science research in the University, the

⁵ Quoted from an interview with Innovation Associates' President in September 1998 for *Developing High-Technology Communities: San Diego*, U.S. Small Business Administration, Washington, D.C., April 2000.

City, and the State. He prompted other prominent corporate leaders to finance and advocate for science and technology initiatives through the Missouri State Legislature. In virtually every state in which a major research university has played a strong role in fostering regional economic development, one can point to a strong president or chancellor who had the experiential background, the vision, and the will to move the institution into a new role.

AVAILABILITY OF SEED CAPITAL FUNDS IS IMPORTANT IN LAUNCHING UNIVERSITY START-UPS

In general there is a lack of seed capital ... Although there are early-stage funds in California and Boston, you need a local fund willing to do the heavy lifting for (early-stage) investments.

- Barbara Schilberg, Managing Director & CEO, BioAdvance

In every exemplary case with significant numbers of start-ups, private and/or public seed capital funds, and often angel networks, were present. In states and communities with little traditional risk capital, state governments and the private sector had to fill the gap by creating seed and venture capital funds. The forms of these funds varied, and communities and states usually established several types of funds that addressed different stages of business development. In some states, funds were directed to specific clusters such as life sciences. During the early 2000's, the availability of early-stage funds became increasingly important as private sources of risk capital decreased, creating a hardship on university and other start-ups.

In order to fill the seed capital gap in Pennsylvania, the Commonwealth seeded three private, early-stage funds to meet the needs of enterprises affiliated with the Life Sciences Greenhouses. The Commonwealth invested more than \$100 million from its pension fund and its public venture capital company (Safeguard). Start-ups from CMU and the University of Pittsburgh have access to these funds as well as a small "pre-seed" fund called the Idea Foundry, as well as funds from Innovation Works, part of the state's Ben Franklin Partnership. In Missouri, the State seeded four locally managed venture capital funds dedicated to biotech and medical companies. These funds leveraged capital totaling more than \$400 million. Foundations and other private sector investors in St. Louis also established a small "pre-seed" fund called the BioGenerator. Like Pittsburgh's Idea Foundry, the BioGenerator provides value-added mentoring and management services in addition to seed capital for very early-stage firms and entrepreneurs. In Indiana, the Indiana Future Fund was capitalized with \$75 million from multiple investors including State pension funds, pharmaceutical and other companies, several universities, and university endowment foundations. This "fund-of-funds" is privately managed and is aimed at seed- and early-stage biotech companies.

Angel capital networks also have been important in many communities. In Pittsburgh, a network of about 100 angels provide "side-by-side" or follow-on funding, adding value to other early-stage investments. In San Diego, entrepreneurs have access to a local chapter of a statewide angel capital network, the Tech Coast Angels.

Universities also have stepped in to fill the seed capital gap for academic-based entrepreneurs with their own pre-seed and seed funds. These funds can be found at most exemplary universities including Georgia Tech, MIT, Purdue, and UWM.

STATE TECHNOLOGY INITIATIVES CAN LEVERAGE MAJOR PRIVATE INVESTMENTS

In addition to the strong leadership from the University's President, state policies and programs have provided critical support to the University and regional technology efforts. This included the use of tobacco funds to form the Life Sciences Greenhouses and life science seed capital funds, tax incentives to support incubators, and development of the Keystone Zones (enterprise zones) to encourage business development.

- Louis Berneman, Managing Director, Center for Technology Transfer, University of Pennsylvania

Some initiatives seeded by state funds have substantially leveraged the state's original investment. In Pittsburgh, the Commonwealth's original investment of \$33 million in the Life Sciences Greenhouse has attracted an additional \$75 million investment for R&D and related activities from corporate foundations and other private sources. In addition, an affiliated seed capital fund – Pennsylvania Early Stage – has invested \$70 million of mainly state funds in life science start-ups, leveraging \$350 million private investment in just a few short years. In Missouri, the State Legislature set aside \$20 million in tax credits for early-stage capital that subsequently was given to Prolog Ventures to manage. Prolog's investments have leveraged more than \$100 million in private investments. During 2003 and 2004, Georgia's \$3 million annual investment in Georgia Tech's Advanced Technology Development Center (ATDC) has leveraged nearly \$387 million investments in ADTC companies.

INNOVATION CENTERS CAN SERVE AS A CENTRAL FOCUS FOR TECHNOLOGY-BASED ACTIVITIES

In many communities and states, technology transfer and commercialization or innovation centers serve as focal points for technology-based activities. Most often these innovation centers are directly or indirectly linked to universities, involve corporate participation, and provide a variety of services and linkages for technology start-ups. Innovation centers vary in funding, size and complexity. Pennsylvania, for example, invested \$100 million in three Life Sciences Greenhouses.⁶ Pittsburgh's Life Sciences Greenhouse offers incentives to attract academic "stars", sponsors collaborative research, and invests in start-ups. In addition, mentoring and CEO-in-Residence programs help entrepreneurs build management capacity. Linkages to angels, venture capitalists, and consulting firms add financial and management services.

⁶ Two of the three Greenhouses – Pittsburgh Life Sciences Greenhouse and BioAdvance in Philadelphia – are described in the CMU and Penn case studies.

Innovation centers are intended to bridge the difficult “valley of death” gap between university R&D and the commercial world by providing multiple elements needed to mature very early stage innovations. The advantage of major innovation centers such as the Life Sciences Greenhouses is that they not only offer key technology transfer services and linkages, particularly seed capital investments and management assistance, they also serve as focal points from which other activities can grow and revolve around. For example, many centers either sponsor or are well connected to various networking activities. They also offer opportunities for corporate participation that is sometimes more difficult in a traditional university setting. At the writing of this report, most centers are too young to demonstrate significant results but many states and communities hold high regard for the concept.

THE PRIVATE SECTOR CAN BE A MAJOR ADVOCATE AND CONTRIBUTOR TO UNIVERSITY TECHNOLOGY TRANSFER

We're extraordinarily lucky in having a lot of philanthropic institutions (in Pittsburgh). The foundations played an important role in the Digital Greenhouse and were very important contributors to the Life Sciences Greenhouse.

- Donald F. Smith Jr., Vice President for Economic Development for the Mellon Pitt Carnegie Corporation

Private industries and foundations in some states and communities have played a major role in promoting and funding science and technology initiatives. In St. Louis, the Danforth Foundation (Ralston Purina) created the Danforth Plant Science Center, a private research institute; Monsanto created the Nidus Center, a non-profit incubator; and the McDonnell Family (McDonnell Douglas) substantially contributed to research at Washington University and other related initiatives. The Danforth Plant Science Center and Nidus Center also served as a platform to leverage additional community and state initiatives. In Pittsburgh, the Pittsburgh Life Sciences Greenhouse has benefited from substantial funding by the Heinz Endowments and other corporate foundations. Corporations also have made major contributions by funding laboratories and other research facilities at universities. Qualcomm's Irwin Jacobs, for example, provided funding for a new engineering building and laboratories at UCSD. In 2002, the co-founder and chairman of Sycamore Networks gave a \$20 million grant to MIT to launch the Deshpande Center. The Center provides grants, advice, mentoring, and networking to move faculty research closer to market. Other universities such as Stanford and Purdue also have received substantial corporate funding to build research and technology transfer capacities.

Corporations also play an important role in sponsoring research projects at most exemplary universities. At CMU, Georgia Tech, and Purdue funding for corporate sponsored research usually composes 15-20% of their total R&D expenditures. Corporate sponsored R&D, particularly when it involves active collaboration, provides a direct pipeline for transferring academic research to the commercial sector. Through the endowment of chairs at universities, corporations also contribute to building specific disciplines that may ultimately benefit the corporation. The Georgia Research Alliance has been particularly successful in its campaign to

endow chairs, and in the last decade has endowed more than 40 chairs at Georgia Tech and other Georgia institutions.

Corporate managers, successful entrepreneurs, and venture capitalists also contribute to R&D and technology transfer by sitting on university advisory boards and participating in entrepreneurial activities. Mentors who help entrepreneurs develop business plans, prepare for venture capital forums, and participate in similar activities provide invaluable support to start-ups. Moreover, business leaders who participate as CEO's-in-Residence can make a difference in the survival of a new start-up. Although not normally viewed in a technology transfer context, corporate sponsorship of academic interns also is a means of technology transfer. It facilitates a two-way flow of academic knowledge and real-world experience, and creates a bond between the corporation and the university that facilitates other technology transfer linkages.

NETWORKING IS A CRITICAL ELEMENT IN AN ENTREPRENEURIAL CULTURE

Networking is a natural part of the Stanford environment.

- Katharine Ku, Director, Office of Technology Licensing, Stanford University

Networking is a major factor in all university-based exemplary practices. Most of that networking is informal involving “get-togethers” often sponsored by venture capitalists and law firms. Other networking is more formal and sponsored by the university or by organizations such as Mass BIO, the Pittsburgh Technology Council, and CONNECT (UCSD). At MIT and Stanford, faculty, students, and technology transfer administrators interact continuously with key individuals in business and investment communities in Boston and Bay Areas respectively. CONNECT at UCSD sponsors several major networking events including an annual innovation awards luncheon that attracts “everyone who is anyone” in the San Diego region. They also sponsor many informal events throughout the year. In Cambridge, England, a group of serial entrepreneurs have moved a long established networking practice onto a business footing and enhanced the service. The Cambridge Network is a privately funded, for-profit business that provides networking among entrepreneurs and connections to university researchers. Whatever the form, technology transfer experts in regions known for technology point to networking opportunities and active engagement from venture capitalists, serial entrepreneurs, service providers, and technology leaders as critical to the region’s ability to create and retain start-up enterprises.

LESSONS FOR ACADEMIC LEADERS

A STRONG, STRATEGICALLY-FOCUSED RESEARCH BASE PROMOTES TECHNOLOGY TRANSFER

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.

- Lita Nelsen, Director, Technology Licensing Office, Massachusetts Institute of Technology

An essential element in all successful examples of technology transfer and commercialization is a strong research base that provides the pipeline for technology transfer activities. In order to build a strong research base, some model universities engaged in strategic planning processes to identify core competencies and emerging science and technology fields. Based on the results of this process, the universities developed and carried out specific steps to capitalize on university strengths and emerging trends. These steps usually involved: (a) hiring “stars” in the field through endowed chairs or by other means, (b) targeting federal R&D funds, sometimes aimed at the development of a center-of-excellence, (c) increasing corporate sponsored research, and (d) promoting state initiatives that sometimes leverage federally funded centers.

The ability of the university to attract federal R&D is often a good gauge of the university’s research strength. Exemplary universities such as Stanford, MIT, CMU, and Washington University are all in the top 10% of federal R&D recipients in their respective fields. Moreover, increases in university patents and new licenses often correspond to increases in federal R&D expenditures.

Just as important as the absolute magnitude of a university’s research portfolio is its strategic focus. Universities that have the leadership commitment to go through the laborious process of assessing and targeting key competencies do much better in the long run in building a R&D heft. If research targets are also selected with an eye toward comparable strengths in the private sector economy, the state and industries benefit as well as the university. Universities such as CMU held in-depth discussions with industries to determine priority research areas. The Georgia Research Alliance also involved industries in targeting research areas of particular interest to industry. As a result, both CMU and Georgia Tech also benefited from substantial industrial funding of not only sponsored projects but also endowment of chairs by industry and industry-related foundations.

UNIVERSITY CULTURE IS KEY TO SUCCESS OF TECHNOLOGY TRANSFER

We conduct technology transfer based on “total impact” to help diversify and generate a high-wage, knowledge-based economy. We take to heart that our real mission is economic development, and we have a clear mission statement that has been strongly supported by the past two Chancellors and the University Administration.

- Alan Paau, Assistant Vice Chancellor, Technology Transfer and Intellectual Property Services, University of California, San Diego

The “culture” of a university is perhaps the strongest and most pervasive influence on its technology transfer and commercialization performance. By culture, we mean the beliefs, values, myths, rewards, and incentives that influence behavior within the organization. For example, universities that are successful in transferring technologies provide rewards and incentives for faculty who participate in technology transfer and commercialization activities. This generally involves giving faculty credit toward tenure if they file a patent application and some credit for filing invention disclosures. Other incentives involve publicizing faculty and student successes through articles in the university newspapers, department or university award ceremonies, and similar recognition. In effect, such fairly simple events convey powerful cultural messages to the larger academic community.

It is also useful for university presidents to articulate the importance of technology transfer, economic development and outreach of the institution in public speeches. Including these activities in mission statements, vision statements and goals sends a positive internal message. In addition, when university and academic unit heads say positive things about the role of the institution in building the state economy, encouraging entrepreneurial behavior or technology transfer it suggests an academic culture that promotes an environment conducive to technology transfer and commercialization. University presidents and chancellors at MIT, Penn, Purdue, UCSD, Washington University and other exemplary universities have sent strong messages in support of economic development and technology transfer missions.

TECHNOLOGY TRANSFER LINKAGES TO RESEARCHERS FEEDS THE PIPELINE

Successful university technology transfer offices often have close linkages to R&D schools and departments. In some cases, such as Penn, the technology transfer office has staff dedicated to a specific school, department or discipline. Some universities such as Washington University expect licensing staff to contact all researchers in their assigned field at least once during the academic year. Often approaches are informal, but also effective. That is, technology transfer staff “walk the halls” of the key centers or institutes, get to know star faculty, and encourage faculty to consider filing disclosures and patent applications.

Model universities not only have close linkages with researchers but also increasingly identify R&D inventions at very early stages. In some universities such as Washington University, licensing officers are alerted to new research awards through the research office’s database.

They immediately contact principal investigators to discuss the technology transfer process and potential commercial outcomes.

“Scouting” or “ferreting” programs by external organizations, which seek to identify promising university research, also can be effective. The Pittsburgh Life Sciences Greenhouse, for example, uses technology scouts/ferrets to identify early-stage research with commercial potential at CMU and the University of Pittsburgh.

SUCCESSFUL TECHNOLOGY TRANSFER OFFICES HAVE LINKAGES TO SEED AND VENTURE CAPITAL FIRMS

Often successful technology transfer offices have close linkages to sources of seed and venture capital and pro-actively interact with those sources. Technology transfer offices at MIT and Stanford, for example, have long established relationships with numerous venture capital firms. MIT’s Technology Licensing Office facilitates engagement of potential investors with researchers, often when the innovation is in a pre-business stage. This encourages the researcher to start thinking about the innovation’s commercial potential and the possibility of a start-up venture early in the process. Washington University has linkages with seed capital sources and with incubators that facilitate early-stage investments. CMU has linkages with the Life Sciences Greenhouse and the Idea Foundry, which provide progressive stages of seed capital and a variety of mentoring and management services.

Moreover, universities in regions that lack venture capital have been pro-active in seeking venture capital from major centers in Silicon Valley, Boston, New York and elsewhere. Directors of technology transfer at Washington University, Georgia Tech, and UCSD regularly market to venture capital companies across the country. Georgia Tech’s Venture Lab, for example, sponsors Technology Day West in which entrepreneurs present to venture capitalists gathered from Silicon Valley. UCSD holds receptions in Silicon Valley and in 2005 will host venture capitalists in China. Other universities hold receptions and other events for potential investors in major venture capital centers.

EXEMPLARY UNIVERSITIES OFTEN CREATE THEIR OWN SEED CAPITAL FUNDS

Exemplary universities not only have linkages to private seed and venture capital firms but many also have established their own early-stage funds for university researchers. Purdue’s Office of Technology Commercialization offers two investment vehicles for inventions originating at the University. Purdue’s Trask Innovation Fund provides faculty with “gap funding” to validate proof-of-concept, and the Trask Pre-Seed Venture Fund invests in start-ups that are commercializing Purdue-licensed technology. UWM’s Office of Corporate Relations also sponsors the Robert Draper Technology Innovation Fund that provides grants for proof-of-concept projects with patent and licensing potential. Funds for the Robert Draper Technology Innovation Fund come from the University’s royalty revenues generated by prior licenses.

Many university seed funds add value to their investments by helping inventors build management capacity in the university start-ups. Georgia Tech's VentureLab, for example, provides pre-seed capital and through their "Fellows" program, matches funded faculty members with successful entrepreneurs who assist them in developing commercialization and investment strategies. MIT's Deshpande Center provides two stages of grants, and offers advice, mentoring, and networking to move engineering faculty's research closer to market.

Other university vehicles to finance university inventions and introduce researchers to potential investors include business plan competitions, venture capital forums, and networking opportunities. These vehicles are discussed later in this section.

ENTREPRENEURIAL ASSISTANCE IS IMPORTANT IN LAUNCHING UNIVERSITY START-UPS

Catalysts (private sector mentors to faculty) are the most important part of the Deshpande Center's program – they put a "real world spin" on academic innovations.

- *Krisztina Holly, Director, Deshpande Center, Massachusetts Institute of Technology*

Experienced technology transfer offices realize that university scientists and engineers often make poor business managers and facilitate management capacity building in start-ups. In some universities such as Penn, the technology transfer office acts as a venture arm, using professional search firms to place CEO's and other key managers in ventures started by the University. Other universities, such as Georgia Tech, provide promising entrepreneurs with a wide range of assistance through in-house programs or through linkages with incubators and service providers.

Most exemplary universities in technology transfer have business plan competitions. These competitions not only help budding entrepreneurs but also provide deal flow for university technology transfer offices. One of the best known is MIT's \$50K Competition sponsored by the Entrepreneurship Center in the Sloan School of Management. The program uses the prize money to lure students into learning about entrepreneurship. Once students enter the Competition they are given instruction and mentoring on developing business plans, identifying markets, and other areas that improve their understanding of the steps needed to create technology businesses. Engineers and scientists who are not business-minded are taught to "think as business people." Other universities sponsor multiple business competitions such as Purdue's Burton Morgan Entrepreneurial Competition with prizes totaling \$100,000, and Life Sciences Business Plan Competition sponsored by Roche with prizes totaling \$150,000.

Some management schools also provide a wide array of entrepreneurship courses, not only for management students but also for engineering and science students. The Stanford Technology Venture Program in the School of Engineering each year offers about 25 courses serving more than 2,000 students. Through MIT's Entrepreneurship Center, about 1,500 graduate and undergraduate students each year attend entrepreneurship courses. Successful entrepreneurs

teach approximately half of these courses, adding an important “real world” dimension. In addition, internships and practicum with start-up and venture capital firms give students an important “hands-on” learning experience. Through MIT’s E-Lab, each student works one day per week over a semester with a start-up company. Interdisciplinary teams of MBAs and engineering students are charged with helping solve a real-world problem for a company. Through the Weinert Applied Ventures in Entrepreneurship (WAVE) Program at UWM, 12 MBA students work with start-up businesses and attend weekly entrepreneurship seminars led by local and national experts.

Many exemplary universities and affiliated programs also use business students to help promising entrepreneurs write business plans, conduct market assessments, identify potential customers, and perform other business functions. At Pittsburgh’s Idea Foundry, for example, business interns from CMU and the University of Pittsburgh form teams to conduct marketing studies and help in the due diligence process. In addition to providing a worthwhile educational experience for undergraduate and graduate students, entrepreneurial centers and programs form an important part of the “soft infrastructure” of networked service providers when start-ups emerge from faculty and student inventions.

UNIVERSITY-INDUSTRY COLLABORATION IN R&D CAN FACILITATE TECHNOLOGY TRANSFER

You have to view the corporation as the customer – we are selling to them; you’ve got to have high quality research but you also have to be talking to industry and have a presence.

- Bryan Renk, Director, Wisconsin Alumni Research Foundation

Technology transfer comes in many forms including corporate sponsored research, consulting, and technical assistance. A good measure of university interaction with and value to industry is the level of its corporate sponsored research and number of industry-endowed chairs. Sponsored research at institutions such as MIT, Stanford, CMU and Georgia Tech, although a small portion relative to their federal funding nevertheless provides substantial R&D funding. In addition, these universities have a high number of endowed chairs.

Many successful examples of technology transfer and university-industry collaboration significantly involve industries in advisory capacities at universities. Institutions such as Georgia Tech, CMU, and Purdue that have high levels of industry research and technology participation also have a heavy involvement of companies in various advisory roles. This involvement may include formal industry-steered centers or institutes or departmental advisory committees.

A key practice of institutions known for exemplary industry linkages is to have an office which functions as a single point of contact for various forms of industry collaboration. One of the most important problems that industries face is trying to sort out the maze that a large research university presents to the external world. Unless one really knows how the universities operate,

it is difficult for a layperson from industry, no matter how technically gifted, to find key researchers and opportunities for collaboration.

UNIVERSITY RESEARCH PARKS AND INCUBATORS CAN PROVIDE A VISIBLE TECHNOLOGY PRESENCE

We have found that those firms (in Purdue Research Park's incubators) that don't receive support in the early stages face a long hard road. For those firms that do receive management, resource, and technical support, they have about a 90% chance of a five-year survival.

- Sam Florance, Director, Gateways Program, Purdue University

Research parks contribute to an entrepreneurial culture and provide a visible “technology presence” at universities. This is particularly true when universities are in rural areas, far from technology and financial business centers. UWM, for example, has developed a very successful research park that has more than 100 companies employing about 4,000 people. The Park has incubation space to house start-up companies, many of which have come through the Wisconsin Alumni Research Foundation (responsible for technology transfer functions at UWM). Purdue is located in a remote area but has one of the largest and most successful research parks in the country. The Purdue Research Park has more than 150,000 square feet of incubation space in addition to its commercial space. Moreover, incubator residents can obtain a wide range of business services through Purdue’s Gateways Program located in the Park. Gateways’ clients go through a "stage-gate" process similar to that used by major corporations to launch new developments. This process includes business assistance from mentors, exposure to seed/venture capitalists, and sometimes assistance with formation of management teams.

Exemplary universities offer entrepreneurs incubation opportunities. Incubators may be housed at the university such as Georgia Tech’s ATDC, part of the university’s research park such as Purdue’s Technology Center, or a community incubator with close linkages to the university such as St. Louis’ Center for Emerging Technologies. All excellent university incubators provide entrepreneurs with what Georgia Tech’s ATDC calls the “4 C’s”: Consulting, Connections, Community and Center. We would add a 5th C – Cash. The facility or “Center” is usually the least important of the “4 C’s”. Most important are the services provided by managers. At ATDC, “Venture Catalysts” are well networked in the business and investment communities and actively facilitate connections between entrepreneurs and investors, customers, potential hires, and service providers. In addition, representatives of law and accounting firms are located in the incubator and conduct some *pro bono* work for incubator residents. ATDC also has a \$5 million Seed Capital Fund available to entrepreneurs. Other successful university incubators exhibit many of the same qualities. Aside from the technical assistance that an incubator can provide entrepreneurs, the incubator’s presence alone sends a powerful cultural message to faculty and the university community generally. This is one reason why it is worth having a physical incubator facility rather than dispersed incubation space or relying on “virtual” programs invisible to the casual observer.

CROSS-CUTTING LESSONS

THE PRIVATE SECTOR GENERATES MOST TECHNOLOGY START-UPS

Most of the emphasis in technology-based economic development has been on using research universities as the pipeline for technology start-ups, but it is important to note that most new enterprises do not come from universities but rather from employees and former employees of corporations. San Diego, Pittsburgh, Boston, and other areas known for technology all benefited from employees starting businesses when major corporations downsized. Research Triangle in North Carolina did not become a hot spot for technology start-ups until IBM went through large layoffs in the early 1990s – along with a painful consolidation of several pharmaceutical companies – which displaced many talented people, none of whom wanted to leave North Carolina. Similarly, San Diego experienced major cutbacks of defense contractors in the early 1990s; at that time, corporations such as Qualcomm spun off from the defense contractors. Entrepreneurs who come from corporations benefit from many of the same services that benefit university-based entrepreneurs – availability of investment capital; particularly seed, “pre-seed” and angel capital; preparation for and introduction to potential investors; business planning and management assistance; mentoring by experienced entrepreneurs and investors; and multiple opportunities for networking with other entrepreneurs, investors, service providers, and potential customers.

THE ROLE OF SMALLER UNIVERSITIES AND COMMUNITY COLLEGES IN THE INNOVATION PROCESS NEEDS TO BE RECOGNIZED

Often forgotten are smaller universities and colleges that offer unique opportunities for playing major roles in developing technology infrastructure in a state. It is important to note that innovations and entrepreneurs come from various sources, including smaller universities and colleges. Moreover, some smaller universities have been quite successful by focusing on a few areas of science and technology, building national class expertise, and nurturing industry partnerships in those areas. Recognizing that smaller universities and colleges sometimes have technologies worth consideration for commercialization, Washington University has initiated a program – the Research Alliance of Missouri (RAM) – to provide technology transfer outreach to the State. RAM has developed a database of technologies in smaller universities and colleges in the State, and Washington University’s Office of Technology Management will evaluate opportunities for them. Supported by modest funding from the State, about 15 universities are involved in this new program.

THERE ARE NO QUICK FIXES

Our program is almost 30 years old ... it takes a long time and a lot of patience. It took us 15 years to break even, and even though it probably would take less time starting up today, it wouldn't take that much less.

- Katharine Ku, Director, Office of Technology Licensing, Stanford University

Technology transfer and commercialization programs take time. Universities known for successful technology transfer such as MIT and Stanford started technology transfer and entrepreneurial activities in the 1980's or earlier. Many of these programs did not hit their stride until more than a decade later. Moreover, the communities around the universities did not fully benefit from the technology transfer activities for many additional years. Directors of technology transfer and commercialization programs concur that the most important lesson is the need for "patience". Too often promising programs in universities and communities are slated as failures because they did not meet the deadlines dictated by political expediency. Investments in technology development are investments in the future. Many states are making substantial investments in technology and those states that do not make investments now risk being left behind.

III. CASE STUDIES

In this chapter we present nine case studies: Carnegie Mellon University, Georgia Institute of Technology, Massachusetts Institute of Technology, Purdue University, Stanford University, University of California, San Diego, University of Pennsylvania, University of Wisconsin-Madison, and Washington University. Each case study briefly describes: (a) history and environment, (b) statistical data on technology transfer and commercialization outcomes, (c) technology transfer and commercialization structure, organization, and activities, and (d) lessons learned. Some case studies additionally cover innovation centers, seed funds, incubators, research parks, and entrepreneurial development programs at the university or affiliated with the university. Most university-based models operate in rich R&D and entrepreneurial environments, and we feature only some of the many noteworthy initiatives. Nevertheless, the university models and related initiatives described here offer exemplary and innovative ideas for academic, corporate, community and state leaders.

CARNEGIE MELLON UNIVERSITY

HISTORY AND ENVIRONMENT

Located in the Oakland area of Pittsburgh, Pennsylvania, Carnegie Mellon University (CMU) is a small private university of 7,500 students and 3,000 faculty members. Philanthropist Andrew Carnegie founded the University as Carnegie Technical Schools at the turn of the 20th century. It was subsequently renamed the Carnegie Institute of Technology in 1912. In the 1960's, Carnegie Institute of Technology merged with the Mellon Institute, substantially increasing its endowment and drawing world-class researchers. CMU has become one of the nation's leading research universities, known primarily for its education and research in engineering and computer sciences.

The University of Pittsburgh (Pitt) is the other major university in the Pittsburgh area. Located within walking distance of CMU, Pitt is a state related university with about 34,000 students. Although this case study focuses primarily on CMU's technology transfer activities, it is important to note that major local economic development initiatives such as the Digital and Life Sciences Greenhouses combine the engineering and computer science strengths of CMU and the biomedical strengths of Pitt and the affiliated University of Pittsburgh Medical Center (UPMC).

In the 1980's and 1990's, the Pittsburgh region experienced a major economic downturn with the demise of traditional industry, particularly the closing of U.S. Steel and Gulf Oil, and the downsizing of General Electric and Westinghouse. But the decline of these industries spurred new growth and diversification, particularly in service and knowledge-based industries as well as in production technologies. In the 1990's, clusters began to emerge in information technology and in biotechnology and pharmaceuticals. These clusters arose from research strengths at CMU and UPMC and were fueled primarily by growing federal research expenditures in those institutions.

Governor Ridge was a tireless advocate of technology and the university's role in technology – that was incredibly important to our success. Pittsburgh's philanthropic foundations also have been very important in supporting our efforts, but it took state leadership to bring it all together.

- Donald F. Smith Jr., Vice President for Economic Development for the Mellon Pitt Carnegie Corporation

In response to declining traditional industries and in an effort to shore up technology infrastructure weaknesses, the state, community, universities and foundations joined together to initiate major economic development efforts. Those efforts began in the 1980's with the state's creation of the Ben Franklin Partnership. This program started four technology "centers" located throughout the state, including Pittsburgh. Although each of the four centers provided somewhat different services to reflect regional needs, they all provided competitive funding and private

sector linkages to research universities. In more recent years, each center was incorporated as a non-profit organization, and some became focused on offering seed capital and a variety of entrepreneurial activities and services. The Pittsburgh Technology Council started at the local level to provide networking for technology firms and to help start-ups. It is now one of the largest and most active technology councils in the U.S. In the 1990's, the Digital Greenhouse was started with a combination of federal, state, university, and foundation funding to develop and promote technologies stemming from CMU's engineering and computer research, along with those at Pitt and Pennsylvania State University. In the early 2000's, the Life Sciences Greenhouse was one of three created by the Commonwealth using a \$100 million tobacco settlement. The Greenhouse combines various forms of R&D investment for universities, seed capital, mentoring, and other services for university spin-offs. A new, small investment fund – the Idea Foundry – also provides pre-seed capital and services to entrepreneurs.

CMU and Pitt have been credited for much of the recent technology job growth and diversification in and around Pittsburgh. A number of factors appear to have contributed to CMU's role. First, CMU (as well as Pitt) over the past couple decades significantly strengthened its research capacity and stature. Under the leadership of Richard Cyert, CMU's research program in less than twenty years (1972-1990) increased almost 10-fold. As part of a strategy that involved industry input in assessing core competencies and setting research targets, CMU's research expenditures continued to grow; and by the early 2000's, CMU research expenditures placed it among the top 25 of private universities. CMU not only was one of the first universities in the country to adopt a business model involving strategic planning, it also made an early and significant commitment to entrepreneurial training, developed one of the first executive education programs, and made significant programmatic investments in unproven but emerging technologies such as robotics and computer science. In addition, its culture and mission have been very supportive of interdisciplinary work; it is home to over 50 multidisciplinary centers including 14 industrial consortia, prestigious NSF and Sloan Centers. Nationally ranked programs include (in descending order): computer engineering, business, computer science, and public affairs. The University's research has produced a number of well-known spin-offs including Lycos, Galt Technologies, and FORE Systems.

CMU's recognition of how closely its fate is tied to the vitality of the regional economy prompted the University to strengthen its formal and informal ties to economic development. In this vein, it created an Economic Development Council that reports directly to the President. It also has developed and partnered with a variety of local initiatives such as Panther Hollow, a research park, the Digital Greenhouse and the recently developed Life Sciences Greenhouse. Finally, in an unprecedented move, CMU and Pitt have created a joint executive economic development position that reports to the Presidents of both Universities.

In the following sections, we discuss CMU's technology transfer and economic development functions in more detail, and describe the Life Sciences Greenhouse, Idea Foundry, and Innovation Works (Ben Franklin Partnership of Western Pennsylvania).

THE STATS

In FY 2003, CMU's R&D expenditures were \$238 million, growing by almost two-thirds from \$145 million only two years earlier. This amount included the Software Engineering Institute (SEI), a Federal Funded Research and Development Center operated by CMU. Without the SEI, CMU's R&D expenditures totaled \$198 million. About two-thirds of total expenditures came from the federal government, with the Department of Defense (DOD) and NSF together contributing about 70% of government expenditures.

In FY 2003, CMU researchers filed 97 invention disclosures, 20% of which were collaborative across schools at CMU and/or with Pitt. CMU that year executed 48 licenses, options and agreements, a 37% increase over the previous year. Royalty income was \$2.3 million. CMU filed 85 patents – a 145% increase from the previous year. Although CMU launched only one new start-up in 2003, it launched a total of 14 start-ups from FY 2000-2003.

For FY 1999-2001, (the latest years available for national comparison), when normalized to account for R&D expenditures, CMU ranked nationally in the first quartile for (a) new U.S. patents awarded (39/174) and (b) start-ups (21/174). It ranked in the second quartile for new and active licenses and license income.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

The Innovation Transfer Center (ITC) is responsible for CMU's technology transfer functions. Started in the mid-1990's, ITC has demonstrated a particularly impressive record of generating patents and start-ups. According to Director Robert Wooldridge, ITC's goal is to move technologies to market. Generating revenues for the University is considered a by-product of ITC activities. This goal in part reflects the regional economic development focus of CMU's President Jerry Cohon who has strongly and publicly supported technology transfer and regional economic development.

ITC has a greater business focus than many other technology transfer offices, and most of its licensing officers have MBA's in addition to training in engineering or science. ITC's staff includes five licensing officers, a marketing manager, and four support persons. ITC staff is organized by discipline, and each licensing officer is assigned to specific schools and departments.

The Center was restructured in the past couple years to increase the direct relationship between licensing officers and researchers and to expand their network inside and outside the University. Since 2003, there has been a major push for licensing officers to increase the frequency of communication with researchers and in 2004 licensing officers were expected to contact every researcher in their coverage areas.

ITC also has expanded its support network in the community and draws upon a wide range of research and entrepreneurial expertise. One way it involves its network is in roundtable reviews of inventions. When particularly promising innovations arise, ITC holds roundtable discussions

with experts including faculty, alumni, business advisors, investors, and other professionals for “real time brainstorming” about commercialization strategies. ITC taps their alumni and its extended networks to participate in roundtables. In 2003, roundtables were held to review five inventions, all of which resulted in licenses. In 2004, ITC expects to hold about a dozen roundtables. In addition, ITC has increasingly tapped external experts for input on product development, pricing, and other areas not traditionally involved in the review process.

ITC works with CMU researchers to accommodate their different needs and levels of management experience. The Center can provide a budding entrepreneur with as much assistance as needed. This assistance includes management help, finding incubation space, introductions to venture capitalists, etc. Researchers can either pay for the service or give ITC a small equity position corresponding to the level of assistance provided. The compensation for such service is typically in the form of an additional increment of equity. However, in the case of physical incubation, cash rent is also acceptable. Each of the services is meant to support the early development of the company while conserving cash in the start-up.

Although the University does not offer inventors non-monetary incentives (such as credit toward tenure), the University’s policy on distribution of proceeds from inventions strongly favors the inventor. At most universities, distribution of proceeds is divided into thirds between inventor, department, and university. At CMU, one-half of net proceeds (gross revenues less actual expenses) go to the inventor, one-fourth to the University administration, and one-fourth to the inventor’s school. In some cases, the Dean of the inventor’s school forwards the school’s quarter to the inventor’s lab, providing even further financial incentive to the inventor. Therefore, an inventor can directly and indirectly receive three-fourths of the total net proceeds from an invention. This provides one of highest financial incentives for inventors of any university.

Within the University’s Tepper School of Business, ITC has linkages with the Don Jones Center for Entrepreneurial Studies (DJC). The DJC is known for its strong entrepreneurial programs and uses several entrepreneurs in non-tenure track positions to teach entrepreneurship courses. The Center offers a Technology Commercialization Workshop in which students work with start-ups, and MBA interns also work in the ITC office with start-ups. In addition, ITC recently created teams involving a business professor, licensing officer, scientist or engineer, and MBA intern to evaluate technologies and help determine the business opportunity; e.g., improvement, product, or platform. This has been done twice on an experimental basis, and in both cases companies were formed around the innovation (though that is not anticipated to always be the outcome). The ITC Director plans to use additional teams in 2005. ITC also has conducted a series of seminars for CMU researchers on technology transfer including intellectual property basics, university start-ups, Pittsburgh Life Sciences and Digital Greenhouses, and bringing new products to market. The seminars were supported, in part, by a grant from the Heinz Endowments.

ITC works closely with the CMU-Pitt Vice President for Economic Development who provides a window to external networks and regional resources. ITC has linkages with the Life Sciences Greenhouse, and references the Executive-in-Residence Program and pre-seed funds as particularly important features that fill gaps for innovations originating at CMU. ITC also works closely with the Digital Greenhouse, the Idea Foundry, and several venture capital firms. ITC’s

Director, like other technology transfer program directors, has said that more early-stage capital is needed to meet the needs of their inventors.

Universities understand that if they can target their investments and leverage their (science and technology) resources it benefits the university and the community. This is a big plus for faculty recruitment and for closer relationship with companies.

- Donald F. Smith Jr., Vice President for Economic Development for the Mellon Pitt Carnegie Corporation

In January 2000, CMU and Pitt formed a joint economic development initiative headed by Donald F. Smith Jr., Vice President for Economic Development for the Mellon Pitt Carnegie Corporation. The Vice President reports directly to the CMU President and the Pitt Chancellor. The joint economic development initiative has been a visible confirmation of the importance placed on cooperation and regional economic development by the two Universities. The Vice President has played a major role in: (a) the transformation of the Ben Franklin Partnership to the present day Innovation Works, (b) enhancement of the Digital Greenhouse, and (c) start up of the Life Sciences Greenhouse. Mr. Smith said that his approach to economic development is to view both perspectives – the Universities’ and the region’s – and to try to benefit both.

LIFE SCIENCES GREENHOUSE

From April 2002 to April 2004, Pittsburgh has created 30 new life science start-ups, all of which received some type of assistance from the Life Sciences Greenhouse. Prior to 2002, Pittsburgh created an average of about two to three life science start-ups per year.

- Pittsburgh Life Sciences Greenhouse

The Pittsburgh Life Sciences Greenhouse (PLSG) grew out of the community’s BioVenture Initiative. This Initiative was intended to build a leading life science cluster in the region based on a collaborative effort between CMU and Pitt. The Commonwealth subsequently dedicated \$100 million of its tobacco settlement funds to form three Life Sciences Greenhouses. After the announcement by Governor Ridge, Pittsburgh’s BioVenture leaders decided to merge their Initiative with the state’s Life Sciences Greenhouses. In order to develop the Greenhouse, independent studies were conducted to identify the region’s core strengths, analyze market and industry trends, and assess the region’s infrastructure for supporting cluster growth. Based on these analyses, a strategic plan was developed for the Life Sciences Greenhouse and activities to support life science growth in the region.

Started in November 2001 and operational in April 2002, the PLSG has total commitments of \$110 million. The Commonwealth provided the initial \$33 million; the additional \$77 million came mainly from several regional foundations. The PLSG is intended to encourage faculty to conduct translational research, and to move the research to proof-of-concept and commercialization stages. It is also meant to fill a shortfall in early-stage capital and to leverage the experience of successful entrepreneurs and business people who mentor life science start-ups. The PLSG focuses on four areas: (a) therapeutics, (b) diagnostics, (c) medical devices, and (d) tools and services.

The Greenhouse's Opportunity Fund helps recruit "stars" in areas of translational research and funds facilities and equipment at the universities. By summer 2004, \$12.5 million had been invested in those functions. Several other funds targeted investment in different stages of R&D and business development:

- Collaborative Research Fund – provides funding for university research conducted on behalf of an established company. In 2004, \$1 million had been set aside for this Fund.
- Technology Development Fund – provides funding for proof-of-principal within the university or a company. In 2004, \$1 million had been set aside for this Fund, which must be at least equally matched by the university or company.
- Pre-Seed Fund – in 2004, five investments of \$100,000 each were made in start-up companies. This Fund is currently operated by the Pittsburgh Biomedical Development Fund and is in the process of being capitalized for future years.
- Seed Fund – is operated by Pennsylvania Early Stage on behalf of the Life Sciences Greenhouse. PLSG contributed \$15 million to Pennsylvania Early Stage, which raised an additional \$5 million for the Pittsburgh region. (See more detailed description of Pennsylvania Early Stage in the Penn case study.)

In addition to various funding vehicles, the PLSG provides assistance to start-ups through several programs. By summer 2004, 80 of the 87 companies that PLSG had served, received business strategy and formation assistance in addition to funding or other services. According to Doros Platika, PLSG Director, the most important Greenhouse activity is the Greenhouse's Executive-in-Residence Program. This program provides mentoring services to entrepreneurs by other experienced entrepreneurs. Each experienced entrepreneur works with about five to seven companies at one time. By summer 2004, five executives had provided assistance to over 50 companies. The PLSG also has worked with 38 companies as part of their Small Business Innovation Research (SBIR) Advance Program. This program provides individualized assistance to help firms prepare SBIR/Small Business Technology Transfer Research Program (STTR) grant strategies. Through the Venture Capital Outreach Program, the Greenhouse sponsors firms to attend venture capital conferences, makes introductions to potential investors, and works with venture capital organizations. The Greenhouse also provides incubator space to nine start-ups, and two venture capital firms. The PLSG conducts networking in the life science area through a partnership with the Pittsburgh Technology Council and works with an angel network of more than 100 angels.

IDEA FOUNDRY

Started in summer 2002, the Idea Foundry is a non-profit organization aimed at funding and developing start-up enterprises. It is capitalized at \$3.6 million with half of the funding from the Commonwealth of Pennsylvania and half from major foundations. Three partners, all whom have started technology businesses, manage the Idea Foundry.

Richard Riederer first developed the concept for Idea Foundry in order to help very early (pre-business plan) enterprises that had promising technologies. Patrick Stewart, one of the Partners said that Idea Foundry's goal is to create "meaningful technology businesses" – sustainable businesses that will employ 20-30 people.

Idea Foundry invests \$100,000-200,000 per company. Only two years after it started, the three partners have founded a total of 15 successful companies, three of which already have follow-on funding of \$.5 million each, and there has been only one failure. Idea Foundry expects to invest in an additional 12 companies by the end of 2004.

About half of the firms that apply to Idea Foundry are independent entrepreneurs, 40% are university related, and 10% are spin-offs from large technology companies where the technology is not part of their core business. Two of the companies they have funded were medical device companies that spun off from other technology companies.

In order to market Idea Foundry, the partners approached venture capital companies, angel investors, and top faculty from the universities as well as the technology transfer offices to identify faculty and students interested in commercializing their technologies. According to one of the partners, it took only one day for potential applicants to start calling, and the rest has been word-of-mouth.

An entrepreneur can apply to Idea Foundry every two months during the year. The entrepreneur is taken through a four-stage evaluation process designed to provide substantial feedback throughout the process. The Partners believe that the "gap analysis", which in stage three identifies the entrepreneurs' weaknesses, is particularly valuable. About one-third of the entrepreneurs who are not approved reapply with improved business plans.

Idea Foundry has 14 advisors who help evaluate the companies and provide advice to the Partners. They are Vice Presidents for Research, CEO's of former start-ups, former executives of major corporations, and others. Faculty also provide technical expertise and five or more business interns from CMU and Pitt conduct marketing and related research on behalf of Idea Foundry clients. Last year a total of 21 interns were used in the evaluation process. Some of the start-ups have hired the interns that provided assistance through the Idea Foundry.

Our business model is very hands-on, real world and customer driven. The paramount thing is that (the entrepreneurs) understand the customers and the customers' problems. They need to see the whole solution not just part of it.

- *Patrick Stewart, Partner, Idea Foundry*

Idea Foundry has two investment models: (1) if an entrepreneur has not yet formed a company – Idea Foundry takes from 10-20% of the company depending on the amount of time invested in developing the new company; (2) if a company has been formed – Idea Foundry takes convertible debt on the company.

After the initial one-year of funding and assistance, Idea Foundry continues to work with the companies to help them obtain follow-on funding. One source of funding has been an angel network. An Idea Foundry Partner said that the angels have been critical in providing follow-on funding for the very early stage firms. Their customer network involving major corporations and other technology firms also are critical in providing technical and market advice to Idea Foundry clients.

The Idea Foundry has a formal agreement with the Life Sciences Greenhouse to conduct joint evaluations and co-fund start-up enterprises. If the Idea Foundry accepts a company working in a field encompassed by the Life Sciences Greenhouses, the Greenhouse provides direct technical input and a match of \$100,000. In exchange, the Life Sciences Greenhouse receives a convertible note for their portion of the money, and the Idea Foundry takes a separate convertible note for their portion. The Greenhouse and the Idea Foundry use the same documents for the company debt instruments making it easier for the company. To date, the Idea Foundry has funded one company in partnership with the Life Sciences Greenhouse, and they expected to fund an additional two to three companies during the remainder of 2004.

The Idea Foundry also has an agreement with the Digital Greenhouse. If there is an early-stage idea of interest to the Idea Foundry that is being funded by the Digital Greenhouse, the Greenhouse will add some additional money (\$30,000) to move the idea to a more advanced stage that may be picked up by the Idea Foundry. The Idea Foundry also works closely with the PA Cyber Security Commercialization Initiative (PACSCI) that forms R&D teams of students in cyber security. Idea Foundry is providing the first round of funding to PASCSCI for projects after it conducts a formal review process of proposed student projects. The partnership between PASCSCI and the Idea Foundry started in late 2003 in the hope that PASCSCI, in addition to the Digital and Life Sciences Greenhouses, can serve as a “feeder system” to the Idea Foundry.

CMU representatives said that they have worked with the Idea Foundry and find them a valuable asset. CMU/Pitt's Vice President for Economic Development and several University trustees from CMU and Pitt serve on Idea Foundry's Board. In addition, the Idea Foundry has review meetings with University teams in: information technology, engineering, and medical devices.

(The Chairman of the Idea Foundry Board is a long-term CMU board member and facilitated this arrangement.)

Other relationships in the community include the Pittsburgh Technology Council that refers members to the Idea Foundry. Idea Foundry companies become members of the Council and they use the Council's benefit plans, networking forums, etc. The Idea Foundry also refers companies for later-stage funding to Innovation Works, part of Pennsylvania's Ben Franklin Partnership.

INNOVATION WORKS

Innovation Works is one of four Ben Franklin Partnership programs in Pennsylvania. Each of the four is incorporated as a nonprofit corporation and is somewhat different in their focus. Innovation Works was revamped in the past couple years to focus on seed stage investing to fill a void in early stage firms. Since 2000, it has invested \$17 million in 52 companies, and cites follow-on funding of \$150 million. Innovation Works receives about \$7 million per year from the state, and has a staff of 12-14 professionals.

Innovation Works actively works with 20-25 companies at one time, with each "Enterprise Associate" directly engaged with four to five companies. Innovation Works has "Advisors" – mentors from the community who volunteer to help start-ups for a period of 18-24 months. The 30-35 Advisors include successful entrepreneurs, technologists, and executives from major industries. Each start-up company has two Advisors assigned to them, and the Advisors are involved a couple of hours every two weeks with the firms, with some involved more, and others forming on-going relationships. According to Florie Mendelson, former President of Innovation Works, the mentoring program has been an invaluable part of their program.

Innovation Works makes investments at different stages: Phase I - \$100,000, Phase II - \$300,000, Phase III - \$500,000 (Phase III is seldom used). Because the companies are in early stages, investments are made with convertible debt that is converted at a discount. Applicants apply during one of three application cycles. After an initial screening, firms make presentations to a panel involving external experts in technology, marketing, and venture capital. During the next six to eight weeks, Associates conduct due diligence and entrepreneurs go through an intensive, two-day "slot analysis" to develop a roadmap including product development, management building, funding strategies, and market positioning. At the end of the process, an Internal Investment Committee makes the final investment decision.

Ms. Mendelson said that they actively work with angel investors and sources of government funding, help the firms find strategic partners, and provide introductions to venture capitalists. Innovation Works also runs an angel network – Southwestern PA Angel Network (SPAN) – that involves over 100 angels. Ms. Mendelson said they involve PA Early Stage early in the decision-making process and have weekly interaction with the Fund. They also work more indirectly with Idea Foundry, which does earlier stage funding, and have linkages with the Life Sciences and Digital Greenhouses.

LESSONS LEARNED

A Strong, Strategically Focused Research Base Generates Deal Flow for University Technology Transfer

CMU conducted a strategic planning process that involved identifying core competencies and targeting related emerging markets. This process provided a roadmap to build CMU's research capacity. The University then aggressively sought federal research funding for targeted R&D, which underpinned the growth and prestige of CMU's research. This research has provided the pipeline for CMU's impressive record of patents and start-ups.

It is Possible for a University to Pursue Both Research Excellence and Commercial Opportunity

CMU has shown its ability to pursue both research excellence and commercial opportunity. It has increased its national standing to the top 10 in several schools and has also achieved successful technology transfer outcomes. In addition, CMU's close working relationship with industries and its focus on mutually beneficial partnerships has added value to CMU's research and presented market opportunities.

A Joint Economic Development Initiative Sends a Strong Message

CMU and Pitt have taken an unusual step in forming a highly placed, joint economic development office. This has sent a strong message on the importance of cooperation as well as the Universities' leadership role in regional economic development.

An Innovation Center such as the Life Sciences Greenhouse Leverages Multiple University and Community Resources

The Pittsburgh Life Sciences Greenhouse has leveraged funding from the Commonwealth and private foundation funding; the research strengths of Pitt, CMU and other medical resources; the mentoring capabilities of experienced entrepreneurs and business people; and well-established networks such as the Pittsburgh Technology Council. Although too early to show many results, it is structured as a winning combination.

The Idea Foundry Adds Value to Existing Infrastructure

The Idea Foundry's focus on investing and building management capacity in very early-stage firms fills a critical gap. Moreover, its external networks and emphasis on linking firms with potential customers is paying off in its early successes.

GEORGIA INSTITUTE OF TECHNOLOGY

HISTORY AND ENVIRONMENT

Atlanta, Georgia is the home of two leading research universities – Georgia Institute of Technology (Georgia Tech), the subject of this case study, and Emory University. Other respected institutions in the area are Georgia State University and the Historically Black Universities of Morehouse College, and Spellman College, as well as Clark-Atlanta University.

In the 1990's, Atlanta experienced impressive growth, creating more than 600,000 new civilian jobs, which is more than double the national growth rate. The number of fast growth firms also exceeded the national average. According to the Council on Competitiveness report *Clusters of Innovation Initiative: Atlanta-Columbus*, three of Atlanta's clusters were ranked by size in the top 10 nationally (in descending order): (a) transportation and logistics, (b) financial services, and (c) information sciences. Moreover, Atlanta's financial services and information sciences were the second fastest growing in those cluster groups nationally. Atlanta also has developed strong clusters in: (a) business services, (b) distribution services, (c) education and knowledge creation, (d) publishing and printing, and (e) heavy industry.⁷

Georgia has a long history of supporting science and technology in its universities and leveraging major economic development initiatives based on the strengths of its research universities. Georgia was one of the first states in the country to support an Industrial Extension Service, now known as the Georgia Tech Regional Network. Created in 1960, Georgia's Regional Network today is considered one of the strongest in the country. It was also one of the first states to promote incubators with the development in 1980, of the Advanced Technology Development Center (ATDC). Located at Georgia Tech, ATDC has consistently been rated one of the top incubators in the nation. In addition, Georgia has sponsored major initiatives to promote university-industry R&D collaboration. Founded by the State in 1990, the Georgia Research Alliance (GRA) has made strategic investments of more than \$300 million in centers of excellence at six Georgia universities, concentrating on advanced communications, biotechnology, and environmental technologies. Through their Eminent Scholars program, GRA has endowed chairs at universities as well as supported faculty hiring and laboratory facilities and equipment. More recently, State and local infrastructure initiatives – Technology Square and Midtown Park – provide research and mixed-use space on or adjacent to Georgia Tech's campus. Technology Square houses Georgia Tech's Economic Development Institute, ATDC, College of Management, Global Learning Center, Center for Quality Growth and Regional Development, Interdisciplinary Institute, Georgia Tech Foundation, Georgia Tech Hotel and Conference Center, and Georgia Tech Bookstore.

Georgia Tech is a medium-sized state university of more than 16,000 students and more than 900 faculty. Georgia Tech's engineering college, which produces more engineers than any university in the country, is consistently ranked in the top five by *U.S. News and World Report*. In 2003,

⁷*Clusters of Innovation Initiative: Atlanta-Columbus*, Council on Competitiveness, et. al., 2001.

nine undergraduate and seven graduate engineering programs were ranked in the top 10. Georgia Tech also is one of the strongest universities in terms of its relationship with and assistance to industries of all sizes and its strong role in statewide economic development. A number of factors and initiatives have contributed to Georgia Tech's ability to aid local and statewide economic development. First, its institutional mission and culture have historically been very supportive of technology-based outreach. Georgia Tech also has developed a comprehensive and professionally run suite of technology-based partnership and outreach mechanisms including one of the nation's longest running industrial extension services. It has more than 50 multidisciplinary, frequently industrial-focused research centers, a strong entrepreneurial training and incubator program, industrial education offerings, and a business-friendly Industry Contracting Office.

Perhaps what is most remarkable about the Georgia Tech model of technology-based economic development is how intertwined it is with State and local economic development initiatives. When one examines the economic development initiatives linked to the university, it is difficult to readily discern which initiatives are State of Georgia and which are Georgia Tech. The Economic Development Institute (EDI) sponsors a wide array of programs, and its close linkages with the Georgia Tech Research Institute (GTRI)⁸, the six Institute Colleges, the Industry Contracting Office, Continuing Education and the GRA, provide a unique and strong mix of research and economic development initiatives. Moreover, the level of private sector involvement in helping shape and direct these initiatives is stronger than in almost any institution in the country. Georgia actively solicits industry input through advisory boards and councils at its colleges and research centers and this has helped shaped the institution's curriculum, R&D focus, and service orientation as well as encourage direct industry investments.

THE STATS

In 2004, Georgia Tech's FaciliTech Program helped attract more than \$112.5 million in new capital investment and helped create or save 450 jobs statewide.

- Office of Economic Development and Technology Ventures

In FY 2003, Georgia Tech's grants and contract awards totaled \$341 million, with \$134 million going to research in GTRI, and \$106 million to the College of Engineering. More than two-thirds of research expenditures were related to engineering, math and computer sciences.

In FY 2003, Georgia Tech filed 53 U.S. patent applications, and received 41 U.S. patents that year. It executed 70 licenses and options, and launched 12 start-ups, almost all of which remained in the State. This showed a trend of increasing patents, licenses and start-ups from

⁸ GTRI is a nonprofit applied research arm of Georgia Tech. It performs more than \$100 million annually (\$113 million in FY 2002) for about 200 industry and government clients.

previous years. Start-ups showed the most impressive gain, almost doubling the average for the four previous years.

The latest comparable data FY 1999-2001, normalized for R&D expenditures, showed Georgia Tech in the third quartiles for licensing and patenting, and second quartile for start-ups. But it is important to remember that Georgia Tech's economic development mission is broader than in most universities, focusing on technology outreach, industrial advancement and upgrading as well as new technology transfer activities. Georgia Tech's ATDC, for example, is responsible for creating more than 100 firms, and in 2004, ATDC member and graduate companies generated more than \$1.75 billion in revenues. Some of the more noteworthy firms that can trace their roots directly to Georgia Tech include Scientific Atlanta, Mindspring Enterprises (now part of EarthLink) and Microcoating Technologies. More outcome data is shown under EDI and ATDC sections of this case study.

ECONOMIC DEVELOPMENT AND TECHNOLOGY VENTURES

The Office of Economic Development and Technology Ventures (EDTV) carries out Georgia Tech's technology transfer and economic development activities through four major organizational units: (a) Economic Development Institute (EDI), (b) Georgia Tech VentureLab, (c) Strategic Corporate Partners, and (d) Advanced Technology Development Center (ATDC). Two organizational units are closely related and work with EDTV: Office of Technology Licensing (OTL), operated as part of the Georgia Tech Research Corporation (GTRC), and Industry Contracting Office (ICO). In addition, Georgia Advanced Technology Ventures (GATV) is a 501(c)(3) nonprofit organization created to facilitate Georgia Tech activities in developing technology parks and facilities to support technology commercialization and incubation activities.

Our goal is to provide a clear path into Georgia Tech for industry, entrepreneurs and investors who are interested in our resources, and clear path out for faculty members who are interested in pursuing the commercialization of research. EDTV is all about getting technology innovation out into the community.

- Wayne Hodges, Vice Provost for Economic Development & Technology Ventures

In July 2003, EDTV's mission was expanded to serve as the umbrella organization for commercialization/business interactions across Georgia Tech, including activities related to economic development, industry sponsored research, faculty entrepreneurship and technology transfer. EDTV is a Georgia Tech organization headed by Wayne Hodges, Vice Provost for EDTV. Mr. Hodges is a nationally recognized leader in the field and has led EDI for more than a decade. All organizational units report to the Vice Provost.

In 2001, Jean-Lou Chameau became Provost of Georgia Tech and made commercialization one of his priorities. Dr. Chameau and Mr. Hodges were the driving force behind EDTV's expanded commercialization mission and the formation of VentureLab. Dr. Chameau, as former Dean of Engineering, has been a strong proponent of university-industry relationships and commercialization. He has sent a strong positive message to the schools and departments promoting the institution's economic development mission and commercialization as part of that mission and, as an example, recently submitted his own invention disclosure.

EDTV encourages industry input through an advisory board composed of representatives from various industries that represent their "customers". An effort being developed by EDTV – the Industry Liaison Group – will provide even closer ties to industry. Similar to MIT's Industry Liaison Group, each industry liaison will work with 10 to 15 major companies to become thoroughly familiar with the industry's emerging technology needs and pro-actively forge links to university research and technology transfer activities. In 2004, a small pilot was launched and it is hoped that the university will support future activities.

Economic Development Institute

A state can't attract and grow (technology) businesses unless it addresses the whole economic development picture. It can't survive based on a single strategy.

- Joel R. "Rick" Duke, Director, Economic Development Institute

Started in the 1940's, EDI is the oldest component of Georgia Tech's outreach arm. It is widely recognized as one of the strongest, if not the strongest university-based economic development program in the nation. EDI serves businesses statewide with a staff of more than 100 professionals and 13 regional offices located throughout the State.

Through EDI, Georgia Tech provides a comprehensive set of services designed to help about 1,000 Georgia companies per year become more productive and competitive. That includes technology-driven solutions in such areas as quality and international standards, energy and environmental management, lean enterprise transformation, information technology, government contracting, trade adjustment assistance, and marketing and new product development. EDI conducts a wide range of activities including workshops and seminars, short courses, certifications, information dissemination, and extension services.

It is important for (Georgia Tech's) outreach that the people in the regional offices are part of the community that they serve. Most of them have lived and worked their whole lives there. They know and understand the community and are a trusted part of it.

- Wayne Hodges, Vice Provost for Economic Development & Technology Ventures

Regional offices are staffed with non-academic faculty who are university affiliated, but not attached to a specific school of the university. The advantage of the regional office network is that staff are part of the communities – they almost all have lived and worked in the communities which they serve. This gives them the advantage of not only understanding the economic base and firms in their regions, but also gives them a “feel” for the industries and people in the region. Most of the professionals in the regional offices have engineering degrees and experience in the private sector and most staff members have worked with the regional offices for 10 to 15 years. Rick Duke, EDI Director, said that over the past decade there has been a shift in regional office staff from generalist industrial engineers to those who have developed distinct areas of expertise in: lean manufacturing, quality systems, energy and environment, and information technology. There also has been increasing focus on addressing “competitiveness” rather than single process engagement.

Extension services include on-site diagnostics, in some cases, followed by consulting free of charge. After the initial period, firms are charged fees for service. According to the Director, firms are paying an increasing portion of services, now about one-third of the total cost, with federal and State government equally sharing the remaining two-thirds. Small manufacturing and technology firms’ greatest results and satisfaction ratings are in the areas of productivity improvements and cost containment (lean manufacturing). In the future, the regional offices will increasingly help firms with product development, marketing, and attracting financing. Georgia Tech is a member of the Manufacturing Extension Partnership (MEP), a national network of technical assistance centers that helps small- and mid-sized manufacturers. Operated by the National Institute for Standards and Technology (NIST), the MEP is the largest federal sponsor for Georgia Tech’s EDI. In early 2004, MEP’s funding to EDI was cut by 75% because of massive federal budget reductions; this cut will lead to the closing of three regional offices and the expected elimination of service to more than 300 firms.

EDI reports the following results in its FY 2004 “Report Card”:

- Served 1,889 customers through projects, technical assistance, counseling sessions and information requests;
- Companies assisted by the Procurement Assistance Center gained contracts worth \$500 million;
- Through its FaciliTech Program, EDI helped attract or retain \$112.5 million investment and create or save 450 jobs; and
- Helped companies create or save 11,778 jobs.

Venture Lab

In 2001, Georgia Tech formed a new commercialization organization – VentureLab – to streamline the technology commercialization process and provide consistent support for faculty who want to bring their innovations to market through their own start-up companies. The creation of VentureLab was partly the result of the Provost’s commercialization thrust and also a response to a commercialization study that concluded investors wanted more credible management in university-based start-ups. VentureLab was created to develop credible management for early-stage enterprises originating in the university and to fill a gap in pre-seed capital.

VentureLab staff members evaluate technologies developed in research laboratories, assess their potential commercial value, map out a commercialization path. VentureLab also capitalizes promising innovations through a small pre-seed fund and introduces inventors to potential investors. Three full-time and two part-time “Commercial Catalysts”, all who have entrepreneurial backgrounds, evaluate innovation disclosures and assist promising inventors. In addition, VentureLab’s “Fellows” program matches successful entrepreneurs with faculty to further assist them in developing commercialization and investment strategies. According to Venture Lab’s Director, Steven Derezinski, Fellows are paid only \$30-\$50 per hour, but participate because they want access to promising deals. The current three Fellows help entrepreneurs write business plans, apply for SBIR/STTR, and generally do the early-stage “heavy lifting” for faculty inventors. In exchange for academic credit, MBA students also conduct research and marketing studies for faculty inventors.

Venture Lab Commercial Catalysts and Fellows also have established relationships with Eminent Scholars in the GRA. According to Ben Hill, Associate Director of ATDC and a Program Manager of VentureLab, in most cases the Eminent Scholars have been very cooperative. Part of VentureLab’s job is to educate the faculty about the commercialization process and staff do so by meeting with Deans and attending faculty meetings. In 2004, VentureLab began assigning staff as liaisons to specific schools.

The Georgia Research Alliance’s umbrella VentureLab program has a small but robust “pre-seed” capital program fund. Through the Fund, the GRA makes \$600,000 per year available to faculty at participating VentureLab programs – at Georgia Tech and other GRA universities – in two phases: Phase I – technology validation (\$50,000) and Phase II – product development and refinement (\$100,000). Phase II requires an equal match. VentureLab takes equity in the firms in which it invests and provides assistance. Equity is held by the university developing the technology.

Twice per year, VentureLab sponsors “Technology Day”, a networking and presentation event that attracts venture capitalists. They also sponsor an annual Technology Day West in Silicon Valley. In 2003, 70 venture capitalists from the West Coast attended and in early 2004, two deals were pending. In 2004, VentureLab sponsored an additional Technology Day in Boston and will hold one in Silicon Valley.

VentureLab will be replicated at five research universities in the State (corresponding to the GRA institutions). In 2004, Venture Lab was being implemented at three universities: University of Georgia (in agriculture and life sciences), Emory University (in life sciences), and Medical College of Georgia. It will be implemented later at Georgia State University and Clark-Atlanta University. VentureLab's plan is to place one Commercialization Catalyst at each university. In addition, Emory University and Georgia Tech's School of Engineering recently signed a Memorandum-of-Understanding to facilitate collaborative commercialization activities through VentureLab involving researchers from both universities. Each university will take equity positions in companies formed as a result of the collaborative research.

In its first three years of operation, VentureLab evaluated Georgia Tech innovations involving more than 145 faculty members. A dozen of these technologies were identified as having significant commercial and start-up company potential worthy of further assistance and with a good possibility of receiving some venture funding. By mid 2004, five firms had graduated and had attracted \$9 million in venture capital funding. In addition, VentureLab assisted six firms that received SBIR/STTR awards. The five companies that graduated have been accepted into ATDC and will continue to mature and grow there.

Advanced Technology Development Center

Started in 1980, ATDC was created to help retain engineering students in the Atlanta area and the State. ATDC was one of the first university-based incubators in the country and has become one of the nation's premier programs winning numerous national awards including a 2004 EDA award.

ATDC receives \$3 million annually from the State, and operates as a unit within Georgia Tech's EDTV. Each year about 140 companies apply to ATDC of which 10-12 new companies are admitted. ATDC's entrance criteria focus on the technology and evidence of a growing market for the technology. In mid-2004, there were 36 companies in incubator space, five of which came from VentureLab. Only about one-quarter of the companies in the incubator are affiliated with Georgia Tech. According to the ATDC Director, although most firms are not directly linked to the university, Georgia Tech's presence is critical because of the credibility and environment provided by the university.

In 2003, ATDC's main incubator moved into new space in the Technology Square development adjacent to Georgia Tech's campus, and is collocated with VentureLab and EDI. The main incubator is about 200,000 square feet, with 80,000 devoted to incubation space, almost all of which is occupied. Other space is used for conference rooms, service providers, etc. For bioscience start-ups, ATDC operates a 22,000 square foot incubator in Georgia Tech's Ford Environmental Science and Technology Building, providing office and wet lab space. In Warner Robins, ATDC supports technology-based companies mainly in aerospace at the Middle Georgia Technology Development Center, and in Savannah ATDC shares facilities with Georgia Tech Savannah. ATDC also manages the Columbus Regional Technology Center, an incubator in Columbus, GA. ATDC charges entrepreneurs about 50-60% of market rate for incubator space.

ATDC's 15 staff work closely with resident firms, providing "cradle to grave" services that focus on ATDC "4 C's": Consulting, Connections, Community and Center. Consulting – seven "Venture Catalysts", all who have entrepreneurial backgrounds, provide consulting. Connections – Venture Catalysts play a facilitating role in making connections to investors, customers, potential hires, and service providers. ATDC staff claim to know every venture capitalist in the Atlanta region as well as numerous national investors. In addition, there are representatives of law firms and accounting firms who have offices in the incubator and who conduct some *pro bono* work for incubator residents. Community – ATDC holds weekly Brown Bag Lunches and sponsors the CEO Roundtable to facilitate networking, promote business opportunities, and encourage shared experiences. Center – the new space consolidates previously disparate space and is physically structured to facilitate networking.

To help expand the amount of seed capital available to ATDC and other start-ups, the State created the \$5 million ATDC Seed Capital Fund. Managed by ATDC, the Seed Capital Fund invests in companies operating in the telecom, broadband and wireless markets. Money from the Fund must be matched at least 3:1 ratio by private investment. By late 2004, 14 State and 8 out-of-State investors had joined the Fund to help finance early-stage companies. Since 2001, the Fund has invested \$3.1 million, which has been leveraged at a nearly 30:1 ratio with funds from private sources, creating total investments of more than \$105 million. Ten early-stage companies, all members of the Georgia Tech's ATDC, have received investments. A new fund, the Evergreen Fund, is being developed to provide additional seed capital for ATDC and other entrepreneurs.

ATDC's evaluations have shown a return of 6.8 times (direct and indirect return) on the State's annual funding of ATDC operations. Over the past 20 years, more than 100 companies have emerged from ATDC and, in 2003, two ATDC companies were acquired for \$60 million each.

ATDC's 2004 "Report Card" summarizes other recent accomplishments:

- Investment in ADTC companies totaled nearly \$387 million during 2003 and 2004;
- ATDC graduate and member companies generated more than \$1.75 billion in revenues and provided more than 4,900 high-tech jobs during 2002; and
- Forty-four companies participated in the ATDC program in CY 2002; five companies graduated in May 2003.

In addition, ATDC's Seed Capital Fund has:

- Leveraged \$3.1 million into \$105 million – a better than 30:1 ratio; and
- Created more than 220 jobs in start-up companies receiving seed capital funds.

OFFICE OF TECHNOLOGY LICENSING

Formed in 1992, the Office of Technology Licensing (OTL) mission is primarily service and economic development. It has a full-time staff of eight professionals and assistants who handle more than 220 invention disclosures per year (226 in FY 2003). Almost three-quarters of inventions come from research conducted at GTRI and the School of Engineering, particularly the School of Electrical and Computer Engineering.

OTL is a division of GTRC, a nonprofit organization that holds title to and manages all intellectual property developed through Georgia Tech's research activities. The OTL Director reports to the managing director of GTRC. In 2003, as part of an effort to coordinate commercialization activities across Georgia Tech, the OTL Director assumed additional responsibility as the Assistant Vice Provost for EDTV. This reorganization has led to a closer working relationship with ATDC, the newly formed VentureLab and the Industry Contracting office.

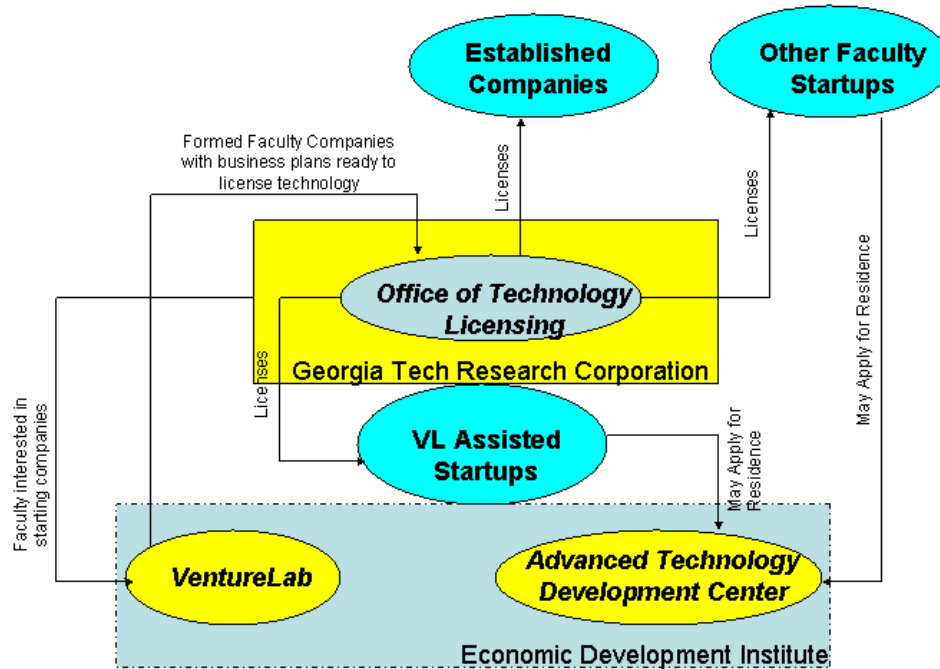
OTL does not focus primarily on income – it is a service-focused organization with an income stream. If given a choice, we'll go with a start-up. This is because start-ups generally stay in Georgia while licensing to existing corporations generally leads to the technology leaving our state. Start-ups create jobs in Georgia and help us fulfill our economic development mission.

- *George Harker, Director, Office of Technology Licensing*

The OTL Director and five licensing professionals work with faculty and researchers to commercialize technology, with one of the five licensing professionals additionally handling proposal and contract activities for the Office of Industry Contracting (a separate unit with a dual reporting to both OTL and the Office of Sponsored Research). All licensing professionals provide services across disciplines and schools. Additionally, there is an attorney who attends graduate school at Georgia Tech and receives a tuition waiver and a stipend in exchange for providing part-time assistance to the OTL group, as well as two undergraduate students who provide administrative and research assistance.

Faculty inventors and researchers receive one-third of net revenues from licensing or commercializing inventions originating at Georgia Tech, net of expenses (mainly patent expenses that the university can not recover). Some departments provide additional incentives by giving credit toward tenure or other advancement for filing patents, and other commercialization activities. The OTL Director said that although credit for commercialization activities is not formally part of the tenure and advancement process, it is a growing consideration in some tenure committee decisions. Moreover, new faculty recruits are increasingly interested in the university's support for technology transfer and start-ups. Dr. Harker said that there is a growing trend for faculty recruits to call or come by the OTL office to inquire about commercialization assistance before they make their decision to join the Georgia Tech faculty.

**Figure 1
Technology Transfer and Commercialization
Organization Flowchart**



Source: Office of Technology Licensing, Georgia Institute of Technology.

In an effort to coordinate technology transfer activities across the state, Georgia Tech took a leadership role in creating the Georgia Technology Transfer Group (GTTG) in late 2001. Representatives responsible for technology transfer activities at the six GRA institutions – Georgia Tech, Emory University, University of Georgia, Georgia State University, the Medical College of Georgia and Clark-Atlanta University – meet every couple months to exchange information on current technology transfer activities, discuss issues, share best practices, and present opportunities for potential collaboration. In June 2002, the national Center for Disease Control (CDC) joined the group. OTL Director Harker said that when the six universities band together they represent a \$1 billion R&D resource – making the State more attractive to industries and venture capitalists.

Georgia Tech also took the lead in creating a regional technology transfer group – the Southeast Technology Transfer Directors’ Group – that encompasses the entire Southeastern region of the nation. The Group meets every six months in Atlanta. An Atlanta patent law firm covers most of the expenses associated with the meetings. The one-day meetings include presentations (e.g., by venture capitalists and industry representatives working with universities) and an afternoon of free-forum problem solving and idea sharing.

COLLABORATIVE RESEARCH

Of special interest for life sciences technology transfer is a collaborative Biomedical Engineering program that facilitates joint research and commercialization between Emory University and Georgia Tech. Faculty members from both universities participate in this translational research program that combines the engineering and life sciences research strengths of both universities. Program directors are Chairman of the Biomedical Engineering and Dean of Engineering at Georgia Tech, and the Dean of Medicine at Emory University. Faculty can conduct research at either university and a shuttle facilitates the commute between the two universities. A privately funded grant has encouraged this cooperation. The Wallace Coulter Foundation endowed \$400,000 per year to fund four grants annually. The grant requires two principal investigators such as a Georgia Tech bioengineering faculty and Emory Medical School clinician to work jointly and equally on projects. In early 2004, the Emory and Georgia Tech Grant Program had begun in its third year. Lee Heron, ATDC's Biosciences Manager said that it took faculty a couple years to respond appropriately – in first two years applicants submitted proposals from one university or the other but by the third year, 11 of 18 proposals were joint Emory-Georgia Tech faculty proposals. Joint cooperation, in itself, is an early program accomplishment.

The program is a feeder system for EmTech – a small incubator that houses four companies on the Emory Briarcliff Campus. ATDC's General Manager for Biosciences works closely with EmTech and has organized networking events such as a Translational Research Dinner Club. The Club focuses on bio-medical translational research and is open to faculty and clinicians of Georgia Tech and Emory University. The Coulter Foundation underwrites these activities.

LESSONS LEARNED

Regional Offices Facilitate Technology Outreach

Georgia Tech's 13 regional offices provide economic development, industrial, and technology services for firms throughout the State. Offices are staffed with professionals who have worked in the private sector and lived in the communities in which they serve. This builds credibility and trust with firms, and reliable, long-term institutional capacity. The State's investment has been paid back many times in productivity gains and jobs created and retained.

Pre-Seed Funding Packaged with Management Building Services Promotes Faculty Start-ups

VentureLab helps develop credibly managed, faculty start-ups. It does so by using Commercialization Catalysts and VentureLab Fellows to build management capacity. It provides additional support through pre-seed funding. In a very short time, this comprehensive package has already created several promising start-ups.

An Incubator Program Can Serve as a Center for Commercialization Activities

ATDC for many years was the focal point for commercialization activities. This included hands-on management services in addition to incubation space, and more recently, pre-seed investment vehicles. It is important to note that most demonstrable results did not occur until more than a decade after the incubator program began. The payoff for patience has been the creation of more than 100 start-ups.

Industry Outreach Can Payoff in Many Ways

Georgia Tech is known for its industry outreach through its broad array of education and services sponsored by EDI, College of Engineering, GTRI, and other schools and centers. Moreover, Georgia Tech actively solicits industry input through advisory boards and councils at its colleges and research centers. EDI's pilot Industry Liaison Group is another step in developing close working relationships between Georgia Tech and industries. These activities benefited the university by helping shape its curriculum and R&D agenda, and in some cases, also resulted in direct support for research.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HISTORY AND ENVIRONMENT

Massachusetts Institute of Technology (MIT) is recognized as one of the top private universities in the nation. It is located in Cambridge, MA in close proximity to Harvard University and other leading research universities in Greater Boston: Boston College, Boston University, Brandeis University, Northeastern University, Tufts University and University of Massachusetts - Boston. MIT is part of the “intellectual infrastructure” that has created and sustained growth of science and technology clusters in Greater Boston.

Greater Boston’s eight research universities are the region's special advantage: an enduring and stable economic engine, constantly changing and developing as new knowledge is gained and new technologies and industries are created ... In the year 2000 alone, they provided a \$7.4 billion boost to the regional economy.

- *“Engines of Economic Growth”*

The study “Engines of Economic Growth” documented the economic impact of Boston’s eight research universities. It concluded that the universities “formed the underpinning of the regional economy, producing human capital and new technologies that fuel economic growth.” The research universities have created technology companies and have been a magnet to attract others. Companies created by Greater Boston universities include Analog Devices, Biogen, and EMC and those attracted to the region include Amgen, Cisco, Merck, Novartis, Pfizer and Sun.⁹ A number of the spin-offs such as Analog Devices and Biogen were created by MIT alumni.

The Greater Boston Chamber of Commerce identified five industry clusters as driving the region’s growth in the 1990’s: (a) high technology (including computer hardware and software, telecommunication, instruments, and biotechnology), (b) financial services, (c) knowledge industries (including higher education, and consulting and research firms), (d) health care, and (e) visitor industries. The annual benchmarking index prepared by the Massachusetts Technology Collaborative (MTC) reported that Massachusetts, like other states in the early 2000’s, was hard hit by the fall out in telecommunications, decreased spending in information technology; layoffs and closings by several local employers, and local government budget cuts. In 2002, there were significant declines in telecommunications, information technology, and software and communications services, but other clusters such as healthcare technology and financial services experienced relatively stable employment. Moreover, despite the economic downturn, almost 27,000 new businesses incorporated, a 26.6% increase from the previous year, and the largest increase in over nine years.

⁹ “Engines of Economic Growth”, Appleseed, Inc., 2003.

Federal R&D expenditures, particularly DOD, NIH and NSF expenditures have fed the pipeline for university technology transfer and commercialization, a key factor in Greater Boston's economic growth. Research universities in Massachusetts, in 2000, together received more federal funding per resident than any other leading technology state, with about two-fifths going to universities in Greater Boston.¹⁰ MIT alone in FY 2003 received almost \$350 million in federal R&D expenditures and an additional \$.5 billion went to Lincoln Labs, operated by MIT. In an interview with Innovation Associates, Lita Nelsen, Director of MIT's Technology Licensing Office, cited a strong research base supported by federal R&D expenditures, as the most important factor in MIT's successful technology transfer efforts.

In addition to high federal R&D expenditures, venture capital has fed the innovation economy in Greater Boston and Massachusetts. According to MTC, Massachusetts received about 13% of the total national venture capital in 2002, placing it second only to California. But venture capital in Massachusetts as elsewhere took a major hit in the past couple years, totaling about \$1 billion in the first two quarters of 2003. Software and biotechnology attracted the highest amounts of venture capital, representing close to half of the total venture capital funding.¹¹

In response to recent economic downturns, the Massachusetts legislature in 2004 enacted a stimulus package, overriding the Governor's veto. This package included several technology development and commercialization initiatives: (a) \$25 million re-capitalization of the Emerging Technology Fund that provides facilities and equipment to tech-based companies; (b) \$20 million for Collaborative Academic Research Centers including establishment of Centers of Excellence in biotechnology, medical devices, and nanotechnology; and (c) \$15 million for creation of the John Adams Institute to promote regional innovation-driven clusters.¹²

MIT has been one of the main generators of new technology spin-offs in Greater Boston.¹³ Founded in 1865, MIT is a medium-sized private institution with 4,100 undergraduate and 6,200 graduate students, and almost 1,000 faculty members. An additional 2,800 researchers contribute to MIT's research base, mainly at Lincoln Laboratory, a federally funded R&D center in Lexington, MA operated by MIT. The university also employs an additional 2,700 graduate research assistants.

MIT is best known for its stellar engineering and business schools and increasingly for its basic sciences. In its 2004 index of graduate schools, *U.S. News & World Report* rated MIT first in engineering and fourth in business.¹⁴ Within engineering, MIT ranked first in the following categories: aerospace, chemical, computer, electrical/electronic, materials, mechanical and nuclear engineering. It also ranked third in civil and biomedical and seventh in environmental engineering. MIT has a rich research base and, despite its medium size, has one of the highest R&D expenditures of any university in the nation (ranked 14th in FY 2001). It boasts 10 Nobel Prize winners and has more than 50 research centers/units, many of which perform interdisciplinary R&D. Some of its cutting-edge laboratories include the Computer Science and

¹⁰ *ibid.*

¹¹ Massachusetts Technology Collaborative.

¹² State Science and Technology Institute.

¹³ Technology Licensing Office, MIT.

¹⁴ "America's Best Graduate Schools", *U.S. News & World Report*, 2004.

Artificial Intelligence Lab, Laboratory for Manufacturing and Productivity, and Biotechnology Process Engineering Center. In addition, Lincoln Labs, operated by MIT, conducts R&D in emerging defense technologies, and MIT is closely affiliated with the Whitehead Institute for Biomedical Research.

MIT is known for its “entrepreneurial spirit”. Its Technology Licensing Office is one of the most productive in the nation, consistently ranking among the top 10 universities for patents, licenses, and start-ups. (See “The Stats”.) Its close relationships with researchers, and linkages to venture capitalists have added value to MIT’s already rich R&D environment. MIT’s Entrepreneurship Center in the Sloan School of Management has been a forerunner in the field of entrepreneurship. It offers a wide range of courses and initiatives such as the \$50K Competition – a business competition that involves business plan workshops and mentoring, and student internships with start-up and venture capital firms. The Sloan School’s Management of Technology degree was the world’s first master’s degree program of its kind. The MIT Enterprise Forum (now a nonprofit organization) has branches throughout the world, providing training and forums that link budding entrepreneurs with potential investors. The Deshpande Center uses a \$20 million donation to provide faculty with grants that advance research from the idea to innovation stages. MIT’s Office of Corporate Relations provides an entry point for industries that want to sponsor or gain access to research. Its Industrial Liaison Program enables member firms to draw upon MIT faculty and researchers to enhance their technology strategies, and also helps faculty members stay abreast of the latest developments in industry.

MIT also has developed a physical presence for its entrepreneurial activities by improving the infrastructure around the university. MIT, working with a private developer and the City of Cambridge, in the 1970’s, redeveloped an abandoned factory that became a commercial enterprise called Technology Square. More recently, MIT renovated and constructed six additional buildings to form the Tech Square complex, vastly improving the area around MIT and making it more conducive to attract technology and related service firms. MIT also has renovated or constructed additional commercial buildings elsewhere in Cambridge, some to accommodate the biotech industry. In addition, MIT’s University Park provides mixed-use space including laboratories and a hotel.

THE STATS

MIT students, alums, and faculty have founded over 5,000 companies. Approximately 150 new MIT-related companies are founded each year. These companies account for employment of over \$1.1 million and annual sales of more than \$230 billion.

- Source: MIT Entrepreneurship Center, 2004

In FY 2003, MIT’s R&D expenditures totaled \$472 million. MIT also operates the Lincoln Laboratory, a federally funded R&D center that had a research budget of \$523 million. About three-fourths of MIT’s R&D expenditures (not including Lincoln Lab) came from the federal

government, with about half of the federal expenditures from DOD and NIH, and the remainder from DOE, NSF and NASA. About 16% or \$73 million came from private industry sponsored programs.

MIT consistently has generated some of the highest levels of patents, licenses, and start-ups of any university in the nation. In FY 2003, MIT's Technology Licensing Office filed 238 patents and 152 patents were issued that year. It executed 90 licenses and launched 17 start-ups (that were capitalized with at least \$500,000 of external funding), slightly below its five-year average of 22 start-ups per year. Gross revenues from more than 1,000 licenses were \$31.7 million. At its height for license revenue, in FY 2001, MIT received \$82.1 million.

From FY 1999-2001, the latest comparable data available, MIT ranked in the first quartile for all standard commercialization metrics – new patents, new licenses, active licenses, license income, and start-ups. Most impressive were the 77 start-ups formed from 1999-2001. Even when “normalized” to account for high R&D expenditures, MIT nationally ranked seventh for U.S. patents awarded, eighth for new start-ups, and tenth for active licenses.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

The Technology Licensing Office (TLO) manages intellectual property patenting, licensing, trade marking and copyrighting for MIT, Lincoln Laboratory and the Whitehead Institute for Biomedical Research (WIBR),¹⁵ together representing about \$1 billion in annual R&D expenditures. TLO handles about 450 invention disclosures per year.

TLO staff of 30 includes a Director, 11 Technology Licensing Officers and Associate Technology Licensing Officers, four Technology Licensing Associates who assist the Officers, four Financial Operations staff, seven information and operations staff, and four administrative staff. Technology Licensing Officers are highly specialized; they are assigned to a discipline and are responsible for specific departments and units. All professional staff have backgrounds in science and engineering areas or functional specialties such as law or finance. Many Licensing Officers and others have worked with TLO for 10 or more years, providing critical institutional memory and consistency. TLO hires outside counsel to file patents.

MIT's policy on the distribution of licensing income is standard for most research universities. TLO retains 15% to cover expenses, and the remaining is split in thirds between the inventor, the academic department, and the university.

MIT's successful commercialization record is based on numerous factors. One factor is TLO's “smart and specialized staff.” Another is the close working relationship between Licensing Officers and university researchers, facilitating early identification of potential commercial opportunities. Lita Nelsen, Director of TLO, said that TLO increasingly identifies research at

¹⁵ WIBR is a non-profit research and educational institution. It was one of the major federally funded centers for genome mapping and sequencing. In 2003, it became the core facility in the Broad Institute, a collaborative effort between WIBR, MIT and Harvard University.

very early stages in order to encourage researchers to consider commercialization early in the innovation process. Another factor is TLO's continuous and often close, informal relationships with venture capitalists. If the TLO Director and staff identify "interesting" research, they often inform venture capitalists about the research before a business plan is ever written. Ms. Nelsen said "we want to establish the venture capitalist's interest early and hope they will then work with the professor or researcher on developing the business plan." Once it is determined that the faculty or researcher has something worth examining further, the TLO spends considerable time working with the inventor. This includes helping inventors obtain legal and financial help.

MIT provides numerous networking opportunities for faculty inventors and students through individual schools. Private venture capital firms and community organizations such as Mass Bio and MIT Enterprise Forum also offer abundant opportunities for faculty inventors to network with potential investors, customers, and service providers.

MIT's strong base of federal funding in basic research as well as applied research has provided a rich pipeline for innovation and start-up firms in engineering, computer science, and biotech. A less tangible, but nevertheless critical factor in MIT's commercialization success has been its "cultural and entrepreneurial environment", built steadily over the years since World War II. The extent of MIT's entrepreneurial philosophy and culture is seen in few other universities except Stanford. From 1990 until 2004, MIT's President Charles Vest reinforced the entrepreneurial tradition and been a strong proponent of commercializing university technologies, frequently expressing his support for the university's dual role of academic excellence and commercial vitality. Interaction between faculty and industries is encouraged. Most faculty members consult to private industry and others outside the university, facilitating natural ties that sometimes result in licensing opportunities or referrals. Ms. Nelsen said continuous interaction with the private sector and networking "is a way of life here".

There are several factors that have contributed to TLO's success:

- 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.

- Lita Nelsen, Director, Technology Licensing Office

MIT ENTREPRENEURSHIP CENTER

The Sloan School of Management began teaching entrepreneurship courses in the 1960's. Building on that experience, the School founded the Entrepreneurship Center (E-Center) in 1996 with seed funding from the Kauffman Foundation's Center for Entrepreneurial Leadership, the

Coleman Foundation, and the Lemelson Foundation. The E-Center successfully recruited experienced entrepreneurs, many of whom were alumni, to teach courses and participate in entrepreneurial activities. As many entrepreneurs as faculty now teach courses through E-Center. Many entrepreneurs teach for the pure enjoyment, participate in \$50 Competition panels or E-Lab, and sponsor networking events. In addition, the Managing Director of the Entrepreneurship Center, Ken Morse, is a successful entrepreneur himself, and is well respected and networked in the community. Through the E-Center, about 1,500 graduate and undergraduate students each year take entrepreneurship courses. Although most students are from management, about one-fourth of the students are from engineering, science and other departments.

The best entrepreneurs understand that building a first-rate company is like winning a decathlon. It's not about sprinting – it's about mustering the courage, discipline, and conviction to excel in many dimensions over the long term. The MIT Entrepreneurship Center provides this coaching and development for the leaders who will pilot the world-class high-tech companies of tomorrow.

- *MIT Entrepreneurship Center*

Entrepreneurship Lab (E-Lab)

One of the most popular course offerings at MIT Sloan is E-Lab. It is a semester-long course in which students work one day a week in a start-up company. Interdisciplinary teams of MBAs and engineering students are charged with helping to solve a real-world problem. Assignments range from conducting market research for a pre-IPO biotech company, to participating in the creation of a semiconductor company's marketing plan, to helping a software company develop high-level customer profiles.

The Sloan School normally recruits about 40 or more start-ups each year to participate in E-Lab. The preferred companies are at an early stage but at least have raised their first round of capital and employ 40-50 people. Each semester 50-60 students participate in the program, and E-Lab matches companies with students according to specialization and interest. Students who participate in E-Lab mainly come from engineering disciplines, but E-Lab is increasingly seeking students from other disciplines. Companies are asked to pay only the student's out-of-pocket expenses, but are encouraged to sponsor student attendance at trade shows, conferences, and other activities to enrich their experience. The program is mutually beneficial – companies gain from a fresh perspective on business strategies and technical problem solving; students gain from first-hand experience with a start-up firm.

Like E-Lab, Global Lab (G-Lab) is designed to provide students with first-hand experience working with start-ups, but does so with international young companies. During the January break between semesters, students work for several weeks in entrepreneurial companies outside of the U.S.

\$50K Competition

Since its inception, 74 companies, including 11 biotech companies, have started as a result of the \$50K Competition. These companies have attracted over \$180 million dollars in venture capital funding.

- Entrepreneurship Center, Sloan School of Management

The \$50K Competition is the cornerstone of the E-Center. In 1986, the MIT Entrepreneurs Club and the Sloan New Ventures Association started the \$50 Competition to encourage engineering students to work with MIT's Sloan School of Management and to become entrepreneurs. The original sponsors included the deans from the Sloan School, the School of Engineering, Thermo Electron and Price Waterhouse. Originally started as a \$10K competition, the Competition now awards \$50,000 – a \$30,000 award to the winner and a \$10,000 award to two runners-up. The majority of participants are engineering students, but students from all schools now participate and inter-disciplinary teams are encouraged.

Each fall about 40-50 students engage in a \$1K warm-up competition with awards of \$100 going to students in each of 10 categories. As part of this warm-up, students write executive plans (partial business plans) and work with the E-Center in refining those plans. Each spring the \$50K Competition involves students from engineering, science and business students teaming together, usually in teams of four to five students, to develop business plans. (Some coming from the earlier \$1K competition.) Others from outside the university can join the Competition but at least one member of the team must be an MIT student. Last year about 120 participants were involved in the Competitions.

Team members are coached by the E-Center and by business mentors. The mentors are experienced entrepreneurs, venture capitalists, lawyers, and other business and management service providers. A panel of about five venture capitalists and other interested parties act as judges. Mentors and judges participate *pro bono*, often participating because it provides them with a window on potential opportunities. Students who do not win the Competition still receive valuable input on business plans from experienced mentors and judges. Moreover, it offers exposure to potential investors, who sometimes follow-up with students after the Competition. Robert Ayan, Program Manager of the E-Center said the \$50K Competition is the most important program offered by E-Center. He said that the Competition accomplishes multiple goals – it builds the entrepreneurial culture at MIT, offers a learning opportunity, and provides real business opportunities for the students.

Entrepreneurship Development Program

The Entrepreneurship Development Program (EDP) is an intensive two-week course that introduces entrepreneurs, corporate venturing executives, and others to MIT's technology transfer system and entrepreneurial educational programs. EDP involves lectures, visits to high-tech

start-ups, and case studies of successful entrepreneurs. The goal is for participants to learn how to identify and evaluate opportunities for new ventures, how the venture capital process works, and how to build companies from corporate or university-based research. The program covers the entire venture creation process from idea generation to building viable businesses, with special emphasis on the nurturing roles of corporations, universities, governments, and foundations.

THE DESHPANDE CENTER

The Deshpande Center was launched in 2002 with a grant of \$20 million from the co-founder and chairman of Sycamore Networks. Although Dr. Deshpande was not a graduate of MIT, he wanted to promote innovation coming from the School of Engineering. The Center, which is part of the School of Engineering, provides grants, advice, mentoring and networking in technology fields to move faculty research closer to market. It is open to faculty from engineering and other faculty who work collaboratively with the School of Engineering. In early 2004, about 100 faculty had applied for grants, and 27 had been funded a total of \$3 million. Two companies had spun out of the program, and one of the two was a finalist in the \$50K Competition.

The Center has four main purposes: (a) to provide significant academic benefit, (b) to influence students and professors, (c) to impact the market place, and (d) to bridge the gap between technology and marketplace. The program does so through a Grant Program, a Catalyst Program, and Innovation Teams (I-Teams).

Through the Deshpande Center, grants are provided to faculty to advance their research. The Grant Program is conducted in two phases – Ignition Grants provide \$50,000 for an invention at the idea stage; Innovation Program Grants provide \$50,000 to \$115,000 for an invention between the invention and innovation stage. Initially Innovation Program Grants were funded up to \$250,000, but were reduced in order to extend the duration of the program, now slated for five years. At the Innovation Program Grant phase, the Center expects some commercial action such as the start of a company or a license within 18 months of funding.

A committee composed of venture capitalists, entrepreneurs and professors meets several times each year to review proposals. There is a pre-proposal and a proposal stage. The Committee reviews pre-proposals and gives recommendations to: (a) proceed to the proposal stage, (b) resubmit in the following year, or (c) go back to the drawing board. At the full proposal stage, the Committee performs a more rigorous evaluation that sometimes involves outside experts for technical, business, and market evaluations.

The Center's Catalyst Program involves 12 "Catalysts" from the venture capital and business communities who provide mentoring to grantees. The Center Director, Krisztina Holly, said that 80% of the value from the Deshpande Center comes from the Catalysts. The Center also sponsors various workshops and forums for faculty members. The IdeaStream Symposium provides an annual, invitation-only showcase for new technologies coming from MIT and is intended to network faculty with venture capitalists. The Ignition Forums bring technology leaders to the university to present corporate challenges with faculty. Faculty Entrepreneurship

Workshops focus on faculty challenges in taking innovations to market. About 150 faculty members have registered for these Center workshops and forums.

Catalysts (private sector mentors to faculty) are the most important part of the program – they put a “real world spin” on academic innovations.

- *Krisztina Holly, Director, Deshpande Center*

The Director of the Deshpande Center said that the Center works closely with the TLO. She said the TLO takes special notice of inventions coming from the Deshpande Center, as well as the \$50K Competition, because the inventions have already been vetted by expert evaluators and have a “stamp of approval.” The Deshpande Center also works closely with the E-Center.

MIT ENTERPRISE FORUM

The MIT Enterprise Forum of Cambridge is a volunteer, non-profit organization based at MIT. It is well known and replicated throughout the country, including chapters in Connecticut. Over the past 20 years, the MIT Enterprise Forum of Cambridge has helped more than 1,000 companies attract investment capital and build their companies. The Forum has become well known for their selection, coaching and presentation of firms before potential investors. The Forum of Cambridge has 10 programs per year with an audience of about 200. Start-up firms are carefully selected and coached by successful entrepreneurs, venture capitalists, and business leaders who help the firms understand and hone presentations for potential investors. Although the audience was originally intended for investors, other service providers increasingly attend as well as other entrepreneurs and students. It has been a good way for entrepreneurs to meet attorneys, accountants, and other service providers in addition to potential investors and also to network with other entrepreneurs. The Forum also provides start-up clinics and other networking events.

LESSONS LEARNED

Close Working Relationships with Venture Capitalists Promotes University Commercialization

TLO as well as individual schools and departments have close relationships with venture capitalists and angels in the community. Venture capitalists routinely contact TLO to inquire about potential investments. Moreover, TLO pro-actively contacts venture capitalists about interesting research at early stages. They encourage the potential investor to work with the MIT researcher to develop commercialization plans. Venture capitalists also routinely interact with students and faculty through informal and formal networking events sponsored by the university, the venture capital companies, and community and state organizations such as Mass Bio.

MIT Actively Promotes A Strong Entrepreneurial Culture

Although MIT has a history of entrepreneurship, they continue to actively promote entrepreneurship through formal and informal networking events, business competitions, entrepreneurial curriculum and coursework for engineering and science students as well as business students, and grant programs that encourage faculty to commercialize research.

MIT Effectively Uses its Alumni Connection

Alumni at MIT provide internships and participate in E-Lab. They mentor students and sit on Advisory and Evaluation Committees for the \$50K Competition, Deshpande Center, and other programs. They teach courses at the E-Center as well as in various Schools. They are the source of or provide leads for commercialization opportunities and investments in MIT inventions. According to an E-Center Manager: “our alumni network is one of our most powerful tools”.

Mentors Play a Key Role in Entrepreneurial Development

Mentors play a key role in the \$50K Competition and as Catalysts in the Deshpande Center. They give first-hand advice on financing, business, marketing and other critical areas that help engineering and science students develop start-ups. Input from successful entrepreneurs, venture capitalists and service providers has been invaluable in helping students understand real-world business challenges and opportunities. It also has benefited the mentors who, through their activities, get a first look at potential commercial opportunities originating at the university.

PURDUE UNIVERSITY

HISTORY AND ENVIRONMENT

Purdue University is one of two major State universities. As a land grant university, Purdue has played a central role in agricultural and industrial extension. In recent years, the universities have played an increasing role in generating technology start-ups and new licenses to advance technology firms. Recognizing the universities as a source of future economic growth, the State of Indiana has begun implementing initiatives designed to accelerate technology transfer and commercialization at its universities and throughout the State. Created in 1999, Indiana's 21st Century Research and Technology Fund aimed at commercializing science and technology through initiatives in two major categories: Science and Technology Commercialization and Centers of Excellence. The Fund provides awards for up to two years for a maximum of \$5 million; but most awards are less than \$2 million. In addition, the Fund provides a cost-share of federal proposals including an equal match (up to \$300,000) on NSF Partnership-for-Innovation proposals and a SBIR/STTR Matching Program. In 2003, Purdue was involved in 15 of the 18 projects granted by the 21st Century Research and Technology Fund.

In 2003, the State Legislature passed Governor Frank O'Bannon's initiative – Energize Indiana Initiative. The \$1.2 billion package of economic development and workforce initiatives included:

- \$344 million in university construction projects, including several research facilities;
- \$75 million to re-capitalize the 21st Century Research and Technology Fund;
- \$50 million over five years for tax credits to promote Indiana venture capital initiatives and extend the state's R&D tax credit of 10% until 2013;
- \$10 million to expand a fiber optic network that includes Purdue University and Indiana University; and
- \$9 million for certified technology parks.¹⁶

In addition, several other initiatives support technology transfer efforts at Purdue University and in the State generally. In 2002, a life science strategy called BioCrossroads was developed by the Central Indiana Corporate Partnership, Eli Lilly, Purdue University, Indiana University, Indiana Health Industry Forum, and City of Indianapolis. BioCrossroads is led by two former Eli Lilly executives and is aimed at building academic and commercial development in life science clusters, particularly ag-biotechnology, biosensors, cancer, evidence-based medicine, protein analysis, and neurosciences. The State's health association – Indiana Health Industry Forum – has developed a “road map” and is implementing complementary regional strategies to advance BioCrossroad's objectives including forming the Indiana Future Fund, a venture capital “fund-of-funds”. By spring 2004, the Fund had raised \$75 million. The Fund is being managed by Credit Suisse-First Boston and its major investors include the Lilly Endowment, Purdue and Indiana Universities, and other private corporations and public institutions.

¹⁶ State Science and Technology Institute, 2004.

The State's 21st Century Fund has been important to (Purdue) because it has "primed the pump" for our technology start-ups. The Lilly Endowment also has been important; they have been aggressive in working with the University and advancing our efforts.

- Sam Florance, Director, Gateways Program

Purdue University is one of the nation's largest land-grant universities. Started in 1874, Purdue has more than 60,000 students, with about two-thirds at Purdue's main campus in West Lafayette. Regional campuses are in Hammond (PU Calumet), Fort Wayne (IPFW), Westville (PU North Central), and Indianapolis (IUPUI), and there are additional statewide technology facilities throughout Indiana. The University houses 104 centers and institutes, and four centers in Discovery Park (a "virtual research park") – e-Enterprise Center, Birck Nanotechnology Center, Bindely Bioscience Center, and Burton D. Morgan Center for Entrepreneurship – provide interdisciplinary R&D. Its Research Park is home to more than 100 companies and is one of the most successful university parks in the U.S. Purdue ranks in the top five producers of engineering bachelors. Its primary strengths are in agriculture, biotechnology, management, education, pharmacy, and veterinary medicine.

In 2001, the Purdue Board of Trustees adopted a five-year strategic plan to advance the University's quality, particularly in basic and applied sciences and engineering, and contribute to economic development. In addition to the University's plan, each school, department, and other academic as well as nonacademic unit developed strategic plans during the 2001-2002 academic year to support the larger University strategic plan.

The mission of Purdue University is to serve the citizens of Indiana, the United States, and the world through discovery that expands the realm of knowledge, learning through dissemination and preservation of knowledge, and engagement through exchange of knowledge.

- Purdue University 2001-2006 Strategic Plan

Major initiatives called for the "integration of Purdue's engagement initiatives with its discovery and learning missions". The Plan's Goal 3 – "to address the needs of society through engagement" – called for enhanced technology transfer and commercialization including:

- Increase partnerships to enhance commercialization of research, entrepreneurial initiatives, support for start-up companies, and assistance to the State and to business, industry, and agriculture. Metrics include: (a) number of license agreements and patents

for technology transfer, (b) number of start-up companies, (c) number of regional technology centers, and (d) number of partnerships.

- Develop an organizational structure for promulgating University efforts to engage key local, state, national, and international constituencies to increase community and economic development and quality-of-life endeavors. Metrics include the number of full-time faculty involved in engagement activities.

THE STATS

Purdue University research generated an estimated 10,906 jobs statewide in FY 2000 fueled by \$263.4 million in research expenditures.

- Source: Purdue Research Foundation

In FY 2003, Purdue's R&D expenditures totaled \$347 million, an 8% increase from the previous year. Seventy-one percent of those expenditures were from the federal government with DHHS (NIH) comprising 18% and NSF comprising 17% of the total. One-fifth of R&D expenditures came from industries and foundations.

In FY 2004, Purdue's Office of Technology Commercialization filed 154 patent applications and 92 patents were issued that year. It executed 80 licenses and options and Purdue's licenses generated \$4.4 million in gross revenues, a 50% increase from the previous year. Although only three start-ups were launched in 2004, 18 start-ups were launched during the two previous years. According to the Director of the Office of Technology Commercialization, the number of start-ups during the two previous years reflected pent-up demand, and she expected four to five start-ups to be launched during 2004.

For FY 1999-2001, the latest years for which comparable data was available, when normalized to account for R&D expenditures, Purdue ranked in the top quartile for: (a) new licenses (15/173), (b) active licenses (31/173), and (c) start-ups (23/173). It ranked in the third quartile for new U.S. patents awarded and for license income.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

Purdue's Office of Technology Commercialization (OTC) is part of the Purdue Research Foundation (PRF), a non-profit organization. The OTC Acting Director, Simran Trana, reports to PRF's Sr. Vice President and Treasurer and has close relationships with Purdue's Vice Provost for Research and the Deans of individual schools. OTC is composed of the Acting Director, six licensing managers and four administrative personnel. Six undergraduate student interns from science and engineering schools provide additional assistance to faculty and student

inventors. The Acting Director and licensing staff all have science or engineering backgrounds, and one of the licensing staff additionally launched his own technology start-up.

OTC is organized by discipline with half of the licensing managers responsible for life sciences and half for engineering; managers are assigned to specific schools and departments. The Acting Director said that because OTC is not directly part of the University, they work through department heads to identify key research faculty. OTC managers attend departmental seminars, introduce OTC to new faculty members, and conduct seminars on intellectual property.

The focus of the University is to be a partner to the State for economic development. In support of that, if we have an option of doing a start-up or a license, we will first look at the possibility of creating the start-up.

- Simran Trana, Acting Director, Office of Technology Commercialization, Purdue University

OTC managers provide University inventors with an “intellectual property landscape” and help inventors map out business plans. Ms. Trana said that because of the University President’s economic development thrust, OTC in the past several years has tried to launch start-ups when possible. OTC works with faculty if they want to be part of the new start-up or will recruit management for the new start-up. The OTC manager, who is a former entrepreneur, helps inventors form new start-ups. She has acted in a CEO or other management capacity, on a temporary basis for a couple of those start-ups. Interns add to OTC’s capacity by helping managers conduct initial screenings, write non-confidential summaries on technologies, and perform market research. The Acting Director expects managers to process disclosures within six to ten weeks.

The University’s distribution of revenues to inventors is standard – one-third goes to inventors, one-third to the department, and one-third to the PRF. Although University inventors do not formally receive academic credit for commercialization activities, Ms. Trana said that several new Deans and faculty committees informally view commercialization positively when considering tenure and promotion. Commercialization activity was a consideration in new hiring decisions in many schools and departments. The OTC Acting Director said that the new emphasis on commercialization activities in hiring decisions and toward promotion in some departments has resulted from the University President’s articulated support for technology transfer activities. OTC also is exploring additional ways to reward inventors in the future through awards dinners and similar events.

Seed Capital Funding

Since 1985, the Trask Innovation Fund has invested in more than 100 proof-of-concept projects with at least one-fourth of those projects resulting in licenses.

- Source: Office of Technology Commercialization, Purdue Research Foundation

OTC offers two investment vehicles for development of inventions originating at Purdue. The Trask Innovation Fund offers faculty commercialization “gap funding” to validate proof-of-concept. The Fund provides interest-free loans up to \$100,000 that go to the faculty’s laboratory. If successful, loans are repaid up to the original loan amount. According to OTC’s Acting Director, since 1985, the Trask Innovation Fund has invested in more than 100 projects with at least one-fourth of those projects resulting in licenses. Started in 2002, the Trask Pre-Seed Venture Fund has been available to start-up companies based on Purdue-licensed technology. The Fund provides a one-time investment of up to \$250,000. By spring 2004, the Pre-Seed Venture Fund had invested \$1 million in four start-ups; three of those were still in business, and one had failed. In spring 2004, OTC was reevaluating the Fund and in the future may require start-ups to have co-investors. This would provide external validation and lower the risk to the Pre-Seed Venture Fund.

Beginning in FY 2005, OTC will be able to invest about \$2-3 million per year in University technologies in exchange for equity. The Acting Director said that OTC will aim for a 25% return on investment, and expected this seed capital activity to be self-sustaining in about seven years. OTC will require private co-investing in the deals.

In addition to OTC’s seed capital programs, the University sponsors two business plan competitions. For 17 years, the School of Management’s Burton D. Morgan Center for Entrepreneurship has sponsored the Burton D. Morgan Entrepreneurial Competition with prizes totaling \$100,000. Since 2002, the Gateways Program with funding from Roche sponsors a Life Sciences Business Plan Competition with prizes amounting to \$150,000. The latter competition is open to students, faculty and those outside of the University. In addition, the State offers a competition – Opportunity for Indiana Business Plan Competition – with a minimum prize of \$25,000 for first place, \$15,000 for second, and \$10,000 for third. Faculty and students also have access to the Indiana Future Fund, a State sponsored “fund-of-funds” that provides \$75 million in venture capital to promising enterprises. OTC also is trying to identify ways to increase exposure of the University’s inventors to potential investors. In June 2004 OTC held a Technology Showcase that involved 10 seed/venture capitalists and four University inventors. OTC expected about eight serious term sheets to result and plans to expand the Technology Showcase in future years. University-related inventors have several other entrepreneurial resources at or affiliated with the University including incubator facilities and services at the Purdue Research Park through the Gateways Program. (The Purdue Research Park and Gateways Program are described later in this case study.)

PURDUE RESEARCH PARK

The Purdue Research Park (PRP), now owned by PRF, was founded as the Purdue Industrial Research Park in 1961 with the development of 100 acres a couple miles from Purdue's main campus. The original site, now referred to as Phase I, in spring 2004 was home to 102 companies with more than 2,500 employees.

Forty of these firms are in the Park's three incubator facilities: The Purdue Technology Center, the Hentschel Center and the Business and Technology Center. Together these three facilities provide about 150,000 square feet of incubation space. In spring 2004, PRF announced a new 60,000 square foot wing would be added to the Purdue Technology Center. The new wing's anchor tenant – Endocyte, Inc. – is a life sciences venture developing Purdue University-licensed technologies that recently attracted \$15 million in venture capital.

Incubator residents can obtain business assistance through the Gateways Program located in the Park. (See "The Gateways Program".) The Small Business Development Center (SBDC) also provides assistance to incubator residents and, in late 2004, will be located in the Park. The Office of Technology Commercialization also is located in the Park's Technology Center.

In addition to PRP, Purdue is developing Discovery Park, a "virtual research park" that is home to several inter-disciplinary research centers. By spring 2004, there were four centers in Discovery Park: e-Enterprise Center, Birck Nanotechnology Center, Bindley Bio-science Center, and Burton D. Morgan Center for Entrepreneurship. A fifth center – Discovery Park Learning Center – was in the planning stages.

THE GATEWAYS PROGRAM

The Purdue Gateways Program assists high-tech start-ups affiliated with the PRP, Purdue University, and some regional technology centers. The Program's offices are located in the Research Park's Technology Center to facilitate interaction with incubator residents and at the Technical Assistance Program. Gateways provides start-ups with business plan development, organizational development assistance, counseling by market-specific mentors, test marketing, assistance with capital formation and technical input. Originally established by the PRF to work with start-ups in the Research Park, Purdue's President in 2000 expanded Gateways' role to serve a wider clientele and support a broader economic development mission. As part of that expanded role, Gateways now reports to the University's Office of Engagement that facilitates linkages with firms outside of the University.

Gateways' clients are faculty and other entrepreneurs interested in commercializing Purdue technologies or other innovations that "will enhance the overall mission of Purdue University and the economy of Indiana." Gateways accepts clients who meet at least one of the following conditions: (a) the company founders include Purdue faculty or student(s), (b) the venture involves the licensing of Purdue intellectual property; (c) the venture offers employment to significant numbers of Purdue graduates; and (d) a significant contribution to the Indiana

economy is expected. The program requires potential clients to be highly-leveraged and prefers companies offering products such as software, scientific devices, drug development and delivery, and advanced manufacturing technologies. About 80% of Gateways' clients are directly licensing technology from Purdue. Sam Florance, Director of the Gateways Program said that other firms may have their own intellectual property but aspire to refine it using Purdue's intellectual property; are located or would like to be located in the Research Park, or they may have anticipated the need for student interns.

Gateways' clients go through a "stage-gate" process similar to that used by major corporations to launch new developments. This process includes business assistance from mentors, exposure to seed/venture capitalists, and sometimes assistance with formation of a management team. Gateways' Director said that they do "anything within the law to get a firm started". This includes identifying and applying a wide range of resources in the University and in the region, particularly management and financial resources. Gateways helps start-ups identify venture capitalists and introduces them. Although they do not formally broker deals, Gateways acts as a "sounding board" for both start-ups and venture capitalists and facilitates communication between the two. According to the Director, it is not unusual for start-ups in PRP's incubation space to grow 400-500%, and therefore Gateway's objectives are not only to help launch start-ups but also to prepare them for growth – "to get start-ups to think beyond their current organizational horizon".

We have found that those firms (in the Research Park's incubators) that don't receive support in the early stages face a long hard road. For those firms that do receive management, resource, and technical support, they have about a 90% chance of a five-year survival.

- Sam Florance, Director, Gateways Program

Gateways also works closely with a local economic development group in West Lafayette and with BioCrossroads, which according to Gateways' Director, has been important in encouraging start-ups in the region. In addition, Gateways has been involved in a Technology Commercialization Working Group within Discovery Park that is developing strategies to commercialize R&D results from Discovery Park.

Gateways' staff includes a Director, Senior Associate, two undergraduate interns and administrative personnel. They handle about 30 to 40 firms per year, and work intensively with about five to six per year. The Gateway's Task Force provides input on advancing clients through the "stage-gate" process and gives general guidance on program direction. The Task Force is composed of Purdue professors, deans and department directors from science and technology disciplines, bankers, lawyers, and successful entrepreneurs and corporate heads.

TECHNICAL ASSISTANCE PROGRAM

From FY 1986 to FY 2003, the Technical Assistance Program has generated \$319 million in increased sales and cost savings to Indiana firms, a 5:1 benefit-cost ratio.

- Source: *Purdue Technical Assistance Program (unpublished data), 2004*

Since 1986, Purdue's Technical Assistance Program (TAP) has provided technology extension services to Indiana companies. In FY 2003, TAP provided assistance to more than 400 companies that involved 321 assistance projects. TAP is generally considered one of the best industrial extension services in the U.S. TAP's team of more than 50 faculty members, graduate students and professional staff provide on-site technology evaluations and problem solving services to Indiana firms. Participating faculty generally devote about 10% of their time to TAP projects. Typical projects involve: (a) advanced manufacturing, (b) business management, (c) product development, (d) information technology, (e) quality manufacturing processes, and (f) human resources. Business services include strategic planning, financial modeling for new products, and market investigations for new products. Product development services include product evaluation and testing, design method selection, design input and review, and problem solving. Faculty leaders available to assist firms in product development include professors of materials, electrical, computer, mechanical, and civil engineering. Services are provided to firms free-of-charge for five days, and modest fees are charged for additional services. TAP also works closely with the State's Business Modernization and Technology Corporation, affiliated with the federal MEP. Purdue's Technical Information Service (TIS) is a companion program to TAP, and provides fee-for-service information retrieval for firms.

In FY 2003, TAP hosted an Indiana High Tech Job Fair that attracted 51 companies and was attended by 1,200 for graduate and undergraduate students. TAP also conducts an annual summer intern program that typically places more than 1,000 students with Indiana firms.

LESSONS LEARNED

The President's Emphasis on Economic Development has Positively Effected the Launching of Start-ups

In response to the President's emphasis on economic development, OTC has shifted its priorities from executing licenses to launching start-ups. This has resulted in OTC significantly increasing the number of start-ups for several years without sacrificing their high-rate of new licenses.

State Venture Capital Initiatives Are Aimed at Retaining Start-ups

Although start-ups have increased, most of the start-ups leave Indiana. To help remedy this situation, the State has recently initiated “fund-of-funds” programs to attract out-of-State investment in firms that locate in Indiana. According to the Director of the Gateways Program, the Indiana Future Fund has already had a “profound effect in venture capital firms from outside the State looking at start-ups in Indiana”. Although too early to demonstrate results, early indications are positive.

A University Research Park can be Successful in a Remote Area

The Purdue Research Park has been one of the most successful research parks in the U.S. It is located in a remote area of the State where the University is the primary economic activity. Moreover, the Park’s incubator, initially 60,000 square feet, was filled within 90 days of opening. One of the reasons for the Park’s success is the unusually close linkage between firms in the Park and the University. Moreover, its successful incubators involve substantial assistance for entrepreneurs through the Gateways Program.

The Technical Assistance Program is a Successful Technology Transfer Vehicle

Technology transfer comes in many forms, and one of those forms is advancement of technological know-how in small and medium-sized companies. TAP for almost 20 years has provided technology assessments and consulting to thousands of Indiana firms, resulting in higher sales and cost savings to most of those firms. A 5:1 benefit-cost ratio and a 90% customer satisfaction rating makes this one of the most successful “technology transfer” programs.

STANFORD UNIVERSITY

HISTORY AND ENVIRONMENT

Leland and Jane Stanford established Stanford University in 1891 as a memorial to their late son. The Stanford bequest mandated the creation of a “university of high degree.” In addition to money, the bequest included 8,800 acres in Palo Alto, California. This “private land grant” has had a significant impact on the San Francisco Bay’s regional economy. Fueled by federal defense research funding, the University in the late 1940’s began spinning out technology-oriented businesses including Fairchild, Hewlett-Packard and Varian Associates. In the 1950’s Stanford’s creation of an industrial park (now the Stanford Research Park) provided a home for Varian and later other technology firms. By the 1960’s the new electronics industry driven by technology originating in Stanford laboratories and government defense contracts had begun to grow rapidly in the region around the University, dubbed in an electronics newsletter as “Silicon Valley”. About that time, the venture capital industry was born to take advantage of the Silicon Valley phenomenon. By the 1980’s, Silicon Valley was in full swing, and although the region’s economy has risen and fallen with the ITC wave over the past decade, it remains strong.

Stanford has a solid history of entrepreneurial successes built on many role models and a culture that encourages and rewards entrepreneurship in academic and business worlds. To a large extent, Silicon Valley’s growth has been based on spin-offs from Stanford faculty and students, alumni, and corporations located around the University that wished to take advantage of the University’s presence. From 1973 through 1993 Stanford faculty and students founded more than 300 companies. There are now several generations of successful start-ups that include Google, Symantec, 3com, Logitech, Sun Microsystems, Silicon Graphics, Netscape, MIPS Computer Systems, Cisco Systems, and Yahoo! The University supports continuous activity in teaching, research, and coordination with the local entrepreneurial infrastructure that sustains what analysts have called the “Silicon Valley Edge.”¹⁷

Venture capital has fed the growth of entrepreneurial start-ups in the San Francisco Bay Area. According to the MoneyTree Survey conducted by PricewaterhouseCoopers, Venture Economics and the National Venture Capital Association, Silicon Valley in 2003 saw a decline in overall local investments to \$5.87 billion from 2002’s \$7.02 billion. However, Silicon Valley still represented almost one-third of all investments nationwide during 2003, with life sciences making up an increasing percentage of local (as well as national) investments.

Stanford is a medium-sized private university of about 14,500 students; a little more than half are graduate students. By any standard, Stanford is a research university of the first rank. Its education programs are highly competitive and its intellectual reach is broad. In 2003, the School of Engineering enrolled 26% of all Stanford students and *U.S. News and World Report* ranked it second only to MIT. The Graduate School of Business was ranked second in the nation

¹⁷ Lee, C-M, Miller, WF, Hancock, MG, Rowen, HS. *The Silicon Valley Edge; A Habitat For Innovation And Entrepreneurship*. Palo Alto, Stanford University Press, 2000.

and third in entrepreneurship. The School of Medicine claimed to have the highest national research expenditure per faculty member in 2003, and *U.S. News and World Report* ranked it in the top 10 among research-oriented medical schools. Stanford's graduate biological sciences ranked first overall and chemical sciences ranked fifth; all other Stanford graduate programs except two appeared in the top 25. As most universities of its stature, the list of faculty achievements is outstanding including 17 Nobel laureates, 21 recipients of the National Medal of Science, and 133 members of the National Academy of Sciences.

THE STATS

Stanford's research expenditures consistently are in the top 10 nationally. In FY 2003, Stanford's R&D expenditures were \$639.9 million, 83% of which came from the federal government. In FY 2003, Stanford ranked 16th in NIH awards and 15th in NSF awards. In FY 2001, the latest year for which comparable data were available, Stanford ranked 8th among all U.S. universities and second only to Johns Hopkins University among private universities. In the same year, 57% of total research expenditures were devoted to life sciences, and most of the remaining went to (in descending order): engineering, physical sciences, and math and computer sciences. Stanford's excellent research has attracted corporate research dollars and, although substantial by any standard, the private sector portion of total R&D funding is dwarfed by massive federal research expenditures.

Stanford's technology transfer performance is impressive. In FY 2003, Stanford grossed \$45.4 million in license income, and executed 128 new licenses and options. It filed 334 U.S. patents and 117 U.S. patents were issued. Seventeen start-ups were launched based on Stanford research. From FY 1999-2001, normalized data to compare performance with other institutions showed that Stanford ranked in the top quartile in every category and was particularly strong in licensing activities: new licenses (13/173), active licenses (7/173), license income (16/174), new U.S. patents (28/174), and start-ups formed (27/173).

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

Stanford University has long been a leader and benchmark institution in technology transfer. Stanford's Office of Technology Licensing (OTL) was established in 1970, ten years before most universities, and it was a pioneer of the "marketing approach" to technology transfer. OTL encouraged faculty to promptly disclose inventions. They quickly and carefully evaluated the market value, obtained intellectual property protection, and pro-actively identified licensees for those inventions. A successful outcome of this approach was the patenting of recombinant DNA technology and a successful program to license the technology widely. This program returned \$255 million over the patent's life to the inventors and to the inventors' institutions – Stanford and the University of California.

OTL is responsible for patenting and licensing all inventions originating at the University.¹⁸ The Office is composed of a Director and 24 staff members including six licensing associates, seven liaisons, a full-time compliance expert, two accounting staff, and three industrial contract officers. Licensing associates have specific science or technology backgrounds and business experience. Licensing associates are dedicated to specific disciplines although there is increasing cross-pollination reflecting the trend in science and technology research. In addition, the Industrial Contracts Office located in OTL has three full-time staff that are responsible for industry funded research contracts, material transfer agreements, and industry collaborations. External counsel handles patents based on University research. The OTL Director reports to the Dean of Research.

In FY 2003, OTL processed 362 new invention disclosures about half of which were in life sciences and half in physical sciences, including computer science technologies. OTL is known for its active marketing approach, and because of its long and respected history in technology transfer, has built up a bank of corporate customers that licensing associates communicate with on a regular basis. Licensing associates work on inventions from “cradle to grave”. This approach provides an identifiable person in OTL throughout the process to both the inventor and the customer. OTL does not provide direct business assistance to start-ups based on University research, but will refer the entrepreneur to angel or venture capitalists and other external sources of business assistance.

We make decisions based on technical merit and good business sense; we do not chase the dollar. Our view is much broader. We want to establish a good relationship with a company where they feel they have benefited from the relationship with us. We want them to come back for the second and third, and the twentieth and thirtieth deal.

- Katharine Ku, Director, Office of Technology Licensing

Stanford’s technology transfer program has followed the pattern of most university programs that have returned substantial financial rewards. OTL Director Kathy Ku reported that of the almost 2,000 licenses granted by September 2000, only eight generated over \$5 million. In total, 31 technologies had generated over \$1 million each. In FY 2003, Stanford reported that only seven active licenses (of 331 active licenses yielding income and 986 licenses in effect) yielded more than \$1 million. This pattern is common among institutions that post large royalty revenues. Most income comes from a limited number of “blockbuster” technologies. Stanford as a matter of policy does not give preference or actively seek local licensees. However as a practical matter, the strong ties between Stanford faculty and students and local businesses and venture capitalists means that a strong regional market exists for new inventions.

¹⁸OTL also is responsible for licensing technologies originating at the Stanford Linear Accelerator Center, a federally funded R&D center (FFRDC) administered by the University.

Stanford can hold equity in start-ups originating at the University. By fall 2003, Stanford held equity in 80 companies. To avoid potential conflicts of interest, the Stanford Management Company that manages the University's endowment, sells the OTL's public equities as soon as it is allowed to liquidate rather than hold equity to achieve maximum return.

Unless the federal government funds the research upon which an invention is based, the faculty inventor has the option to place the invention in the public domain (where there is no agreement between the University and the research sponsor to the contrary). However, most inventions originate from federally funded research. For an individual invention, OTL recovers its expenses up to 15% of the gross license income plus out-of-pocket expenses. The remaining net income, usually in the range of 80-85%, is split evenly between the inventor(s), the inventor(s)' department(s), and the inventor(s)' school(s). This has the effect of returning most of the proceeds to the academic units where inventors work. If OTL recovers its expenses amounting to less than 15% of the gross income, the remainder of the 15% goes to the University's Dean of Research (Chief Research Officer) to be used for research and education purposes such as scholarships. This can be a sizable sum and in the last couple years has totaled several million dollars. Since the mid-1980's, OTL has been a self-sustaining unit in the University.

ENTREPRENEURSHIP CULTURE AND RELATED ACTIVITIES

Stanford's entrepreneurial culture is an important factor in the University's ability to conduct technology transfer. On the surface, Stanford's faculty culture appears to be quite traditional. Following the "steeple of excellence" approach articulated by Fredrick Terman in the 1960's,¹⁹ Stanford recruits the best and the brightest in fields where it seeks to build excellence. Expectations for continued academic achievement are high, and for the most part, tenure and promotion are based solely on academic achievement and building an outstanding academic reputation. However, faculty members are expected to support their research activities with minimal help from the institution. As a result, there has been an open environment in which conducting research with a company or a new venture has been considered positive as long as it enhances the education of students and contributes to substantial, nationally visible research. Moreover, there appears to have been little "either/or" attitude about corporate versus government research support. Corporate support is seen as useful supplemental resources.

In past years, taking a leave-of-absence to work in a company generally did not occur until a faculty member received tenure. This pattern began to change in the 1990's as younger, non-tenured faculty members spurred by the high cost of living in the area began to take leave to start businesses or work with other businesses. Moreover, there was a shift in the types of businesses with which the faculty members worked – from established companies to technology start-ups. Bruce Wooley, Chair of the Department of Electrical Engineering pointed out in an interview that Stanford President John Hennessey, when he was a professor at Stanford, took time off from the University to launch and work in his own company (MIPS) for two years. Moreover, it is notable that Stanford promoted this technology entrepreneur and scientist to Dean, Provost, and

¹⁹Terman, F. "Steeple of Excellence," 1968.

then President. Dr. Hennessey's experience and that of other faculty leaders continues to present strong role models for other faculty and students.

Although much of Stanford's entrepreneurial culture arose naturally from a liberal attitude toward faculty relationships with corporations and leaves of absences, Stanford also developed specific programs and initiatives to support the emerging entrepreneurial culture. Importantly, Stanford has supplemented a rigorous engineering curriculum with formal and experiential education in entrepreneurship, drawing on the local alumni base and faculty role models.

Most technology transfer activities focus on faculty. (The Stanford Venture Technology Program) 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.

- Tina Seelig, Executive Director, Stanford Technology Ventures Program

Starting in 1996, the Stanford Technology Ventures Program (STVP) provides courses, seminars, mentoring and internships for engineering and science students. The Program is located in the School of Engineering's Department of Management Science and Engineering and is supported by private contributions from private foundations, corporations, venture capitalists and others. STVP each year offers about 25 courses serving more than 2,000 students. Unlike entrepreneurial courses in most other universities, these courses are taught primarily for science and engineering students not business students.

STVP's Mayfield Fellows Program (MFP) provides a nine-month work-study program. MFP runs from April to December each year, in which a dozen undergraduate students: (a) attend courses on the management of technology ventures, (b) perform a paid summer internship at a start-up company, and (c) receive additional mentoring and participate in networking activities. It is open to undergraduate or co-terminal engineers and scientists and intended to offer the students a comprehensive entrepreneurship education. Several other activities are held jointly by STVP, the Department of Management Science and Engineering, and the Business Association for Stanford Engineering Students. This includes the popular Entrepreneurial Thought Leaders Seminar that is held weekly and features major business and academic leaders. The series can be taken for credit and is also available to those outside the University through the Center on Professional Development (described later in this section).

Founded in 1996, the Business Association for Stanford Engineering Students (BASES) is one of the largest entrepreneurship organizations in the nation and one of the largest professional groups in the San Francisco Bay Area. It has more than 5,000 members; half are students and faculty members from all schools at Stanford, and half are alumni, entrepreneurs, executives, venture capitalists, and service providers in the community. BASES hosts a wide range of programs including employment resources, business plan development assistance, and start-up seminars.

BASES sponsors three student-run business plan competitions. The Entrepreneur's Challenge (E-Challenge) is an annual business plan competition conducted by BASES. The competition is open to students from all disciplines and involves three competition categories: (a) hardware, (b) software, and (c) biomedical. Throughout the year, applicants form teams and participate in workshops, team building activities, mentorship programs, and seminars by industry leaders. In the winter, quarter participants submit executive summaries and detailed business plans, which are evaluated by qualified judges. In the spring, finalists present their business ideas to a panel of venture capitalists. The Grand Prize is \$25,000, and an additional \$25,000 is split between second place winners. In 2004, BASES added the Social Entrepreneur's Challenge for social-oriented ventures that may be either for-profit or non-profit. The Innovators' Challenge (I-Challenge) is a business competition held jointly by BASES and VERTEX, the Engineering Entrepreneurship Club of the University of California, Berkeley. Student teams from all departments in the School of Engineering at each institution submit entries and a select number of teams showcase their work to a panel of judges representing both universities. Prizes of \$25,000 are awarded. The Innovation Showcase is an annual spring event that exhibits ideas and technologies from the three business competitions. Venture capitalists and industry representatives attend this Showcase.

Through Interact, BASES provides additional networking opportunities within the University and the larger Silicon Valley community. Some of these events are:

- High-Tech Panels – are quarterly events geared toward a technical research and business audience involving a keynote speaker, panel discussions and mixers.
- Interact Dinners – involve small groups of 15 and a distinguished speaker. Dinners are intended to promote networking with successful business leaders and are often underwritten by corporations and foundations.
- Venture Capitalist for a Night – gives students the opportunity to watch companies make presentations to venture capitalists and hear their critiques.
- Office Hours – Venture capitalists and attorneys provide 15-minute consultations to entrepreneurs *pro bono*.

Since 1996 the Center for Entrepreneurial Studies (CES) in the Stanford Graduate School of Business has provided case development, research, curriculum development, and student programs in the areas of entrepreneurship and venture capital. The annual Stanford Graduate School of Business Conference on Entrepreneurship brings together about 500 students, investors, and business people for panels, interactive workshops, and networking. In addition, CES offers supplementary funding to selected first year MBA students who find summer employment with an entrepreneurial company that cannot pay "average" wages; this facilitates an unusual opportunity for hands-on experience with start-ups.

Operating independently but in close coordination with CES, are three clubs:

- Entrepreneur Club – started in the late 1970’s, this club is one of the oldest student-run entrepreneur clubs in the nation. The club’s activities include brown bag luncheons, skill development workshops, “Second Tuesday” Dinners, alumni receptions, mixers, and a wide range of other educational and networking events.
- Venture Capital Club – involves about half of all graduate business students and provides networking opportunities with entrepreneurs and venture capitalists, seminars, small group dinners, and other social events.
- High-Tech Club – is comprised of over 250 graduate students. The club involves networking, business development, and facilitates industry recruiters and other linkages.

The Stanford Entrepreneurship Network (SEN) is an on-campus grass roots effort to coordinate the activities of a variety of entrepreneurship-oriented groups across the University. SEN includes members from OTL, STVP, CES, BASES, the Medical Device Network, the Silicon Valley Networks Project, the Law School, and the Office of Corporate Relations. Although it is University-based, members of the Silicon Valley entrepreneurial community participate in many of the Network’s activities. Like a number of University activities, it has evolved “bottom-up” based on the need of multiple University organizations to keep informed, coordinate activities, and jointly work on “events” of common interest. The Network also provides a vehicle for venture capitalists, attorneys, and others in the area to stay in touch with activities in Stanford’s laboratories and classrooms. Other entrepreneurial connections are multi-layered and include alumni, particularly entrepreneurs, “returned faculty” who have worked in businesses, faculty consultants, and student-workers.

Center for Professional Development²⁰

Beginning in the 1950’s, Stanford saw the need for advanced continuing education for engineers at some of the pioneer Silicon Valley companies. The transistor and the semiconductor were coming on the scene and the firms had to deal with rapidly changing technologies to remain competitive. The School of Engineering started a unique graduate program called the Honors Cooperative Program that allowed working engineers to take courses at night and earn advanced degrees. Dr. Terman encouraged the development of this program to support new and growing companies in the area. The Honors Cooperative Program continues with strong support from the Stanford Center for Professional Development.

The Stanford Instructional Television Network (SITN) run by the School of Engineering began providing off-campus links to Silicon Valley firms and became a leader in distance learning. In 1995 SITN became the Stanford Center for Professional Development (SCPD). It evolved into a leader in Internet as well as televised distance learning. Through these two media, SCPD

²⁰Material for the Center for Professional Development section was largely abstracted from *Innovation U: New University Roles in the Knowledge Economy*, by Louis G. Tornatzky, Paul G. Waugaman, and Denis O. Gray. Research Triangle Park, Southern Growth Policies Board, 2002.

reaches over 6,000 students a year who participate in more than 250 courses offerings. The Center also is experimenting with “on demand” presentation of content, and subdividing courses into smaller “chunks” of learning information. The Center employs 50 people and has the technical capability to have course sessions online or on-the-air within one hour of the original presentation. SCPD supports distance learning and web-based instruction for all Stanford academic units on a charge-back basis and SCPD is now self-sustaining. SCPD also has considered joint ventures with for-profit organizations and other academic units, but is closely tied to its primary mission to promote Stanford education.

LESSONS LEARNED

Federal Research Funds are Important in Providing a Base for Commercialization Activities

Since the 1950’s Stanford faculty members have been very successful at attracting federal research funding. Throughout the years until present, Stanford has been one of the top recipients of federal government funding, mainly from DOD but increasingly from NIH and other agencies. This has provided the pipeline for technology transfer and has fed corporate commercialization interests. These factors were further supported by Stanford’s open culture that encouraged corporate interaction and cross-fertilization, important elements in successful technology transfer.

Movement Between the Academic and Corporate Worlds Bolsters Commercialization

There are many examples of Stanford faculty taking leaves of absences and moving back and forth between academia and business either to start their own business or to work for other start-ups and corporations. Moreover, part-time consulting by faculty is common. This “cross-over” between university and business employment is widely accepted and has contributed to building a broad and active entrepreneurial cultural. This includes Stanford’s President who, as a tenured faculty member, took leave to start a business and later return to academia.

Venture Capital is Plentiful and Investors Routinely Work with Early-Stage Enterprises

Many venture capital funds got their start in Silicon Valley, and they are accustomed to dealing with the University, faculty/student researchers and early-stage technologies. Stanford spin-offs have a tremendous advantage because they can work with investors who understand their strengths and weakness and are able to draw from experienced fund managers.

A Combination of Factors Converged to Form Silicon Valley

The Stanford story is not one of a formal deliberate strategy by the University, private sector, or state and local governments. Rather it is a story that involves building excellence in research at the University, infusion of major federal research funding, leadership, recognition of and flexibility of faculty to pursue commercial opportunities, development and sustained presence of investment capital, and a robust entrepreneurial spirit.

UNIVERSITY OF CALIFORNIA, SAN DIEGO

HISTORY AND ENVIRONMENT²¹

The University of California, San Diego (UCSD), located in La Jolla near San Diego, is one of 10 campuses that compose the University of California (UC) system. UCSD, along with Scripps Research Institute, Salk Institute for Biological Studies, major defense and communication firms, and growing life science firms provide a strong research base for the region.

The San Diego region is one of several in the U.S. that have exhibited resiliency in the face of economic downturns. San Diego in the late 1980's and early 1990's was hard hit by defense cutbacks that caused severe economic dislocations of defense workers, particularly in aerospace and supplier industries. But less than one decade later, all of the lost jobs were replaced mainly by new jobs in business services, high-technology clusters, and tourism.

From 1990 to 1998, high-technology clusters added over 46,000 new jobs to the San Diego region. Some of this growth mirrored rapid national expansion in high-technology clusters. But growth in some clusters such as biotechnology and pharmaceuticals, and communications exceeded the national average employment growth. Jobs in biotechnology and pharmaceuticals doubled adding almost 12,000 new jobs to the San Diego region. Employment in software and computer services, also doubled, and communications grew by over one-half, together adding 16,000 new jobs. QUALCOMM, Inc., which started in San Diego in 1985, became a dominant force in the region's communications cluster. In addition to biotechnology and pharmaceuticals, communications, and software and computer services, other promising high-technology clusters in the San Diego region are recreational goods, environmental technology, and biomedical products.

San Diego's technology growth was not the result of a master strategic plan, and the region's business, academic, and public sectors were not always in sync. In the 1980's San Diego mounted unsuccessful bids for major national R&D centers, particularly the Microelectronics and Computer Corporation and Sematech, which were awarded to another city. The loss of these centers to a city in which key players banded together, taught San Diego about the importance of community cohesiveness. The San Diego Regional Economic Development Corporation (EDC) took the lead in promoting greater community participation by private sector leaders and involvement of the academic community to reduce the region's economic dependence on defense. At a time of impending economic distress, the EDC's efforts resulted in better networking among business leaders, a closer working relationship between UCSD and the business community, and improved communication between the public, academic, and private sectors. Although the intent of early community efforts was to attract diversified businesses and R&D centers to the region, the efforts rallied business leaders and brought together key players that ultimately resulted in strengthening the region's environment for technology development.

²¹ Much of "History and Environment" has been excerpted from *Developing High-Technology Communities: San Diego*, Innovation Associates Inc., Washington, D.C.: U.S. Small Business Administration, March 2000.

These early initiatives included the Financial Forum, the San Diego chapter of the MIT Enterprise Forum, and UCSD's CONNECT program. Some of these efforts also attracted federal funding from EDA that seeded entrepreneurial initiatives at San Diego State University (SDSU), and small business incubation at the Center for Applied Competitive Technology, San Diego City College.

San Diego's defense industries provided the base for spin-offs in fields such as wireless communications, and computer and software services. Two of the largest homegrown technology firms – Science Applications International Corporation (SAIC) and QUALCOMM Inc. – started by serving the defense industry in the San Diego region. Although SAIC's defense work increased with the rapid expansion of its business in the late 1990's, the company diversified, and the majority of its business is now devoted to commercial sectors. QUALCOMM Inc. also started its business based on its predecessor's defense communications work. The firm used its expertise in defense communication technology to develop commercial products in cellular technology, making it the second largest producer of cellular telephone technology in the world. Although San Diego suffered from major losses in aerospace and related industries in the early 1990's, the rich R&D base left behind by the defense industry provided fertile ground for new technology growth aimed at meeting the demands of emerging commercial markets. San Diego's world renown research institutions – Scripps Research Institute (formerly the Scripps Clinic and Research Foundation) and Salk Institute for Biological Studies – also provided fertile ground for growth in medical services, biotechnology, and medical device industries.

The development and growing prestige of UCSD was particularly important in promoting the development of high-technology firms in the region. UCSD not only trained many of the engineers and scientists who would later take positions with new and growing high-technology firms, but also provided a valuable science and technology base for these firms. Both of QUALCOMM's founders – Irvin Jacobs and Andrew Vertabi – were UCSD faculty members; Hybritech Inc., which is credited with starting the biotechnology industry in the San Diego region was started by a UCSD professor, Dr. Royston, and a UCSD research staff member Howard Bernstein, and other firms trace their roots to UCSD. According to UCSD, most of the high-technology firms in the San Diego region were based on technology developed at the University or founded by its faculty or graduates.

Much of the University's research expansion and technology transfer mission resulted from the leadership of former Chancellor Richard Atkinson who went on to become President of the UC system and is now retired. Dr. Atkinson and the subsequent UCSD Chancellor – Robert Dynes – championed the University as an economic development force in the region, actively engaging private sector leaders and promoting networking among major corporations, start-ups, and service providers. UCSD CONNECT, founded in 1985 in the University's Extension Service, was important in developing and promoting entrepreneurs as well as networking the business and academic communities. The late William Otterson led CONNECT from its inception for almost 15 years, building the organization's activities and prestige that attracted all significant corporate leaders and service providers in the region.

Today, UCSD has more than 23,000 students. Its research base and technology transfer activities over the past decade have consistently grown stronger. UCSD's graduate and professional schools include Scripps Institution of Oceanography, School of Medicine, School of International Relations and Pacific Studies, School of Pharmacy and Pharmaceutical Sciences, Jacobs School of Engineering, and the new Rady School of Management. The campus also is home to the San Diego Supercomputer Center, California Institute for Information Technology and Telecommunications, Center for Research in Computing and the Arts, Institute on Global Conflict and Cooperation, and Institute of the Americas.

UCSD is among the best universities in the nation in several medical, engineering and multi-media communication fields. *U.S. News and World Report* ranked UCSD seventh overall for best public universities. It ranked the School of Medicine seventh among medical schools with a research focus; bioengineering - third; cellular development biology - eighth, biochemistry - ninth; molecular biology - tenth; and neurosciences - tenth. The Jacobs School of Engineering was rated thirteenth. In FY 2003, UCSD ranked sixth in the nation in National Academy of Sciences membership.

UCSD is an engine for regional economic growth. UCSD faculty and alumni have spun off close to 200 local companies, including over a third of the region's biotech companies.

- *UCSD CONNECT*

THE STATS

In FY 2003, UCSD's total research expenditures were \$438.9 million and research awards totaled \$627 million. About 81% of the total research awards came from the federal government and a significant portion – 17% came from corporations and the private sector. A little less than half of all research awards went to the Medical Center. In FY 2004, UCSD's private support totaled \$131.9 million, making it the second most successful year in the University's history.

Although UCSD does not report separately from the UC system for the AUTM Licensing Survey™, UCSD provided Innovation Associates with the following data. In FY 2003, UCSD filed 182 U.S. patents and 52 U.S. patents were issued. It executed 51 new licenses bringing the total active licenses to 256, and generated \$10.7 million in license revenue. In FY 2003, UCSD launched seven start-ups. In FY 2002, it launched nine start-ups and generated about \$17 million in license revenue that year.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

In late 1994, UCSD established its office of Technology Transfer and Intellectual Property Services (TechTIPS) to process intellectual property and facilitate commercialization of University technologies. TechTIPS serves two main functions: managing technology transfer and maintaining an intellectual property portfolio, and providing educational and liaison services to faculty and industry.

We conduct technology transfer based on ‘total impact’ to help diversify and generate a high-wage, knowledge-based economy. We take to heart that our real mission is economic development, and we have a clear mission statement that has been strongly supported by the past two Chancellors and the University Administration.

- Alan Paau, Assistant Vice Chancellor, Technology Transfer and Intellectual Property Services

The TechTIPS office is composed of a director Alan Paau, Assistant Vice Chancellor, and about 25 staff divided into four groups: (a) Licensing and Liaison, (b) Policy and Outreach, (c) Patent Management, and (d) Finance and Operations.

In the Licensing and Liaison Group, nine senior licensing agents and two additional staff members establish relationships with firms and negotiate licensing deals. Six work in life sciences and three in physical sciences and engineering fields. The division of staff is based on the distribution of the University’s licenses. In addition, one of the life science specialists is physically located in the Medical School and one of the physical sciences and engineering specialists is located in the Jacobs Engineering School. Their presence in the Schools facilitates daily interaction with faculty and keeps them current on emerging trends and potential innovations. The senior licensing specialists not only handle relationships between University inventors and potential licensees but also negotiate industry agreements and provide other services involving intellectual property issues to academic units. This includes university-industry arrangements for research, consulting, purchasing, and philanthropic interests. This group also helps start-ups with intellectual property and business development issues.

The second group – Policy and Outreach – is headed by an attorney, and involves four additional professionals. This group oversees technology transfer policies, provides direction, conducts educational activities on intellectual property and technology transfer for faculty inventors, and is the outreach arm to industry. Dr. Paau said they take the educational part of their job seriously, devoting about half of the entire staff’s time to these activities. He attributed a sharp increase in invention disclosures over the past five years to TechTIP’s educational and university-industry networking activities.

Every year TechTIPS organizes seminars for faculty on issues such as the differences in intellectual property between industrial and government contracts, how to handle complications that arise from interactions with industry, and other helpful topics. In addition, they conduct a one-day “boot camp” to educate and provide advice to faculty. The “boot camp” features lawyers, venture capitalists who have worked with university start-ups, and faculty members who have failed as well as those who have succeeded. In the past three years, more than 100 faculty members have attended “boot camp” events.

TechTIPS holds Breakfasts about every two to three months for faculty and industry representatives. Breakfasts feature a faculty member (often one who has worked with TechTIPS) who gives a 30-45 minute talk about his/her work. Typically 40-50 industry representatives attend the breakfasts that keep them abreast of current University research opportunities and facilitate networking with faculty and TechTIPS senior staff. Once every two to three months TechTIPS also participates in “Friends Raising” receptions hosted by major firms in the region. These receptions showcase industry research and provide a platform for UCSD’s senior administrators to present the University’s research and to encourage linkages. In the past these receptions have featured the Vice Chancellor for Health Science and Deans of the Medical School, Biological Sciences, and Physical Sciences. In addition, TechTIPS conducts major annual events that involve most of the “movers and shakers” in the region’s high-tech and biotech business community.

TechTIPS’ Policy and Outreach Group also develops linkages with venture capital in the region, nationally, and internationally. TechTIPS participates in receptions and dinners in many regions of the country with venture capitalists and entrepreneurs who specialize in targeted science and technology disciplines. The events are normally hosted by local groups such as law firms on behalf of TechTIPS and have been held in San Francisco, Menlo Park and Seattle. In 2004-2005, TechTIPS will hold similar receptions/dinners in the northeastern U.S. and in China. The TechTIPS Director said that meeting face-to-face and cultivating personal relationships with venture capitalists has been valuable and in the past couple years these activities have resulted in funding two UCSD start-ups.

TechTIPS also works with angel networks through San Diego Tech Coast Angels, which is affiliated with and has offices in CONNECT. (See CONNECT later in this case study.) Many of these angels are previous entrepreneurs who have spun off from UCSD through TechTIPS.

TechTIPS provides additional support for start-ups by critiquing business plans and introducing entrepreneurs to legal, management and financial teams. MBA interns from SDSU Business School help start-ups with marketing plans and competitive analyses. The UCSD Business School is newly formed and TechTIPS plans to develop a similar relationship with the UCSD School. TechTIPS also works with UCSD CONNECT, which provides services to entrepreneurs. TechTIPS licensing agents participate in Springboard’s review panels and the Financial Forum’s steering committee. The relationship between CONNECT and TechTIPS is described as mutually supportive and beneficial. (These activities are described in greater detail in the next section.) Moreover, TechTIPS’ Director said that the TechTIPS senior staff members interact with everyone in the community – financial, technology, service providers, and industries – and that this interaction is important in building the support for start-ups.

TechTIPS' Patent Management Group works with outside law firms that handle the University's patents. The Finance and Operations Group maintains an extensive database on University inventions that is accessible by faculty and industries.

UCSD's royalty income distribution is more complex than in most universities: 35% of net income (gross income minus legal fees) is shared among inventors; 10% goes to the Principal Investigator's laboratory; and 5% goes to the Principal Investigator's department. Of the 50% remaining, half goes to the State's general fund (which usually comes back to UCSD as an offset in the State budget), and half remains on campus at the Chancellor's discretion. Normally the Chancellor uses these funds for a legal reserve, and to support various research and educational initiatives. In that way, most departments in the University reap some benefit from the University's technology transfer activities.

UCSD's Technology Transfer Advisory Committee is composed of two Vice Chancellors and Deans of science and technology departments. The Committee advises TechTIPS on policy, implementation, outreach, and general direction.

CONNECT

You will not find another high-technology community as closely associated as in San Diego ... and it started with the University.

- *The late William Otterson, Director of CONNECT 1986-1999, UCSD*

Founded in 1985 at the urging of San Diego's business community, CONNECT is widely regarded as one of the nation's most successful regional programs linking high-technology and life science entrepreneurs with business development and investment resources, and potential partners and customers. Since its inception, CONNECT has assisted more than 800 technology companies.

CONNECT provides a wide range of programs that help entrepreneurs, early- and mid-stage firms develop their businesses and network. CONNECT also provides a forum for bringing together established technology and life science companies with each other and with entrepreneurs, investors, and service providers to exchange ideas, explore new partnerships, and network with peers. Much of CONNECT's success is owed to the late William Otterson who led CONNECT from its beginnings until late 1999. Mr. Otterson was a widely respected business person in the community and pro-actively courted major corporate leaders to not only sponsor but also actively participate in events such as annual innovation award luncheons, mentoring programs for young entrepreneurs, and numerous networking events. Because of its success, the CONNECT model has been replicated in other cities and several countries.

CONNECT is part of UCSD's Extension Service. This is quite unusual since most programs of its kind are separately incorporated as non-profit organizations and have at most an "arm's-length" distance from the university. CONNECT is self-supporting and receives no funding from UCSD or the State of California. It is supported through membership dues, course fees, and corporate underwriting for specific programs. Membership is on a sliding scale and runs from \$100 to \$3,000 per year. Springboard and the Most Innovative Product Award are CONNECT's signature programs. These programs and other major activities are described below.

From 1993-2003, CONNECT's flagship program – Springboard – has assisted 203 technology companies in starting and funding their businesses. These companies have raised more than \$550 million and 120 are still doing business in the San Diego region.

- UCSD CONNECT

- Springboard – helps early- to mid-stage technology and life science companies refine business and financial plans through a multi-level mentoring process. Entrepreneurs accepted into the program spend three to eight weeks in coaching sessions with experienced business people. At the Springboard Graduation event, start-up companies present their business plans to a panel of 8-10 business experts who critique the plans and serve as future resources for the companies. The panel of experts is tailored to the individual company but usually includes a venture capitalist, a successful entrepreneur with domain expertise, an accountant, corporate and patent attorneys, marketing professionals, and an executive from a successful company in the same industry. After a company has graduated from Springboard, it is eligible to participate in the Springboard Mentor Program. This program is a 90-day private mentorship with a domain expert to help the company identify its next steps and achieve its milestones over the next six to twelve months. Springboard mentors are successful entrepreneurs who have experience coaching technology and life science budding entrepreneurs. More than 300 people from the San Diego investment and business community attend the Springboard Annual Breakfast. The Breakfast showcases a select group of Springboard graduates, addresses trends in venture funding, and provides an opportunity for networking.
- The Most Innovative Product (MIP) Award – is an annual competition that honors corporations for their innovative new products. In 2003, CONNECT received almost 100 product nominations and more than 900 people attended the annual Awards luncheon. This luncheon is one of the most popular business networking events in Southern California. Corporate sponsors support the award and the annual luncheon.

Firms that have participated in the Life Sciences and High-Tech Financial Forum (formerly the Technology Financial Forum) have raised over \$1 billion in new capital.

- *Source: UCSD CONNECT*

- The Life Sciences and High-Tech Financial Forum – provides pre-screened companies a chance to showcase innovations to capital providers, industry professionals, and companies from the life sciences and high-tech industries. Companies are in the fields of: therapeutics, diagnostics, medical devices, drug discovery instrumentation and software, bio-informatics, software/internet, electronics, computer hardware, and telecommunications. Through the Forum, 40-50 firms annually make presentations to potential investors and corporate partners. To select firms, about 50 financial, legal, and corporate members of CONNECT conduct a rigorous screening process. CONNECT's staff and business mentors help prepare entrepreneurs for their presentations. The Forum is conducted over two days with morning devoted to presentations and afternoons devoted to individual meetings between entrepreneurs and investors. Generally, more than 100 potential investors attend the annual Forum.
- The San Diego Tech Coast Angels (SD TCA) – is a CONNECT affiliated group of angels who invest in and assist early-stage, Southern California companies. It is the San Diego network of the Southern California-based Tech Coast Angels organization, which also has networks in Santa Monica and Newport Beach. The SD TCA has its own Board and works cooperatively with the other TCA networks. According to SD TCA, an entrepreneur in San Diego can access more than 200 individual investors between the San Diego, Orange County and Los Angeles networks of the Tech Coast Angels.
- The CONNECT Angel Seminar – provides an in-depth overview on angel investing for accredited investors who are interested in becoming angel investors or those who want more information on angel investing. Three experienced angel investors and two local entrepreneurs whose firms have been financed by angels lead the Seminar. Legal and tax experts also provide input to the Seminar.
- UCSD Global CONNECT – has developed an extensive portfolio of international linkages, mainly with the Pacific Rim. For example, it has developed a partnership between the Australian Capital Territory (ACT) and the Larta Institute of Los Angeles. Under the Canberra-California Bridge Program, CONNECT will work with ACT to select 12 ACT-based tech companies that will go through an intensive training program designed to prepare them to enter the U.S. market. Four of these companies will be selected to participate in extensive feedback, mentoring and presentation events in the United States. Another example is a recent agreement between UCSD's Extension Service and the National University of Singapore (NUS) Extension. The partnership focuses on education and training in drug systems biology, development and clinical research for Singapore's rapidly growing biotechnology sector. Beginning January 2004,

NUS Extension offers a cross-section of courses in medicinal chemistry, bio-statistics, molecular biology, regulatory affairs, new product development, and biotech business, developed by UCSD Extension's Bioscience Department. Coursework will be delivered online and on location by UCSD instructors in both Singapore and San Diego.

LESSONS LEARNED

The Senior Administrators' Clear Vision and Support for Tech Transfer is Essential

At UCSD, the Chancellors and Senior Administrators have made clear that technology transfer is part of the University's mission to disseminate knowledge and to serve the community through economic development. Administrators regularly communicate their support for technology transfer and provide the resources to support TechTIPS educational and outreach activities as well as their technology transfer activities.

TechTIPS Education and Outreach Activities Encourage Faculty Participation and Industry Collaboration in Technology Transfer

TechTIPS' faculty seminars, "boot camp", and breakfasts educate faculty about intellectual property and technology transfer, and encourage invention disclosures and faculty start-ups. In addition, corporate receptions, seminars and breakfasts that involve corporate participants facilitate corporate networking with faculty and Senior Administrators. These activities facilitate support for university-industry collaborative research and promote technology transfer.

CONNECT and TechTIPS Provide Complementary and Mutually Supportive Activities

CONNECT is a visible presence of the University's commitment to entrepreneurial development and university-industry relations. Activities such as the Most Innovation Product Award provide visibility and networking opportunities for business leaders and the academic community. These activities also help build an entrepreneurial culture and reinforce technology transfer activities conducted by TechTIPS.

Venture Capital Activities by CONNECT and TechTIPS are Important in Helping Start-ups

CONNECT's Life Sciences and Technology Financial Forum and the Springboard program have resulted in financing for hundreds of the region's entrepreneurs. These programs not only provide the opportunity for introductions and showcasing, they also prepare entrepreneurs through workshops, mentoring, and other supportive activities. These activities also have raised the visibility and credibility of UCSD as a science and technology leader in the eyes of venture capitalists.

UNIVERSITY OF PENNSYLVANIA

HISTORY AND ENVIRONMENT

The University of Pennsylvania (Penn) is an Ivy League University located in the heart of downtown Philadelphia. Penn is one of about 80 universities and colleges in the region, including Drexel University, Thomas Jefferson University, and Temple University. The region also is home to major research institutes such as Fox Chase Cancer Center, Wistar Institute, and the Joseph Stokes Jr. Research Institute of Children's Hospital of Philadelphia.

Penn is the City of Philadelphia's largest employer. The Greater Philadelphia Region has more than 140,000 companies that employ 3.4 million people. The region's three largest clusters – Business Services, Education and Knowledge Creation, and Financial Services – have a greater concentration than the nation, and accounted for two-thirds of the region's employment gain in the past decade. Medical Devices and Information Technology clusters also added to about 12% of the job growth.²² According to BioAdvance, the Greater Philadelphia Region in 2003 had the second largest concentration of biopharmaceutical jobs in North America.

Beginning in the 1980's, the Commonwealth of Pennsylvania launched several major initiatives that supported technology-based economic development in the region. In 1986, it established the Ben Franklin Technology Partners (BFTP), one of the oldest state technology programs in the nation. The Commonwealth now provides about \$55 million per year through the Ben Franklin Technology Development Authority (BFTDA) to four non-profit BFTP centers across the state. BFTP of Southeastern Pennsylvania provides an array of services, networking and seed capital to stimulate entrepreneurial development and technology commercialization. Many of these programs and services are linked to Penn and other major research universities in the region. In 2001, the Commonwealth of Pennsylvania used tobacco settlement funds to invest \$100 million in three Life Sciences Greenhouses. Philadelphia's Life Sciences Greenhouse – BioAdvance – provides seed funding and other commercialization services, and works closely with Penn and other academic institutions in the region. In 2003, as a companion effort to the Life Sciences Greenhouses, the Commonwealth placed \$20 million each in three funds – PA Early Stage Partners, Quaker BioVentures, and Birchmere Ventures – to invest in early-stage biotech ventures. The funds were required to match state monies 3:1, resulting in total capitalization of at least \$180 million. In addition, the BFTDA created a \$500,000 Innovation Partnership to increase the number of SBIR awards to Pennsylvania firms. In 2004, legislation was passed that included almost \$400 million for two new venture capital programs, a loan guarantee program, and R&D tax credits.

Philadelphia also has a history of supporting university-based economic development and recently launched additional initiatives. In 2001, Mayor John Street joined forces with Penn's President Judith Rodin, Comcast Corporation, GlaxoSmithKline, and other community leaders to establish Innovation Philadelphia. Innovation Philadelphia provides technology-based and early-

²² "Innovation and Entrepreneurial Index", Innovation Philadelphia, 2002.

stage businesses in the Greater Philadelphia Region with traditional seed capital, access to alternative funding, skilled human capital, commercialization assistance, entrepreneurial resources and intellectual capital. Philadelphia's Science Center (formerly the University City Science Center) is one of the nation's oldest research parks. Located in the inner city near Penn and Drexel University, it houses lab, office and incubation space. It also provides an array of networking and educational opportunities for corporations as well as academic and research institutes. Penn also plans to build a research park adjacent to its campus and has purchased land for this purpose. In fall 2004, Penn will complete the renovations for a translational research building that may become part of the future park. (Later in this case study, we provide more detail on BioAdvance, Early Stage Partners, Innovation Philadelphia and the Science Center.)

Occupying a key economic and geographic position in the fabric of urban Philadelphia means that Penn is a major factor in determining the quality of life and attractiveness of the Delaware Valley region – in turn, a crucial determinant of our ability to attract students, faculty, and staff to the region, and especially to West Philadelphia. Finding ways to help Philadelphia renew its regional economy will be one major determinant of our own future success.

- *Building on Excellence: the Leadership Agenda – A Strategic Plan for the University of Pennsylvania, 2003*

Penn is one of the top research universities in the nation and has been ranked consistently in the nation's top 10 universities by the *U.S. News and World Report* survey. The University has almost 10,000 undergraduate students and an additional 10,000 graduate students enrolled in 12 graduate and professional schools. This includes the prestigious Wharton School of Business. Other Schools that are in the top 10 include the School of Medicine, School of Veterinary Medicine, School of Nursing, Graduate School of Arts and Sciences, Law School, and Graduate School of Education. Among Penn's 25 research centers and institutes are several interdisciplinary institutes such as the Institute for Medicine and Engineering and the Management and Technology Program sponsored jointly by the School of Engineering and the Wharton School of Business.

During the past decade, former President Judith Rodin and former Provost Robert Barchi strongly promoted technology transfer and regional economic development, and made an effort to bring Deans on board. They took the lead in establishing major initiatives such as Innovation Philadelphia, the Nanotechnology Institute, and the Greater Philadelphia Bio-informatics Alliance that brought together the region's universities, research institutes, and corporations. They created an Office of Strategic Initiatives to coordinate technology transfer, R&D collaborations, and economic development. Moreover, the University's strategic plan – The Leadership Agenda – raised technology transfer and commercialization activities to a higher level of importance and clearly promoted Penn's role in regional economic development.

THE STATS

From FY 1996 to FY 2003, Penn's Center for Technology Transfer has distributed \$59 million to faculty and their laboratories, departments, schools, and other stakeholders.

- Center for Technology Transfer

In FY 2003, Penn's R&D expenditures were \$704.5 million, with about 80% coming from the federal government. Life sciences represented about 70% of total R&D expenditures.

Penn's Center for Technology Transfer (CTT), in FY 2003, executed 83 licenses and options, and generated license income of \$13.6 million, a 52% increase compared to the previous year. It filed 442 patent applications, an increase of 58% compared to FY 2002. About two-thirds of the patents came from life sciences and about one-third from physical sciences. CTT generated 12 new start-ups, and in 2004 expected to create about 14-15 new enterprises.

CTT reported that from FY 1996 to FY 2003 it:

- Consummated 452 commercialization agreements with companies;
- Facilitated the creation of 50 new ventures;
- Generated \$77 million income from licenses; and
- Produced an average return on investment of 193%.

From FY 1999-2000, the latest available data for comparison, when normalized to account for R&D expenditures, Penn ranked in the second quartile on new patents awarded, new licenses awarded, and start-ups launched; it ranked in the first quartile for license income.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

Started in 1986, CTT conducts technology transfer and commercialization and related activities on behalf of Penn's faculty, students, and researchers. In the past two decades, CTT has gone through several transformations. In 1995, CTT was spun out of the Office of Research Administration as a stand alone function reporting to the Executive Vice President and Vice Provost for Research. In 2003, Penn created the Office for Strategic Initiatives (OSI), reporting to the Provost, to serve as a single access point for corporate collaboration and economic development. OSI has responsibility for technology transfer and commercialization, corporate R&D collaboration, and regional economic development. CTT's Managing Director now reports to the Vice Provost for Strategic Initiatives.

CTT's staff specialize in functional areas: (a) identification and triage of innovations, (b) intellectual property, (c) marketing, (d) licensing to established companies, and (e) licensing to start-ups. Several staff members specialize in physical and life sciences, the two major areas that generate license and patent activities. Louis Berneman, Managing Director of CTT, said that structuring the office according to function has resulted in greater productivity and has expedited the commercialization process. Several schools and departments have assigned staff to CTT and are housed at CTT; they report to their home unit as well as CTT. These schools and departments/units are: medicine, radiology, pathology, medical genetics, biology, chemistry, and materials. In this way, CTT has been able to build close relationships with the various science and technology departments, and according to the Managing Director, has increased the number of invention disclosures. There is also a staff member from the University's treasury department and general counsel office assigned to CTT.

We have a different business model than MIT and Stanford. Penn creates the venture – we hire a recruiting firm and get experienced CEOs to manage the venture. This creates real start-ups with real management ... and our interests are always in line with management.

- Louis Berneman, Managing Director, Center for Technology Transfer

In FY 2003, CTT handled more than 300 invention disclosures and almost 2,000 transactions. Each disclosure is assigned to a staff member and the triage process involves direct discussion with faculty members who submit the disclosures. In addition to CTT specialists who carry out due diligence, MBA students from the Wharton School of Business conduct market research, and students from the Management and Technology Program (a joint program between the School of Engineering and the School of Business) help analyze the invention's commercial potential. CTT holds weekly triage meetings in which the Managing Director and staff review and assess invention disclosures. Once a technology is licensed, CTT uses a license-monitoring system to insure compliance with the licensing terms.

CTT is highly selective in establishing starting-ups. Start-ups present a challenge to any technology transfer organization, and at Penn, CTT works with external consultants to devise business models, recruit management, secure financing, and launch the business. In order to launch a start-up based on Penn technology, CTT retains a recruiting firm to hire a CEO. Once on board, the CEO becomes responsible for attracting capital to the new enterprise. Penn prohibits faculty and administrators from having management or fiduciary responsibilities in the new venture. Faculty are permitted and encouraged, however, to become involved as advisors and consultants.

Penn is generous to its inventors. Penn distributes 30% of income received from commercialization to the inventor(s). Another 15% goes to the inventor(s)' laboratory and 15% to the inventor(s)' department. At the discretion of the department, all or part of their share may be given to the inventor(s)' laboratory. Thus, the inventor(s) could feasibly receive (directly and indirectly) more than half of the income. The inventor(s)' school receives an additional 17.5%;

Penn's Research Foundation retains 17.5%; and an additional 5% is placed in an Intellectual Property Fund. The Intellectual Property Fund reinvests in research and innovation and is administered by the Office of the Provost.

CTT's efforts extend beyond traditional technology transfer activities. For example, CTT played an important role in establishing a multi-year drug discovery initiative with Penn's School of Medicine and GlaxoSmithKline. It negotiated the terms for joint discoveries and helped seal this major research partnership.

CTT has some incubation space located in its offices. A Translational Research Facility, slated to open in October 2004, is located across the street from CTT and will include 120,000 square feet of life science labs, and additional incubation space. A research park is also planned on 20 acres across from the Translational Research Facility.

CTT has become increasingly involved with regional economic development organizations and initiatives, particularly: (a) BFTP of Southeastern Pennsylvania, (b) BioAdvance (the Life Sciences Greenhouse in Southeastern Pennsylvania), (c) Innovation Philadelphia, and (d) Science Center. We briefly discuss each of these organizations and institutions later in the case study.

ENTREPRENEURSHIP PROGRAMS

For more than 20 years, The Wharton School has provided entrepreneurial studies. They now offer a wide array of courses, research, internships, business plan competitions, and related activities that support entrepreneurial training and outreach. Through the Goergen Entrepreneurial Management Program, more than 2,000 students and entrepreneurs each year attend about 20 courses taught by entrepreneurs as well as faculty. The Wharton School also houses a federal SBDC that provides business assistance to student and other entrepreneurs. Other entrepreneurship activities sponsored by the Wharton School include:

- Wharton Business Plan Competition –has annually drawn more than 180 student teams comprised of more than 400 participants. Students who enter the Competition attend business development workshops and receive mentoring from entrepreneurs. Semi-finalists receive additional help in preparing presentations for potential investors. There is \$75,000 available in prizes, including a first prize of \$20,000, second prizes of \$10,000, and third prizes of \$5,000. Each winning team receives an additional \$5,000 worth of legal services and \$5,000 worth of accounting and business strategy services. In addition, the Frederick H. Gloeckner Award for \$5,000 is given to the highest-ranking Wharton undergraduate. Sponsors include: Goldman Sachs Foundation, Sovereign Bank, Johnson & Johnson, Microsoft, and Business 2.0. Additional in-kind services are provided to winners by major national accounting and legal firms.

- Wharton Venture Initiation Program – helps students with implementing business plans. Administered by the federal Small Business Development Center (SBDC), entrepreneurs are eligible to receive up to \$20,000 in seed capital.
- Entrepreneur-in-Residence Program – provides students with expert advice from successful entrepreneurs. Students are given half-hour sessions on business planning and related topics. In 2004, nine entrepreneurs participated in the program.
- Wharton Entrepreneurial Program Awards – honor outstanding graduate and undergraduate student entrepreneurs. Some awards provide seed capital and fellowships.

BIOADVANCE

Launched in fall 2002 as one of the Commonwealth's three Life Sciences Greenhouses, BioAdvance funds early-stage life sciences projects. BioAdvance has allocated over \$20 million to invest in promising proof-of-concept projects related to bio-therapeutics, diagnostics, devices and tools, and platform technologies. By spring 2004, BioAdvance had completed two competitive funding rounds. Six advisory panels involving regional and national experts from science, business, and investment communities evaluated over 100 applications in the two rounds. Applications were evaluated for: (a) commercial opportunity (40%), (b) technical merit (40%), and (c) intellectual property (20%). Based on this review, 15 technologies were selected for investments totaling \$6 million. Less than half the funds were invested directly in university technologies, but about three-fourths involved businesses connected with universities in some way.

In general there is a lack of seed capital. The Commonwealth and the (Life Sciences Greenhouses) have met some of the needs, but the demand in southeastern Pennsylvania is greater than anticipated. Although there are early-stage funds in California and Boston, you need a local fund willing to do the heavy lifting for these types of investments. One of the BioAdvance goals is to establish an early-stage venture fund to serve the region, as the second funding step after the Greenhouse Fund.

- *Barbara Schilberg, Managing Director & CEO*

BioAdvance's \$20 million Greenhouse Fund provides two major types of investments: (a) direct investment in companies using convertible notes, and (b) investments in university projects in which the university retains 50% ownership. BioAdvance has the right to start a new venture based on a university invention within 24 months if the university does not choose to do so. Barbara Schilberg, BioAdvance's Managing Director and CEO, said that as soon as a university knows BioAdvance is interested in an invention, the university spins off the technology and takes ownership. Therefore, BioAdvance has not had the opportunity to use the second form of investment.

Ms. Schilberg said that BioAdvance preferred investing in start-ups that involved university faculty partnering with an experienced corporate manager. BioAdvance has funded a couple start-ups like this, including one in which a young investigator from Drexel University teamed with an executive from a large pharmaceutical company. The successful innovation that resulted was a different product than the one originally envisioned, in part, because of the corporate executive's experience. In order to foster similar partnerships, BioAdvance is exploring implementation of an Executives-in-Residence program that would involve recently laid-off pharmaceutical company executives. BioAdvance also is starting a program for universities to mine very early-stage technologies in certain research departments. (This type of program has been implemented in the two other Life Sciences Greenhouses.)

In addition to financial investments, BioAdvance helps start-ups identify service providers and venture capitalists, and helps them prepare presentations for potential investors. BioAdvance also has an "informal and ad hoc" database of consultants available to start-ups. BioAdvance plans to work more closely with the Science Center's Executives-in-Residence program, and BioAdvance's Managing Director said that she also hopes to enhance in-house business assistance activities.

In 2002, BioAdvance joined forces with universities and life science companies to form the Greater Philadelphia Bioinformatics Alliance. The Alliance was formed as a result of Penn's initiative to create a regional inter-institutional "center of excellence" in bioinformatics and systems biology. The purpose is to accelerate innovations in bioinformatics by linking researchers and practitioners with pharmaceutical and biotechnology companies. The Alliance initially has focused on workforce development, including industry input in curriculum design as well as K-12 educational activities. In 2004, the Alliance involved nine partners including Penn, Drexel University, Children's Hospital of Philadelphia, and Wistar Institute.

In spring 2004, BioAdvance was working closely with several regional organizations such as Innovation Philadelphia to examine co-location and to secure incubator space for life sciences. In the near future, Ms. Schilberg envisions BioAdvance becoming the region's central source for assisting corporations identify and access clinical trial resources.

BioAdvance's staff is composed of two professionals, two support staff, and several part-time consultants; at the writing of this report additional staff were being hired. A Board oversees operations and is composed of 12 representatives divided equally among industry, academia, and community organizations.

PENNSYLVANIA EARLY STAGE

By early 2004, Pennsylvania Early Stage had invested about \$70 million in 41 companies, and had leveraged an additional \$350 million. Seven companies were sold for a total of \$1.4 billion and these companies now employ about 1,500 people.

- Source: *Pennsylvania Early Stage*

Pennsylvania Early Stage (PA Early Stage) is a seed capital fund started by the Commonwealth of Pennsylvania. The fund initially was capitalized with \$50 million; half of which came from Pennsylvania pension funds; \$15 million from Safeguard – a public venture capital company, and \$10 million from a private foundation. Safeguard was part of the general partnership. By spring 2004, the fund had drawn down \$44 of \$49 million received. A second fund was capitalized with \$100 million from Safeguard and Pennsylvania pension funds.

The fund invests in early stage firms. The fund has formed companies with technologies taken from 13 universities including Penn, Princeton, and Cornell. PA Early Stage has invested less than \$200,000 in 12 of the companies, and first round investments can be as high as \$2 million.

PA Early Stage has 19 service providers who offer various services to the fund's start-ups. For the firms that are at "zero stage", PA Early Stage typically invests about \$50,000 - \$100,000 in business and management assistance and in return takes about half of the value of the services in stock.

In spring 2004, a third fund was being capitalized with new limited partners; Safeguard will take a subordinated position to the Pennsylvania Pension Fund in this new fund. Five medical centers had invested in the fund, and several states also had invested. Because of the significant investment made by West Virginia, PA Early Stage was establishing an office in the State and will have on-site presence there one day every two weeks. Paul Schmidt, a Partner in PA Early Stage, said that when fully capitalized, the fund was expected to reach \$150 million. The fund has committed that 70% of total investments will be made in Pennsylvania.

OTHER RELATED EFFORTS

BFTP of Southeastern Pennsylvania

BFTP of Southeastern Pennsylvania (BFTP/SEP) is one of the four BFTP's funded, in part, by the Commonwealth of Pennsylvania. BFTP/SEP pursues four key objectives: (a) develop and support large-scale regional partnerships to strengthen the region's innovation infrastructure; (b) provide and stimulate investment capital, business services and networks for pre-seed and seed stage technology enterprises; (c) manage product development and commercialization services, and partnerships that accelerate industry adoption of technology; and (d) bridge underrepresented populations to the technology sector. BFTP/SEP invests approximately \$5 million annually in

technology enterprises. In FY 2004, its investments leveraged companion funding of \$14.9 million; other portfolio investments secured follow-on funding of \$33 million. BFTP/SEP has invested in or stimulated the formation of seven regional investment funds. It created and launched the Ben Franklin Investment Partners (BFIP), an innovative guarantee vehicle seeded by \$2 million from the Commonwealth designed to increase angel investment activity in the region. In 2004, BFTP/SEP launched the Minority Angel Investment Network (MAIN) designed to source, develop, and stimulate investors and investments for minority-owned enterprises.

BFTP/SEP's Technology Commercialization Network (TCN) consists of 21 university research centers and a network of private and non-profit organizations. It assists companies address technical and product development needs. The TCN provides consulting and use of laboratory facilities for analysis, experimentation, and prototyping. Through TCN, BFTP/SEP co-funds engagements between a TCN service provider and a company. One of the centers is Penn's Center for Materials Testing and Processing. TCN also identifies and develops university-industry collaborations that compete for federal funding, including a recent 18-member Partnership for Broadband Wireless Innovations and Consortium for Sustainable Design and Research. BFTP/SEP's work with such collaborations has also led to its involvement in many emerging Keystone Innovation Zones, a new Commonwealth initiative to stimulate technology and enterprise development and investment around universities.

Innovation Philadelphia

In 2001, Innovation Philadelphia was conceived by a group of City of Philadelphia leaders led by University of Pennsylvania President, Dr. Judith Rodin, J.P. Garnier of GlaxoSmithKline, and Brian Roberts of Comcast who worked with Mayor John Street's transition team in effort to make the Philadelphia region more competitive. A consultant was hired to perform a regional analysis and recommended that the New Economy Development Alliance (NEDA) be formed to support entrepreneurship and innovation. Innovation Philadelphia was formed by the Alliance in December 2001 to catalyze and broker the region's technology assets and connect industry leaders in technology, finance, and human resources. Richard Bendis of the Kansas Technology Enterprise Corporation was hired to become its President and CEO. In 2004, Innovation Philadelphia's goals were to: (a) increase the number of knowledge-based companies in the Greater Philadelphia region; (b) increase the knowledge economy workforce and stimulate "brain gain"; (c) develop and grow entrepreneurial financing resources; (d) foster and leverage regional cooperation to accelerate technology commercialization and wealth creation; (e) provide value-added services; and (f) "brand" the greater Philadelphia Region.

Since its inception, Innovation Philadelphia has launched numerous initiatives. The Economic Stimulus Fund co-investments, with other partners, in technology enterprises through loans, convertible debentures, equity or a combination of debt and equity. The Research Dollars Fund provides financial and technical assistance to help entrepreneurs secure federal program funding in the SBIR/STTR and the Advanced Technology Program. The Mid-Atlantic Commercialization Corporation provides managerial services to help entrepreneurs move from product development to successful market launch. A recently launched initiative – CareerPhilly – conducted jointly by Innovation Philadelphia and the Knowledge Industry Partnership, aims at retaining the 50,000 annually graduating students from the region's universities and colleges.

Innovation Philadelphia also conducts SBIR seminars, cluster-specific workshops, conferences, a global initiative, and international conferences. It has been instrumental in bringing major technology conference such as BIO 2005 to Philadelphia. Innovation Philadelphia also produces numerous publications including regional guides, planning and benchmarking reports, and a quarterly technology magazine highlighting the region's technological strengths and issues.

Science Center

Started 40 years ago, the Science Center (formerly the University City Science Center) is an urban research park located near Penn's Medical Center and Drexel University. The Science Center has helped launch more than 350 companies, creating more than 26,000 jobs. It now occupies more than 2 million square feet employing about 8,000 people. There are 34 shareholders in the Science Center; these shareholders represent all major academic institutions in the Greater Philadelphia Region, medical facilities, foundations, and nonprofit research organizations.

In 1968, Science Center began providing full-service business incubation services, and in 1999, it expanded this effort with the opening of the Science Center Port. The Port provides sophisticated plug-and-play and wet lab space to firms in information technology and life sciences. The Port's business mentors help entrepreneurs develop business plans. Its Executives-in-Residence and Entrepreneur-in-Residence give entrepreneurs experienced advice in structuring and managing start-ups. Moreover, each entrepreneur is assigned an Executive-in-Residence as an account manager to ensure that business milestones are achieved. For the general entrepreneurial, academic, and corporate community, the Science Center holds networking events, seminars in life sciences, a monthly knowledge series, and venture capital forums.

LESSONS LEARNED

Coordinated Efforts Can Create a Whole Greater than the Sum of the Parts

The Greater Philadelphia Region has a number of initiatives that bring together multiple universities, research institutes, corporations, and organizations. The Nanotechnology Institute and Greater Philadelphia Bio-informatics Alliance, for example, leverage the resources of Penn, Drexel University and several other research institutions and major corporations. Technological innovations in life sciences, nanotechnology, and other emerging fields increasingly require integration of multi-disciplinary fields. These technology alliances leverage the individual institution's strengths in medicine, engineering, computer sciences, and other fields that together are more powerful than any one institution's resources alone.

A Prestigious Research University Can Rally Resources for Economic Development

Penn's former President Judith Rodin and former Provost Robert Barchi made economic development a priority at the University, and took the lead in several regional economic development initiatives. They played a major role in initiating Innovation Philadelphia, for example, to develop and implement a strategic plan for the region's technology-based economic development and took the lead in other related efforts. Within the University, they formed a new internal structure – the Office of Strategic Initiatives – to better coordinate external relations, technology transfer and economic development. They communicated technology transfer and economic development as priorities to their schools and departments and in their leadership plans.

State Government Initiatives Can Stimulate and Leverage Local Technology Development

When asked what were the most important factors that promoted technology transfer at Penn, CTT's Director Louis Berneman said that in addition to the strong leadership from the former University's President, state policies and programs provided critical support to the University's and the region's technology efforts. This included the use of tobacco funds to form the Life Sciences Greenhouses and life science seed capital funds, tax incentives to support incubators, and development of the Keystone Zones (enterprise zones) to encourage business development.

UNIVERSITY OF WISCONSIN - MADISON

HISTORY AND ENVIRONMENT

The University of Wisconsin (UW) System is one of the largest public university systems in the nation. Its main campus is located in Madison, seat of the state government. The Madison campus and government employ about one-quarter of the county's workforce. High-technology employment is growing in the county, and now represents about eight percent of the total workforce. Moreover, the number of high-technology firms is growing at an average annual rate of 10%, mainly in software and other computer-related fields, biotechnology, medical/bio-medical research, and microelectronics. The City credits the University of Wisconsin-Madison for this high-technology growth.²³

This hotbed of radicalism has grown into a seedbed of bio-capitalism, propelling the region to the number one slot on (*Forbes*) list of Best Places for Business and Careers ... Some 120 technology companies employing 8,000 people have sprung up in Madison during the past decade.

- "Miracle in the Midwest", *Forbes*, May 24, 2004

The University of Wisconsin (now the University of Wisconsin-Madison) was founded in 1849 as a public land-grant institution. In 1971, it became part of the UW System composed of 13 four-year campuses, 13 two-year campuses and UW Extension. University of Wisconsin-Madison (UWM) is by far the largest institution with more than 41,000 students, about two-thirds of whom are undergraduates.

UWM has a strong research base and consistently has one of the highest research expenditures of any university. The University has about 90 research centers, most of which perform interdisciplinary R&D. As a land-grant institution, UWM has a longstanding and well-deserved reputation for being very engaged in efforts that contribute to the social and economic development of the State. Much of the credit for this reputation can be traced to the "Wisconsin Idea," a 100-year old policy that places a strong premium on outreach to various communities in the State in the context of teaching, research, and service. The "Wisconsin Idea" also provided the basis for technology transfer and university-industry relationships. Unlike other institutions where there has been an ideological conflict between technology transfer and academic pursuits, the transfer of knowledge and business extension has always been viewed as part of the University's mission. This ideology has manifested in the strong State and University support for UWM technology transfer and corporate relations, and more recently, a successful research park. This is complemented by entrepreneurial development efforts targeted at faculty and students. The College of Engineering also has developed a strong industrial education program, and about 15 of the research centers have industrial membership programs.

²³ "2003 Fact Sheets", City of Madison.

Perhaps the most unique and important element of the UWM model is the flexibility and effectiveness of its technology transfer function. The Wisconsin Alumni Research Foundation (WARF), a non-profit “university-linked technology development organization”, files patents, issues licenses and works with the inventors to implement commercialization plans. Although faculty do not have to license inventions through WARF, unless the invention was developed with federal funding, most do, in large part because of its reputation for effectiveness and high quality service. In addition to the significant share of licensing provided to inventors, WARF provides a significant portion of the income to the inventor’s laboratory, department and research program.

The State of Wisconsin has implemented several initiatives that support UWM’s technology transfer and commercialization activities. Under three initiatives – WISTAR, HealthStar and BioStar – the State has invested over \$900 million in various research and facility construction projects to promote life sciences, mainly through UWM. The current BioStar initiative provides \$317 million for a UW Biotechnology Center addition and three other new biosciences buildings. WARF has contributed \$80 million to the effort. The State also offers several investment vehicles for entrepreneurs, including a \$50 million CAPCO through three private firms and a \$50 million program (total capitalization with private matching is about \$100 million) for early-stage firms run by Venture Investors and Mason Wells. Additionally, the State’s Technology Development Fund provides low-interest loans that cover a maximum of 75% of R&D and commercialization activities, and a Technology Development Loan supports infrastructure development. The current Governor Doyle included technology development as a key part of his election platform and, in 2003, released a plan to fulfill those election promises. His proposals (pending in spring 2004) included the creation of a new public authority to invest \$300 million in venture capital over a ten-year period; a \$100 million bioscience research fund; and a \$5 million fund to provide matching for federal awards to university researchers.

THE STATS

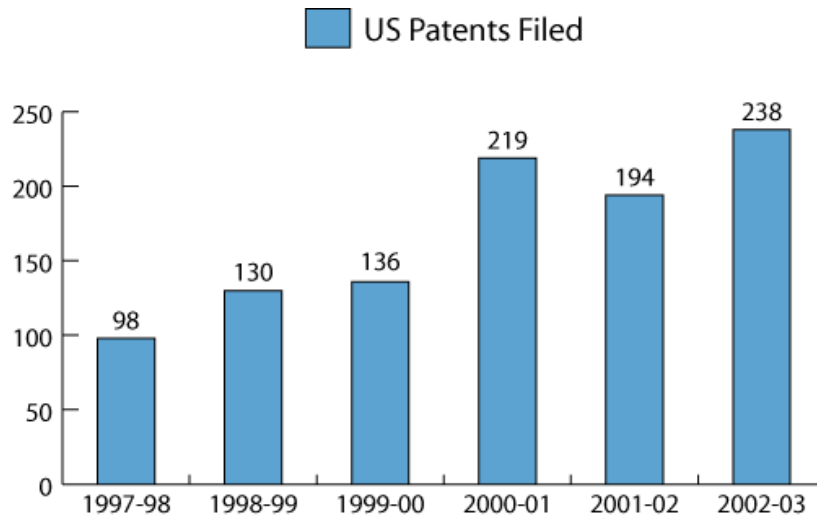
Since making its first grant in 1928, WARF has contributed about \$1.3 billion dollars to the University of Wisconsin-Madison. In 2004, WARF was expected to contribute about \$45 million to fund research, build facilities, purchase land and equipment, and support faculty and graduate student fellowships.

- *Wisconsin Alumni Research Foundation*

In FY 2003, UWM received \$583 million in extramural R&D awards. Nationally, UWM ranked second among public universities and third among all universities for research expenditures.²⁴ Almost two-thirds of research expenditures were from federal grants and contracts; about one-fourth was from gifts and endowments. The Medical School received the greatest portion, 29% of all research expenditures, and agriculture and life sciences received an additional 17%. Most of the remainder went to engineering and various graduate programs.

²⁴ Source: University of Wisconsin-Madison.

WARF Patents and Licensing Activity History



Source: Wisconsin Alumni Research Foundation

In FY 2003, WARF filed 238 patents, 57% higher than only three years earlier, and it launched four start-ups. From FY 1999-2001, the latest comparable data, UWM was in the first quartile nationally for new licenses (32/173), active licenses (37/173), and license income (30/174), even when normalized to account for very high R&D expenditures. It was in the second quartile nationally for start-ups.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

Founded in 1925 to manage the UWM discovery that eliminated rickets disease, WARF is the oldest and one of the most successful technology transfer programs in the nation. WARF is a non-profit organization that conducts technology transfer and commercialization activities for UWM. It processes invention disclosures, files patents, executes licenses and provides other assistance to help inventors implement commercialization plans arising from UWM inventions. A wholly owned subsidiary, WiCell, is responsible for technology transfer related to research on human embryonic stem cells, and WiSys Technology Foundation, Inc., a wholly owned subsidiary of WARF, handles licensing for the other four-year UW campuses.

WARF has 50 employees, 30 of whom work in patenting and licensing. Most patent and license managers have science and/or patent backgrounds and some have government, public relations and legal backgrounds. WARF has assigned two managers to physical sciences and two to life sciences; other managers handle multiple disciplines. WARF's patent and licensing functions are divided between a Licensing Group that conducts marketing, sales, and licensing negotiations and a Patent Group that processes invention disclosures and identifies potential patent opportunities. WARF hires outside counsel to process patents. In 2003, WARF handled 380 invention disclosures; 60% were accepted for patent and licensing activity. Currently, 40% of WARF's portfolio is licensed. In 2004, WARF expected to handle about 450 invention disclosures.

WARF tends to work with a wide range of invention disclosures rather than “cherry pick” disclosures. It is especially proactive in its licensing activities, and managers frequently travel nationally to meet with companies to license technologies. WARF, for example, is one of the only universities to meet annually with Amgen at their corporate office. Since 2002, WARF has had a representative based in San Diego who exclusively develops licensing leads for the west coast, and in 2003, WARF added a representative who exclusively develops leads in Wisconsin. WARF’s Director, Bryan Renk, said from an academic standpoint this is a new model, and although experimental, appears to be working well.

At the same time, WARF is stepping up activities to increase the percentage of licenses that go to Wisconsin companies. Currently about 20% of WARF inventions are licensed to Wisconsin companies. In 2003, WARF started the “Wisconsin Initiative” aimed at identifying corporations in Wisconsin that might be candidates for licenses. Mr. Renk said that although the office cannot be partial geographically to specific companies (based on federal-funded research), “it’s natural to prefer companies close to home, just as venture capitalists prefer near-by deals.” UWM has been particularly successful with pharmaceutical companies. The Director said, however, that pharmas had become increasingly risk adverse and required more and later-stage proof-of-concept technologies. This has placed increasing pressure on WARF to find other outlets for early-stage technologies and to determine better ways to develop the technology to a point where pharmas are interested in licensing. WARF also handles patent donations from corporations. The Director said that although WARF welcomes donations, it is sometimes difficult to identify faculty members to work with donated patents and to demonstrate that the faculty intends to commercialize the patented product/process.

You have to view the corporation as the customer – we are selling (technology) to them; you’ve got to have high quality research but you also have to be talking to industry and have a presence.

- Bryan Renk, Director, Wisconsin Alumni Research Foundation

WARF acts as a facilitator to help start-ups find legal and accounting professionals and, to the extent possible, find business and management expertise. Mr. Renk said that finding management expertise has been particularly difficult because of the lack of serial entrepreneurs in the State, particularly in life sciences. In order to provide greater assistance to start-ups, the Director said WARF was examining closer relations with the Business School. In the future, WARF also may implement an Entrepreneur-in-Residence program.

UWM’s policies on intellectual property ownership and income distribution are the key motivators for faculty to submit invention disclosures. UWM’s policies give inventors much more latitude and ownership rights than most universities. Unless the research is federally funded, UWM’s presumption is that the academic inventor owns the invention. For all inventions, WARF gives 20% of the first \$100,000 gross royalties to inventors and 70%, net of expenses, to the primary investigator’s laboratory. Once the maximum \$70,000 laboratory share threshold has been reached, the inventors’ department receives 15%, net of expenses, of the

license revenue. For the past couple years, WARF's Trustees have permitted WARF to invest in companies, and by spring 2004, WARF had directly invested in eight companies.

WARF contributes more than \$40 million per year to the University. WARF's contribution supports R&D through research grants, scholarships, internships, laboratory facilities, and equipment. They also provide funds for faculty recruitment and retention. Through a "cluster hire initiative", WARF has supported the hiring of interdisciplinary faculty. WARF surveyed UWM's colleges to identify their future research priorities, and based on the results of that survey, provided funding to hire faculty members in strategic fields. Most of the new hires involved joint appointments between two or more departments and/or schools, particularly life sciences and engineering. WARF's Director said that hiring of interdisciplinary faculty ultimately benefits WARF because the interdisciplinary faculty tends to be more entrepreneurial and more likely to commercialize inventions.

The University Chancellor and Administration in recent years have shown support for technology transfer in policy statements, speeches and actions. WARF management meets weekly with the Administration. It also has continuous interaction with the Office of Corporate Relations, and meets monthly with the Office of Sponsored Research, and the University legal group. It meets monthly with the University's Communication Group to help insure that its successes are publicized locally and nationally. WARF conducts seminars for UWM's colleges and departments on intellectual property and related topics and, when new faculty members join the University, WARF's "Welcome Wagon" greets them with a coffee mug and a laboratory notebook.

It should be noted that for many years WARF proceeded cautiously after having had its non-profit status removed in 1972 when it was accused of operating a for-profit enterprise. After a few changes (WARF sold its development labs), its non-profit status was reinstated. Nevertheless, the case not only had a "chilling effect" on WARF's technology transfer activities but also on other university technology transfer programs around the country. Over the past half-decade, WARF has become more aggressive in its licensing, patenting, and start-up activities and this renewed pro-active approach has resulted in the rapid rise in patents and licenses, making it one of the most successful programs in the country.

CORPORATE RELATIONS

As a land-grant institution, UWM has a tradition of outreach to and interaction with agriculture, industry, and business. In 2002, the Chancellor appointed a task force on university-industry relationships, and as part of this effort, the University conducted focus groups with business leaders around the State. The majority of the participating business leaders said they wanted one place in the University for corporate assistance. As a result, the former University-Industry Relations Office was dissolved and the new Office of Corporate Relations (OCR) was created. OCR now provides a central point of contact for corporate interaction with the University. Its Managing Director reports directly to the Chancellor. OCR's main functions are: (a) to inform the business community about the resources available to it on the UW-Madison campus, (b) to field questions and refer businesses to the appropriate place in the University, and (c) to promote

entrepreneurship as a key to economic development. According to OCR's Managing Director, Charles Hoslet, OCR has increasingly focused on identifying researchers for specific corporate projects. OCR staff is expected to respond to business inquiries within 48 hours. Its Community of Science database facilitates retrieval of information on faculty and current research, and corporations also can access the Wisconsin TechSearch (WTS) that provides a searchable database for research and services. OCR assists corporations from outside the State as well as those in State to access resources at the University.

The assistance we give to corporations is paid back in many ways. (Moreover), as state budgets decrease, placing more pressure on universities, it helps to have corporations as your constituents.

- Charles Hoslet, Managing Director, Office of Corporate Research

About one-fifth of UWM's 90 research centers have corporate membership programs. One of the most successful of those centers – E-Business Institute – combines the resources of the Business and Engineering schools and involves corporate research on a wide range of areas from corporate security to supply chain management. The Center for Quick Response Manufacturing is a popular research institute with manufacturers as members. It provides services in manufacturing techniques, organization, human resources, and other manufacturing issues.

Each school and college, WARF, University Research Park, and the UW Foundation (the University's philanthropic arm), has appointed a liaison to OCR. Liaisons formally meet quarterly, but informally communicate on a regular basis regarding corporate needs and issues. OCR also has an Internal Advisory Board that includes representatives from the Schools of Business, Medicine, Agriculture, Engineering, Graduate, and Letters and Science, WARF and the University Research Park. The Board provides input to OCR regarding individual school's relationships with corporations as well as general direction. In addition, most schools and colleges have an Industrial Advisory Board to facilitate corporate input on curriculum development and issues concerning corporations in the State.

ENTREPRENEURIAL DEVELOPMENT

In addition to WARF, OCR and UWM's School of Business provide entrepreneurial assistance and commercialization support. OCR sponsors two grant programs to support faculty projects that show commercialization potential. The Robert Draper Technology Innovation Fund provides about \$400,000 annually in grants, averaging \$30,000 for proof-of-concept projects that have patent and licensing potential. Funds for this program come from the University's royalty revenues generated by prior licenses. The Industrial and Economic Development Research Program (I&EDR) provides about \$900,000 annually in grants of up to \$50,000 for early-stage research. I&EDR grants often leverage additional public and private sector support for research.

Other support for faculty and student entrepreneurs is housed in UWM's School of Business. The technology-focused SBDC housed in the School of Business provides entrepreneurs and start-ups with business assistance. The Weinert Center Applied Ventures in Entrepreneurship Program provides 12 MBA students with a yearlong practicum in starting and growing a technology enterprise. The UW Entrepreneurs Club provides networking opportunities. The Technology Business Development Institute, recently started in the School of Business, provides seminars, counseling and networking for scientists and engineers. In addition, the UWM School of Business, College of Engineering, and College of Agriculture and Life Sciences jointly launched the Technology Enterprise Cooperative (UW-TEC), a non-profit organization that provides business plan competitions, seminars, and workshops. Competitions sponsored by UW-TEC are the G. Steven Burrill Technology Business Competition, the Tong Prototype Prize, and an undergraduate inventors competition called Brainstorm.

The State and community have implemented other resources to support entrepreneurs at UWM and statewide including:

- Governor's Business Plan Contest – started in 2003 by Governor Jim Doyle, the Contest made its first awards in June 2004. It is co-produced by the Wisconsin Technology Council and the Wisconsin Innovation Network.
- Wisconsin TechSearch – is a fee-based information retrieval service in the College of Engineering for business and industry focused on scientific and technical publications.
- SBIR Federal-State Partnership – supported by the federal SBIR FAST program, the State provides product and customer assessments and partnering assistance in addition to the more traditional SBIR assistance.
- Wisconsin Technology Council (WTC) – was established by the State Legislature to create a master plan for the development of science- and technology-based businesses in Wisconsin. Networking events sponsored by WTC include: Wisconsin Entrepreneurs' Conference, Life Sciences and Venture Conference, and High-Tech Luncheons.
- Wisconsin Innovation Network (WIN) – is the Council's membership-based networking arm that operates through local-based organizations throughout the State.
- Wisconsin Technology Network (WTN) – is a cluster-driven networking and information association connecting people in the State and throughout the Midwest.
- Accelerate Madison – offers mentoring and business support, workshops, and forums focused on information technology; its aim is to cross-pollinate industry leaders with emerging high-growth, start-up enterprises.
- Wisconsin Biotechnology and Medical Device Association – is a networking and information association focused on biotechnology and medical device companies.

UNIVERSITY RESEARCH PARK

Started in 1984, the University Research Park (URP) is one of the most successful research parks in the country. Located three miles from the UWM campus, the Park's has a technology incubator – the Madison Gas & Electric (MGE) Innovation Center – and 34 buildings (with total space of 1.5 million square feet) that are leased from University Research Park, Inc. (URPI). URP is a non-profit corporation that owns and manages the 300-acre Park.

Unlike most research parks, URP is self-sustaining; it receives no City or State funds, and URP pays property taxes to the City of Madison. Total value of the Park's buildings has been estimated at \$160 million. In early 2004, the Park had 107 companies employing almost 4,000 people with an average annual income of \$60,000. Most of the companies were related to biotech and about two-thirds of the companies had some linkage with the University, a much higher portion than found in most university research parks.

Having the “start-up infrastructure” in WARF has been important to the Research Park. One of the reasons we have few failures (in the incubator) is because most of the firms come to us from WARF. The technologies are vetted there, and that lowers the risk to us.

- Mark Bugher, Director, University Research Park

The Park's incubator – MGE Innovation Center – was created in 1989 as a collaboration between the University Research Park and MGE to facilitate technology transfer from UWM. MGE leases the facility and subleases space to start-ups. The Center has 117,000 square feet of office space and laboratories, including wet labs. In spring 2004, there were more than 70 early-stage companies in the facility, and almost all of the early-stage companies came through WARF. The Park Director, Mark Bugher, said the incubator has had very few failures and that one of the reasons is many of the incubator's companies start at WARF and are vetted by them, which lowers the risk to the incubator. Companies in the incubator have one-year leases and are permitted to stay up to three years. The facility houses 33 office suites, 42 laboratories, 9 conference rooms, a shared shop facility, and common areas.

Phase II of URP, which is expected to be built out over the next 10-15 years, will almost double the current Park and allow for 53 additional sites for science and technology development. Phase II also will have some mixed-use space such as restaurants and banks that are not now part of the Park. The land has been purchased, and early Phase II plans were expected to get underway in late 2004.

LESSONS LEARNED

Corporations Benefit from A Central Point of Entry

In response to corporate input, UWM created its Office of Corporate Relations to serve as a central point of entry to access University research and services. OCR benefits corporations by responding quickly to inquiries and identifying appropriate resources at the University to assist companies. At the same time, it screens inquiries that might otherwise overwhelm WARF and individual faculty.

Pro-Active Licensing Pays Off

WARF's recent increase in licenses has been attributed to its pro-active, direct approach to potential corporate clients. WARF views corporations as customers and licensing agents are permitted some flexibility in closing deals.

The University Research Park and Incubator Provide Visible Support for Technology Transfer

The University Research Park has attracted 107 companies, including 70 start-ups in its incubator. This entrepreneurial presence provides visibility and additional incentives for a growing entrepreneurial culture at UWM. The incubator offers space close to the University for start-ups that otherwise may have left the State. The Research Park also offers space for expanding incubator companies thus facilitating retention of those companies and contributing to growing local clusters.

Start-ups Beget More Start-ups

A combination of UWM's strong R&D base, particularly in its Medical School, WARF's technology transfer efforts, and the University Research Park have led to an increase in start-ups. These start-ups, particularly in life sciences, have begun to form a "critical mass" through increasing cross-pollination and budding serial entrepreneurship.

WASHINGTON UNIVERSITY

HISTORY AND ENVIRONMENT

Washington University is a medium-sized, private university located in St. Louis, Missouri, a metropolitan area of about 2.6 million people. Until recently, St. Louis was a center for aerospace development and defense production. But like other regions whose economies depended on defense, it was hit by industrial closures and downsizing. Despite the economic downturn, St. Louis has remained one of the top 15 cities in the number of “*Fortune 500*” firms. These firms include Anheuser Busch, Monsanto, Charter Communications and other corporations in electronics, health care, and retail. In 2003, St. Louis’ transitioning economy had a higher than national average concentration of employment in computer systems analysis, hardware engineering, software applications engineering, medicine, and industrial chemicals. Moreover, according to the Progressive Policy Institute, St. Louis ranked 10th among all metros in the percent of workers in “gazelle” firms, a good indication of a growing economy. The growing technology sectors included plant and life sciences, information technologies, and advanced manufacturing.

Over the past decade, St. Louis became a community united in launching a technology-based strategy and forging a new direction for the region. In the 1990’s, the St. Louis Regional Chamber and Growth Association (RCGA) contracted a study on the St. Louis regional economy and identified five industry clusters: (a) plant and life science, (b) information technologies, (c) advanced manufacturing, (d) banking and financial services, and (e) transportation, cargo and distribution. RCGA then commissioned Battelle Memorial Institute to identify the region’s core competencies and develop a strategy starting with plant and life sciences. Battelle found research excellence at Washington University, Saint Louis University, University of Missouri–Columbia, the Missouri Botanical Garden, the Donald Danforth Plant Science Center, and the National Corn-to-Ethanol Research Center, and additional private intellectual assets at Mallinckrodt, Monsanto, Sigma-Aldrich, the Solae Company, Wyeth BioPharma, and Pharmacia (now Pfizer).

In order to capitalize on the region’s research and private intellectual assets, local champions drove a regional campaign to increase federal research dollars to the universities and launch other initiatives in support of technology commercialization. Most prominent among those champions was William Danforth, the former Chancellor of Washington University. Dr. Danforth was instrumental in increasing federal R&D dollars to Washington University. The Monsanto Corporation and the Danforth Foundation (Ralston Purina) jointly created the Danforth Plant Science Center, a major private research institute in St. Louis. The Monsanto Corporation also contributed to local university research, was a strong advocate for State plant and life science initiatives, and with its corporate funds created the Nidus Center, an incubator on Monsanto’s “campus”. The John McDonald’s Foundation (McDonald Douglas Corporation) also made major investments in local seed capital funds. The Coalition for Plant and Life Sciences, jointly established by the RCGA and Civic Progress, and chaired by William Danforth, became an active networking organization to promote the “BioBelt” region.

The State of Missouri implemented additional university-based initiatives to support technology development in St. Louis and the State. In the 1980's, the State funded four Innovation Centers associated with the University of Missouri campuses. The St. Louis Center, now the Center for Emerging Technologies, provides incubation space as well as other entrepreneurial services. Through the New Enterprise Creation Act, the Missouri State Legislature also passed \$20 million in tax credits for early-stage capital to be administered by a private fund manager. In 2001, Prolog Ventures was selected as the fund manager, and almost doubled the state's investment.²⁵

Through the efforts of community leaders, there has been a substantial increase in venture capital in the St. Louis region. By August 2004, about \$400 million had been raised in four local-managed venture capital funds dedicated to biotech and medical companies. In early 2004, a small "seed" fund – the BioGenerator – was established with philanthropic contributions from local foundations to provide proof-of-concept funding to life and plant science start-ups. In late 2004, the Vectis Fund, a State "fund-of-funds", was expected to reach \$100 million over the next several years. In 2004, the Danforth Foundation also announced it was devoting 60% of its uncommitted assets – about \$124 million – to the region's plant and life sciences cluster.

Local infrastructure developments added to the mix of public and private technology support. The Center of Research, Technology and Entrepreneurial Experience (CORTEX) is developing a research and development district located in mid-town St. Louis that encompasses the two major medical schools. CORTEX is a non-profit collaboration of Washington University, Saint Louis University, Missouri Botanical Garden, Center for Emerging Technologies, BJC Health Care System, RCGA, Civic Progress, City of St. Louis, and University of Missouri-St. Louis (UM-St. Louis). The three universities and BJC Health Care System are contributing \$29 million to the effort, and the State has committed \$12 million in tax credits over five years to help with land assembly. There are also plans to build a multi-tenant office and wet lab facilities near the Donald Danforth Plant Science Center and Nidus Center.

Networking in St. Louis, particularly in the life sciences area also has substantially increased. In the 1990's, there were several events per month, mainly sponsored by Technology Gateway²⁶; by spring 2004, there were many times that amount. These events were sponsored by numerous organizations including the Donald Danforth Plant Science Center that hosts daily seminars, Technology Gateway Alliance that holds monthly cluster group meetings, the Washington University Medical School, Center for Emerging Technologies, Missouri Venture Forum for Entrepreneurs, Missouri State BIO (MOBIO), and others.

²⁵ Because the State ultimately funded \$17 million, the total amount from the State matched by Prolog Ventures totaled \$34 million.

²⁶ Technology Gateway is the Science & Technology Council of the St. Louis Chamber & Regional Growth Association.

THE STATS

By early 2004, Washington University researchers had developed over 150 NIH-funded inventions, with approximately half of these being licensed to private companies through exclusive or non-exclusive agreements.

- Office of Technology Management

In 2004, *U.S. News & World Report* rated Washington University's School of Medicine second in the nation, and rated 17 Washington University graduate and professional programs in the top-10. R&D expenditures in FY 2003 totaled \$474 million, with about 80% going to the Medical School. Washington University was one of the highest recipients of federal R&D funding in 2003, ranking third after Johns Hopkins University and Stanford University. NIH and NSF funding composed most of Washington University's federal R&D expenditures.

In FY 2003, the Office of Technology Management (OTM) doubled their licensing revenue to \$12.8 million. The Director of the OTM attributed the increase to "hard work, getting a home run, and the competence that has been built over the last several years." OTM executed 41 licenses, and had 1,463 active licenses. They launched three start-ups.

From FY 1999-2001, the latest comparable data available, when normalized to account for R&D expenditures, Washington ranked in the first quartile for new licenses (16/173) and active licenses (8/163). They placed in the second quartile for new patents awarded, license income, and start-ups.

TECHNOLOGY TRANSFER AND COMMERCIALIZATION

Started in 1985, the Office of Technology Management (OTM) at Washington University until recently did not have the resources and administrative support to mount a competitive technology transfer program. In the late 1990's, technology transfer began to take on greater importance, and since 2001 the service-oriented approach of the OTM has resulted in a stronger commercialization outcomes and return to the University. In large part, this change reflected the approach to technology licensing of Mark Wrighton, the Chancellor of Washington University. Dr. Wrighton joined Washington University in the late 1990's, coming for a previous position as MIT's Provost. He brought with him the MIT philosophy that academic excellence and an entrepreneurial culture could co-exist. The University leadership recruited Michael Douglas to head the OTM because of his combined academic and entrepreneurial backgrounds. This included credentials as an academic investigator, Professor of Biochemistry and Department Chair, and experience as the corporate head of a multinational company and founder and CEO of several small pharmaceutical companies. Dr. Douglas restructured OTM to make it part of the Office of the Vice Chancellor for Research in order to increase its visibility and support within

the University as well as increase its visibility in the community. The OTM Director reports to the Vice Chancellor of Research.

The noblest part of our mission is to start new technology businesses and transform the economy of this region from one based on traditional manufacturing, which is currently declining in St. Louis, to one based on the technical strength that is unique to our region.

- Michael Douglas, Director, Office of Technology Management

OTM focuses commercialization activities in eight areas: (a) genomics, (b) therapeutics, (c) clinical chemistry, (d) biotechnology research materials, (e) plant sciences, (f) electronics, (g) telecommunications, and (h) computer science and engineering. The Office's 12 professionals specialize in one of two major disciplines – biomedical/biotechnology or physical sciences. Within the two disciplines, professionals are functionally divided into three categories: (a) Business Development Managers who are the team leaders, (b) Licensing Case Coordinators that provide support to the managers, and (c) database administrators. In addition, OTM has recently been reorganized to leverage technology information that can be found in the University's research database and through extranet business transactions. The Business Development Managers are trained in specific technology as well as functional areas that facilitate structuring technology licensing deals. Each Business Development Manager is responsible for cases involving 300-400 faculty members, which is higher than most peer institutions. This responsibility involves learning about faculties' research, and encouraging and guiding the submission of invention disclosures. The Business Development Managers also work with industry contacts to find licensing partners for faculty patents. The OTM professionals all hold advanced degrees in the biological sciences or engineering and have at least five years experience in business; two are attorneys who have worked for pharmaceutical or device companies.

As soon as the faculty or researcher receives research funding, an OTM business development manager contacts the researcher to discuss potential invention opportunities. Our ideal situation is to work with the principal investigator as soon as they get funding ... not to wait until they're about to publish a paper.

- Michael Douglas, Director, Office of Technology Management

OTM tracks all patent prosecution, materials transactions, licensing agreements, and revenues through a central database. When faculty members submit invention disclosures, patents, materials transfer transactions, and industrial research agreements the transactions are recorded in a database at OTM (as part of the Office of Research). The OTM currently processes and tracks at least one new transaction each hour in this database. OTM also uses the database to market its inventions to industry. It is the responsibility of the Business Development Managers

to mine the database for promising inventions and to commercialize these with an appropriate industrial partner. Most commercialization activity is in the form of exclusive or non-exclusive licensing agreements with a company or other institutions. Case Coordinators track patent applications and agreements and keep Business Development Managers and researchers apprised of progress. The increased demands of technology transfer tracking and marketing functions have led to the creation of new database programs that are now entering the market. Washington University is currently transferring to one of these new systems. OTM's Director considers a "marketing friendly" database and its use by Business Development Managers as "the heart and soul" of the OTM operation.

OTM has become pro-active in working continuously with the capital investment community, local seed funds, and technology incubators, and keeps them informed about promising new technologies emerging from the University. Through the efforts of the Chancellor, Washington University has developed a small seed fund, the "Bear Cub Fund" to assist in the funding of proof-of-concept work within the University prior to company formation. OTM also works closely with the venture capital community in St. Louis and throughout the country. It holds workshops and conferences such as "Tech Connect" that attracts more than 400 people annually including technology firms, service providers, and investors. OTM works particularly closely with the two major incubators – the Center for Emerging Technology and the Nidus Center, and the pre-seed program – Bio-Generator. (Each of these programs is described later in this case study.)

Started in November 2003, the Research Alliance of Missouri (RAM) provides technology transfer outreach to the State. RAM has developed a database of technologies in smaller universities and colleges in the State, and when fully operational, Washington University's OTM will coordinate the evaluation and marketing of these opportunities. Fifteen universities in the State are involved in the program. The State supports this pilot program with modest annual funding.

RELATED ENTREPRENEURSHIP ACTIVITIES

OTM has particularly close relations with the Olin School of Business' Skandalaris Entrepreneurship Program (SEP), named for its benefactor. SEP activities began in 1988 with the creation of the Olin Cup – Washington University's business plan competition. In 1991, the Olin School of Business also started the Olin Center for Experiential Learning (CEL) to promote "hands-on" learning and consulting in entrepreneurship, corporate, international and community projects. The program targets learning and research in: (a) corporate innovation, (b) application and commercialization of early-stage science, and (c) bootstrap ventures. Through CEL, MBA students conduct valuation and marketing assessments on behalf of potential licensees working with OTM. Students receive academic credit and the University covers related out-of-pocket expenses. By spring 2004, 20 students had worked with OTM, several of whom were subsequently hired by start-up businesses. OTM also works with the School of Law and has created a clinic for second year law students who, under the supervision of qualified attorneys, work on patenting aspects of University inventions.

The younger people coming into universities these days are savvy – they want opportunities to work with industry and start businesses.

- Duke Leahy, former Director, Office of Technology Management

Major entrepreneurship programs administered by SEP are:

- The Olin Cup Competition – is a \$50,000 competition that establishes teams to develop business plans on new ventures. Teams are comprised of students and faculty, often from several departments, and experts from the community. Teams attend in-depth workshops and external mentors provide advice to teams.
- The Entrepreneurship Practicum – is a consulting course in which student teams are matched with client companies to perform projects proposed by the company. The teams execute work plans that sometimes involve OTM start-ups.
- The Boeing Corporate Innovation – sponsored by Boeing, MBA students support selected spin-out and spin-in ventures using Boeing Intellectual property to start new companies or business units.
- The Entrepreneurial Internship Initiative – students serve as management team members in early-stage ventures, newly formed venture capital firms, or private equity firms. Supported by the Kauffman Foundation, this program allows students to gain experience in start-up ventures and equity firms, and benefits the firms that could not otherwise afford this type of assistance.

Two University seed capital funds also provide capital for University innovations. The Bear Cub Fund was started in 2003 by Washington University to increase awareness and prompt faculty to submit invention disclosures to OTM. The Fund provides \$250,000 in grants each year to five or six faculty inventors. OTM screens applicants and a board involving faculty and business leaders makes the final selection. The Office of Research administers the program. By May 2004, the Fund had launched three companies that raised an additional \$3 million. Hatchery Seed Capital Fund is a \$1 million investment fund managed by SEP. The Fund targets student-initiated ventures. Its investment board is composed mainly of external experts.

CENTER FOR EMERGING TECHNOLOGIES

Since 1998, the Center for Emerging Technologies has helped start 17 companies. Its tenants have attracted more than \$250 million in venture capital, corporate contracts, and research grants.

- *Center for Emerging Technologies*

Located just three blocks from Washington University, the Center for Emerging Technologies (CET) is a national award-winning incubator.²⁷ At the urging of the late Governor Mel Carnahan, the Missouri Department of Economic Development hired Marcia Mellitz as a consultant to develop strategies that led to the creation of CET. (Ms. Mellitz subsequently became President of CET.) CET was designed to create new technology businesses in the St. Louis area. Monsanto also was a strong advocate for the Center. In order to develop the Center, the Chancellor of Washington University hired the Center President and paid her from the University's discretionary funds. The University initially provided office space, administrative support and other in-kind assistance to support Center development. The University of Missouri-St. Louis and Washington University were intended to operate the Center, but the universities decided to incorporate the Center as an independently operated, non-profit organization.

Using Community Development Block Grants (CDBG), the City of St. Louis purchased a building located strategically between Washington University's Medical School and St. Louis University's main campus (the University of Missouri Medical School also is about one mile from the Center). Originally an old warehouse, the building was renovated using \$3.5 million from an EDA grant and matching State tax credits. A couple years later, the City purchased and renovated a second warehouse, and there is a walkway that now connects the two buildings. Total purchase and renovation costs for the two buildings were about \$16 million. In addition to CDBG and EDA grants, the Center benefited from the State's Small Business Incubator Tax Credit Program. This Program offers tax credits up to 50% for a contribution to a State certified incubator by an eligible donor. Additional loans and investments from private corporations and foundations also helped develop the Center.

The first Center building opened in June 1998, and the second opened in August 2001. Together the buildings offer 92,000 square feet of wet, semi-wet, and other laboratories, assembly-type production space, office space, conference rooms, and classroom facilities. The Center's space is fully occupied. Since its inception, about 21 businesses including biotech, diagnostics and therapeutics, medical instruments, medical devices, and engineering-based companies have occupied the incubator facilities; 13 firms are current residents. Firms vary in scope and size from one to 100 employees. In order to be accepted to the incubator, firms must have some connection to the universities. Several Washington University faculty members have founded

²⁷ In 2003, the Center for Emerging Technologies was named one of the top 10 incubators in the nation by the National Business Incubation Association.

firms that have located in the incubator. Current resident firms are working with the University Medical Schools and Washington University's engineering school.

The Center's three full-time professionals offer a wide array of flexible, hands-on service to incubator firms. The Center sponsors seminars for technology entrepreneurs taught by faculty and researchers. Participants who attend the seminars can receive continuing education credit. Interns from Saint Louis University assist in the logistics of the training courses as well as conduct market research for the Center's entrepreneurs. The Center also sponsors a two-day SBIR conference and monthly breakfast meetings for information and networking.

The Center recently started a CEO Roundtable for entrepreneurs. The first one was devoted to life sciences entrepreneurs; additional CEO Roundtables in the future will focus on other clusters. The CEO Roundtable is intended to mix large and medium-sized businesses with entrepreneurs, and to provide them with peer support. The Center also plans to start a mentoring program using successful entrepreneurs as mentors to resident firms.

There is much peer support within the Center and a willingness of firms to share their resources and technical advice. Two serial entrepreneurs who have firms in the incubator have been especially helpful to the new entrepreneurs. We try to encourage this type of peer support and networking in everything we do.

- Marcia Mellitz, President, Center for Emerging Technologies

In order to provide resident firms with additional networking, business assistance and capital, the Center has formed close relationships with Technology Gateway, Coalition for Plant Life Sciences, Bio-Generator and other local groups. The Center works closely with the University technology transfer offices, and with the Skandalaris Entrepreneurship Program at Washington University. The Center Board includes Washington University's Dean of Engineering, Dean of the Medical School, Vice President for Facilities, Chancellor, and Vice Chancellor for Research.

Ms. Mellitz, the Center President, has been active with other community leaders in establishing and attracting early-stage investment capital for the community. Ms. Mellitz said that creating more seed capital has been critical to the success of the Center's firms.

NIDUS CENTER

Started in 2000, the Nidus Center is owned by the Monsanto Corporation and operated by a non-profit corporation completely funded by Monsanto and governed by a separate national Board of Directors. The Nidus Center's three full-time staff members are Monsanto employees. Monsanto's aim in establishing the Center was to help St. Louis become a world-class center for the Plant and Life Sciences. The 41,000 square foot Center was built in 1999 at a cost of \$10.5 million. Under the direction of Robert Calcaterra, CEO and President, the Center assists a range

of plant and life science companies that includes medical services, drug discovery, plant biotechnology, and medical devices.

The Center is located on the grounds of Monsanto world headquarters and is across the street from the Donald Danforth Plant Science Center, a private research institute. According to Dr. Calcaterra there is constant interaction between the two Centers, and the CEO of the Plant Science Center is on the Nidus Board. Moreover, companies in the Nidus Center attend frequent seminars, and can use the laboratory instruments and green houses of the Plant Science Center as well as Monsanto's license and waste removal services. Employees of client companies in the Nidus Center also have access to Monsanto's fitness and childcare facilities.

Most of Nidus' incubation firms are headed by scientists who have come from local research institutions or who have developed technologies independently, and several companies have been attracted from other parts of North America. The Nidus Center has two CEO's-in-Residence who are provided with free rent in exchange for helping other firms in the incubator. Two of the past CEO's-in-Residence have become CEO's of Nidus Center incubation firms.

The Nidus Center Director works with the technology transfer offices of Washington University and Saint Louis University. The CEO and President said that he and others in the community have devoted considerable time assisting local venture firms raise money and recruiting venture capital firms for St. Louis entrepreneurs, making frequent trips to San Francisco, Chicago, and North Carolina. The Center has a very close relationship with Prolog Ventures, and Nidus has helped raise about \$70 million for the Center's firms. He also championed the creation of the BioGenerator and has provided leadership in creating the InvestMidwest Venture Forum and attracting BIO Mid-America Venture Forum to St. Louis. He is active in Technology Gateway on its executive committee, Missouri BIO, The Plant and Life Sciences Coalition Executive Committee and Chairs the Missouri Venture Capital Roundtable and is on the Missouri Technology Corporation Board.

The Nidus Center has stringent selection criteria, choosing about 3% of companies that apply. Since its start, the Nidus Center has had 14 companies; three have graduated, three have failed, and three will graduate in 2005. In summer 2004, there were eight companies in the incubator. In order to retain expanding firms from the incubator, there is a community effort to build accelerator facilities across the street from the Nidus Center on the Plant Science Center site.

BIOGENERATOR

The BioGenerator is a "virtual technology transfer and commercialization center". It is designed to provide entrepreneurial assistance and seed capital to new life science start-up companies in the St. Louis region. It will provide deal flow for locally managed life science venture capital funds, and the two major incubators – the Nidus Center and CET. Started in October 2003, BioGenerator was funded with almost \$6 million of institutional support from the Danforth

Foundation, James S. McDonnell Family Foundation, Monsanto Foundation, and Bunge North America.²⁸

BioGenerator's annual operating budget is about \$1.4 million with two-thirds being directly invested in start-up companies. The staff is composed of a President and CEO, a half-time professional staff member who is responsible for due diligence on prospective clients, an administrative assistant, and part-time MBA interns from Washington University. The interns help conduct due diligence and provide market research, grant writing, business plans, financial projections, and other support for client companies. BioGenerator's Board includes John McDonnell from the McDonnell Foundation, Donald Rubin from the Life Sciences Coalition (representing the Danforth Foundation), presidents of the two life science incubators, the heads of the technology transfer offices at Saint Louis University and Washington University, and a representative from the RCGA.

BioGenerator invests a maximum of \$250,000 in each client company and provides an additional \$100,000 to \$200,000 of services and management support. The BioGenerator takes equity for both its cash and services. Patricia Snider, President and CEO, said her goal is to invest in about 20 start-ups in four years. She said most often the \$250,000 provided by BioGenerator is not sufficient to accomplish milestones necessary for the next round of funding, and therefore, BioGenerator often approaches angels or other small funds to co-invest.

BioGenerator works closely with the two incubators – CET and Nidus Center. CET offers wet lab space to BioGenerator clients, as well as access to their resource networks and business assistance programs. BioGenerator also works closely with the technology transfer offices at Washington University, Saint Louis University, and University of Missouri, St. Louis. The technology transfer offices assist BioGenerator by identifying potential technologies and faculty who may be prospective clients for the BioGenerator. These types of relationships allow the BioGenerator to operate with a minimum budget for administration and to invest a maximum portion of their budget directly to companies.

BioGenerator's goal is to create 'fundable' companies. We view venture capital firms as our customers and spend time talking with them about their expectations as well as our criteria for viable candidates.

- Patricia Snider, President & CEO

Candidates for the BioGenerator include incorporated companies that may or may not have received prior funding and may not have started operations. Pre-funding valuation for these companies is generally less than \$2 million. In some cases, a researcher or a technology transfer office may approach BioGenerator about starting a new company in which they would play role, but not be the driving force. In these situations, BioGenerator will found the new company and take a greater share of the equity.

²⁸ CORTEX (Center of Research, Technology and Entrepreneurial Expertise) directly provides BioGenerator's funding which comes from local foundations and is leveraged by state tax credits.

A candidate goes through several stages before being awarded funding. If a firm passes the basic screening criteria, it proceeds to an evaluation phase where the firm is invited to make a formal presentation to BioGenerator staff and relevant consultants. It then proceeds to formal due diligence in which staff examines intellectual property, market opportunities, management, risk and other factors. In the next stage, firms that receive high marks in the due diligence phase make formal presentations to a Venture Capital Advisory Board. The Board is composed of seven venture capital funds that invest in early-stage life science firms in the Midwest. The Board provides feedback to BioGenerator and the candidate firm about issues that must be addressed and milestones that must be met to make the firm a viable candidate for a Series A venture capital funding.

Based on the input from the Venture Capital Advisory Board, BioGenerator works with the firm to develop a plan that addresses gaps and establishes milestones, timelines, and funding requirements. This becomes the basis for negotiating a term sheet with the candidate company. Finally, the Operations Committee, a subcommittee of the Board, reviews the proposed investment, development plan, and term sheet and has full authority to release funds. BioGenerator's funds cannot be used for patent reimbursement or licensing fees with universities. However, some creative solutions have been found. In one case, the university agreed to take \$150,000 in equity for licensing fees over three years and invested an additional \$100,000 from their endowment fund to help the firm pay for previous, on-going, and future patent work.

BioGenerator plans to provide entrepreneurs with substantial and flexible assistance to meet their needs and achieve success – everything from helping them set up payroll services and employee benefits to bookkeeping, market research, and most importantly, helping them find follow-on funding. BioGenerator also has established a network of preferred providers who give discounted services to client companies.

From October 2003 until August 2004, 47 firms have been referred to the BioGenerator and 28 were invited to present for a initial evaluation. Of these, BioGenerator initiated due diligence on 16 companies, with 9 making the grade for presentation to the Venture Capital Advisory Board. From the nine presented to the Board, five investment proposals with term sheets were presented to a subcommittee of BioGenerator's Board. As of August 2004, two deals had been closed and a third one was in process. Most of the entrepreneurs who apply to the BioGenerator were referred by venture capitalists, the incubators, or by the technology transfer offices at local universities. Ms. Snider said that the strongest candidates have been those already screened by incubators and universities.

PROLOG VENTURES

Through the New Enterprise Creation Act, the Missouri State Legislature set aside \$20 million in tax credits for early-stage capital to be administered by a private fund manager. About 15 firms applied, and Prolog Ventures was selected. According to Brian Clevinger, the Fund Manager, Prolog Ventures was selected because: (a) Directors all had extensive careers in life sciences, (b)

the Fund promised to raise an additional \$20 million, and (c) their focus on transferring biotech innovations from Washington University. Because of State budget cuts, the Fund was capitalized at a total of \$34 million. Prolog A was formed using the original State funds; and Prolog B was formed using private funds in order to allow investments outside the State. According to the Managing Partner, the Fund's ability to invest outside of the State has been important in leveraging additional investment. Investments are restricted to life science firms.

By spring 2004, Prolog Ventures had invested \$15 million, leveraging \$100 million in total investments, a 7:1 leverage.

- Prolog Ventures

Seventy percent of the matching funds came from institutional investors including: Monsanto Corporation, Danforth Foundation, Carpenter's Union Pension Trust Fund, Stifel Financial Corporation, Alafi Capital, and university endowments from Washington University, University of Missouri, and Saint Louis University. Thirty percent of the matching was raised from high net worth individuals such as the John McDonald family (McDonald Douglas).

Typically when a fund is started there is a lead investor. Mr. Clevinger said that local investors were nervous about investing in the new fund until the Washington University Endowment took the lead by investing \$4 million. After the initial University investment, the Danforth Foundation and others invested. Mr. Clevinger believes that tax credits are a "pretty painless" way for the State to invest, particularly when the fund is equally matched with private monies. He said that non-profit organizations and out-of-State investors were able to sell the investment tax credits to banks and receive 90% of their worth. Washington University sold the credits to the banks and invested in this way.

At least two of the companies in which we invested would have located in other states but stayed in Missouri because of the Prolog Ventures' investment and the availability of wet lab incubators at the Nidus Center and the Center for Emerging Technologies.

- Brian Clevinger, Managing Partner

The Fund's three partners handle about three to four companies at one time. Two of the partners have run early-stage companies and early-stage funds. The Fund began to invest in November 2001, and by spring 2004, a total of \$15 million had been invested in 11 firms, nine in St. Louis and two out of state. The \$15 million investments leveraged over \$100 million from outside investors – 7:1 ratio. The State of Missouri has an oversight Board – the Missouri Seed Capital Board. The Managing Partner said that the Board stays out of investment decisions, and this is critical to the efficient operation of the Fund.

Mr. Clevinger said the strong technology base of Washington University has been key to Prolog's investments. Although no direct deals have come from Washington University, most

have had some linkage to the University. He said the two excellent incubators also have been very important to their efforts – out of the nine investments in St. Louis, four have been placed with firms at the Nidus Center and three with firms in the Center for Emerging Technologies. Mr. Clevinger sits on the boards of both incubators.

At the writing of this report, Prolog Ventures was about to raise another seed fund with a capitalization goal of about \$100 million, part of which the partners hoped to evolve into a regional fund. The partners also were trying to establish an angel network. They now work with several angel investors most of whom are outside the State.

LESSONS LEARNED

Champions can be Critical to Launch Economic Initiatives

In St. Louis, William Danforth, former Chancellor of Washington University, led the way to make St. Louis one of the top life sciences regions in the nation. He solicited the help and involvement of other prominent business leaders who together funded and attracted investments in major R&D and business development initiatives. St. Louis in a few short years greatly increased federal R&D expenditures and investment capital and is now starting to show the results of these efforts through its growing life sciences industry.

Private Sector Leaders can be Powerful Advocates

Private sector leaders took a lead role in St. Louis by establishing research institutes such as the Donald Danforth Plant Sciences Center and incubators such as Monsanto's Nidus Center. Private firms and foundations also heavily contributed to investment funds and innovative pre-seed efforts such as Bio-Generator in addition to advocating for State seed capital and incubator initiatives.

Multiple Technology Initiatives can be Implemented Simultaneously

Technology-based development initiatives were launched in St. Louis on several fronts simultaneously. This included university activities to increase R&D expenditures, State and private sector establishment of incubators, State and private sector creation of seed and pre-seed funds, and local infrastructure development.

Strong Linkages Between Seed Capital Funds and Incubators Leverage Resources

Through close relationships, the Bio-Generator and the Center for Emerging Technologies leverage each other's resources. The Center screens clients and builds management capabilities, making clients a better risk for Bio-Generator investment. Bio-Generator, in turn, provides critically needed seed and "pre-seed" capital to start-ups, making them stronger candidates for the Center. Close relationships between the Nidus Center, Bio-Generator and Prolog Ventures also effectively leverage each entity's resources.

APPENDIX A

Connecticut Technology Transfer & Commercialization Advisory Board of the Governor's Competitiveness Council

Advisory Board (in alphabetical order)

Bruce D. Alexander, Vice President & Director of New Haven-State Affairs, Yale University

Victor Budnick, President & CEO, Connecticut Innovations

John F. Cassidy, Jr., Senior Vice President of Science and Technology, United Technologies Corporation

Peter R. Farina, Ph.D., Vice President of Development, Boehringer Ingelheim Pharmaceuticals, Inc.

Susan Froshauer, Ph.D., President & CEO, Rib-X Pharmaceuticals

Louis Hernandez, Jr. – *Chairperson*, Chairman & CEO, Open Solutions, Inc.

William J. Kaufmann, Senior Advisor, Connecticut Department of Economic and Community Development

Ravi Kiron, Ph.D., MBA, Global Head, Strategic Analysis & Knowledge Management, Pfizer Global R&D

Michele M. Macaуда, President & CEO, SBC

Frank J. Marco, Esq., Partner, Wiggin and Dana

Fred J. Maryanski, Interim Provost & Executive Vice President for Academic Affairs, University of Connecticut

Martha Matteo, Ph.D., Director, Knowledge Management and R&D Planning, Boehringer Ingelheim Pharmaceuticals, Inc.

Samuel F. McKay, General Partner & Co-Founder, Axiom Venture Partners

John D. Petersen, Ph.D., President, University of Tennessee, and Former Provost and Executive Vice President for Academic Affairs, University of Connecticut

Elaine A. Pullen, President, Gerber Scientific Products Inc.

Connecticut Technology Transfer and Commercialization Advisory Board of the Governor's Competitiveness Council (*continued*)

Jennifer Smith Turner, Deputy Commissioner, Connecticut Department of Economic and Community Development

Zulma Toro-Ramos, Ph.D., Dean, School of Engineering and Applied Sciences, University of New Haven

Joseph E. Wall, Ph.D., Senior Vice President & Chief Technology Officer, Pitney Bowes Inc.

Expert Panel

Bruce Carlson, Special Assistant for Economic Development, University of Connecticut

Michael Newborg, Ph.D., Executive Director, Center for Science & Technology Commercialization, University of Connecticut

Jon Soderstrom, Managing Director, Office of Cooperative Research, Yale University

Rita Zangari, Executive Program Director, University of Connecticut Technology Incubation Program

Cluster Representatives and Staff

Matthew Nemerson – *Cluster Representative*, President & CEO, Connecticut Technology Council

Paul R. Pescatello – *Cluster Representative*, President & CEO, CURE

Oley Carpp – *State Representative*, Managing Director, Industry Cluster and Business Recruitment Division, Connecticut Department of Economic and Community Development

Jeff Blodgett – *Economic Advisor*, Vice President of Research, Connecticut Economic Resource Center

Alissa K. DeJonge – *Project Manager*, Economist, Connecticut Economic Resource Center

APPENDIX B

NATIONAL ADVISORY GROUP

(in alphabetical order)

Richard A. Bendis, President & CEO, Innovation Philadelphia Inc.

Daniel Bergland, Executive Director, State Science and Technology Institute

Jay Brandinger, Ph.D., Former Executive Director, New Jersey State Science Commission

Denis Gray, Ph.D., Professor, North Carolina State University

Patricia Green, Ph.D., Dean, Undergraduate Studies, Babson College

Wayne Hodges, Associate Vice Provost for Economic Development & Technology Ventures, Georgia Institute of Technology

Robert Heard, President, Edge Development Capital, Inc. and Former President, National Association of Seed and Venture Funds

Philip Singerman, Ph.D., Executive Director, Maryland Technology Development Corporation and former Assistant Secretary, U.S. Economic Development Administration

Teri Willey, Ph.D., Managing Partner, ARCH Development Partners and Former President of the Association of University Technology Managers

APPENDIX C

EXEMPLARY UNIVERSITIES BY SELECTION CRITERIA

Univ.	Public	Private	Bio-tech	IT/Soft-ware	Entrep. Links	New Patents 1-2 Q	New Licens 1-2 Q	Total Active Lic. 1-2 Q	Start-ups 1-2 Q	Total R&DS 1-2 Q
Cambridge		✓	✓	✓	✓	N/A	N/A	N/A	N/A	N/A
CMU		✓		✓	✓	✓	✓	✓	✓	✓
Georgia Tech	✓			✓	✓			✓	✓	✓
Purdue	✓			✓	✓		✓	✓	✓	✓
Wash U		✓	✓		✓	✓	✓	✓		✓
U Wisc-Madison	✓		✓		✓	✓	✓	✓		✓
Stanford		✓	✓	✓	✓	✓	✓	✓	✓	✓
UCSD	✓		✓	✓	✓	N/A	N/A	N/A	N/A	✓

APPENDIX D

**Carnegie Mellon University
(FY 1999-2001)**

Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	39	1st	.198 ^a	84
New Licenses (N=173)	59	2nd	.146 ^b	62
Total Active Licenses (N=173)	71	2nd	6.21 ^c	88
License Income (N=174)	48	2nd	2.39% ^d	\$10,164,846
Start-ups Formed (N=173)	21	1st	.918 ^e	13

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

**Georgia Institute of Technology
(FY 1999-2001)**

Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	109	3rd	.095 ^a	83
New Licenses (N=173)	136	3rd	.057 ^b	50
Total Active Licenses (N=173)	83	2nd	5.28 ^c	154
License Income (N=174)	79	2nd	1.16% ^d	\$10,122,609
Start-ups Formed (N=173)	44	2nd	.583 ^e	17

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

Massachusetts Institute of Technology (FY 1999-2001)				
Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	7	1st	.366 ^a	469
New Licenses (N=173)	20	1st	.246 ^b	316
Total Active Licenses (N=173)	10	1st	18.25 ^c	780
License Income (N=174)	12	1st	9.39% ^d	\$120,538,532
Start-ups Formed (N=173)	8	1st	1.802 ^e	77

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

Purdue University (FY 1999-2001)				
Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	127	3rd	.078 ^a	56
New Licenses (N=173)	15	1st	.314 ^b	225
Total Active Licenses (N=173)	31	1st	11.52 ^c	275
License Income (N=174)	103	3rd	0.80% ^d	\$5,759,000
Start-ups Formed (N=173)	23	1st	.796 ^e	19

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

Stanford University (FY 1999-2001)				
Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	28	1st	.217 ^a	297
New Licenses (N=173)	13	1st	.336 ^b	459
Total Active Licenses (N=173)	7	1st	23.81 ^c	1,085
License Income (N=174)	16	1st	7.39% ^d	\$101,057,355
Start-ups Formed (N=173)	27	1st	.724 ^e	33

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

**University of Wisconsin – Madison
(FY 1999-2001)**

Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	57	2nd	.152 ^a	252
New Licenses (N=173)	32	1st	.212 ^b	351
Total Active Licenses (N=173)	37	1st	10.48 ^c	579
License Income (N=174)	30	1st	3.91% ^d	\$64,862,497
Start-ups Formed (N=173)	98	3rd	.235 ^e	13

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

Washington University (St. Louis) (FY 1999-2001)				
Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	53	2nd	.159 ^a	172
New Licenses (N=173)	16	1st	.285 ^b	309
Total Active Licenses (N=173)	8	1st	22.79 ^c	824
License Income (N=174)	51	2nd	2.12% ^d	\$22,990,252
Start-ups Formed (N=173)	121	3rd	.166 ^e	6

^a New patents per \$1 million research expenditures.

^b New licenses/options awarded per \$1 million research expenditures.

^c Active licenses/options per \$10 million research expenditure, 2001 only

^d Total license income as a percent of total research expenditures.

^e Start-ups formed per \$1 million average research expenditure.

Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

**University of Pennsylvania
(FY 1999-2000)**

Measure	Rank	Quartile	Ratio to Research Expenditures	Total
New US Patents Awarded (N=174)	55	2nd	.155 ^b	132
New Licenses (N=173)	62	2nd	.0141 ^c	120
Total Active Licenses (N=173)	92	3rd	4.88 ^d	187
License Income (N=174)	35	1st	3.45% ^e	\$29,477,392
Start-ups Formed (N=173)	81	2nd	.281 ^f	12

^a AUTM Licensing Survey data for the University of Pennsylvania is available for 1999 and 2000. Ratios are based on 2000 expenditure data only.

^b New patents per \$1 million research expenditures.

^c New licenses/options awarded per \$1 million research expenditures.

^d Active licenses/options per \$10 million research expenditure, 2001 only

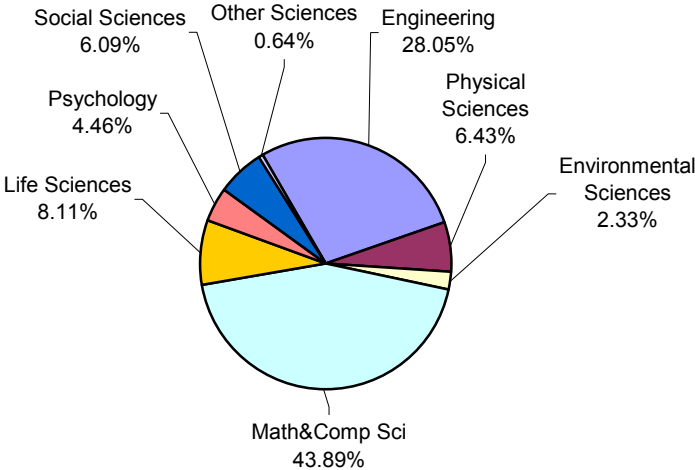
^e Total license income as a percent of total research expenditures.

^f Start-ups formed per \$1 million average research expenditure.

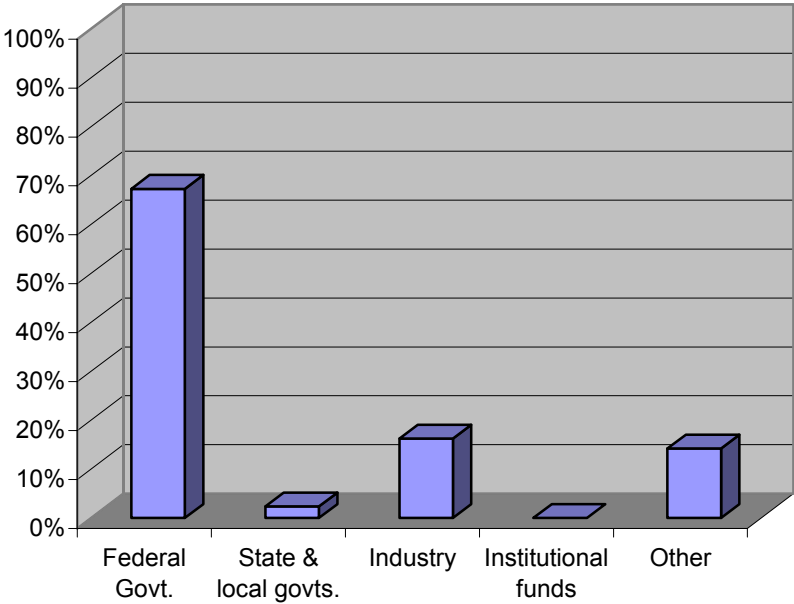
Source: Prepared by the Technology Commercialization Group LLC based on data from the FY 1999, 2000, and 2001 AUTM Licensing Survey™, and Academic Research and Development Expenditures for FY 1999, 2000, and 2001. Tables B-36 and B-37. National Science Foundation 2001, 2002, and 2003.

APPENDIX E

Carnegie Mellon University R&D Expenditures by Science and Engineering Field: FY2001

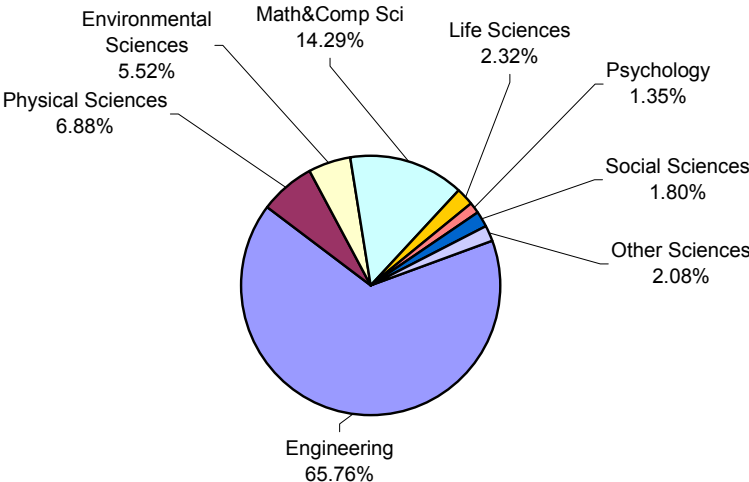


Carnegie Mellon University R&D Expenditures by Source of Funds: FY2001

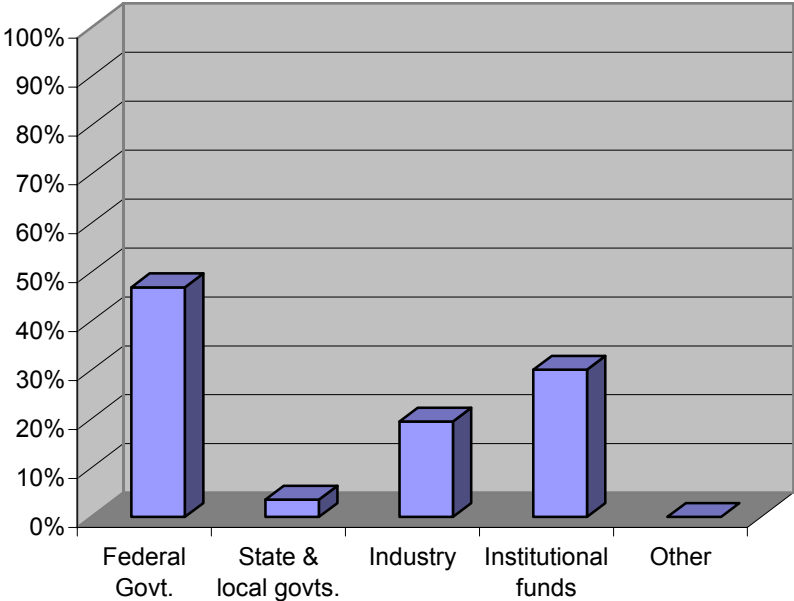


Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
Note: Total R&D Expenditures = \$144,882,000.

Georgia Institute of Technology R&D Expenditures by Science and Engineering Field: FY2001

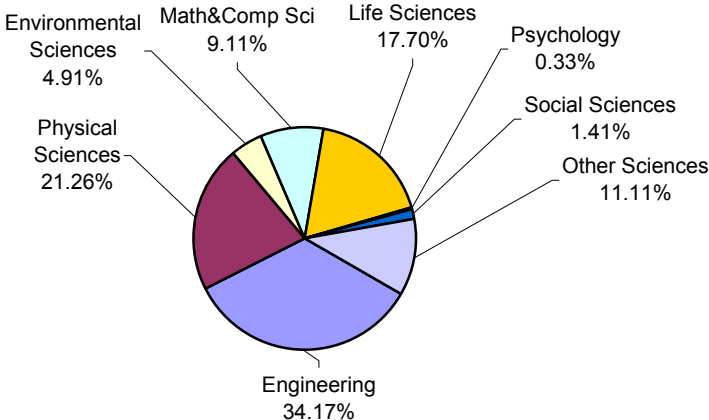


Georgia Institute of Technology R&D Expenditures by Source of Funds: FY2001

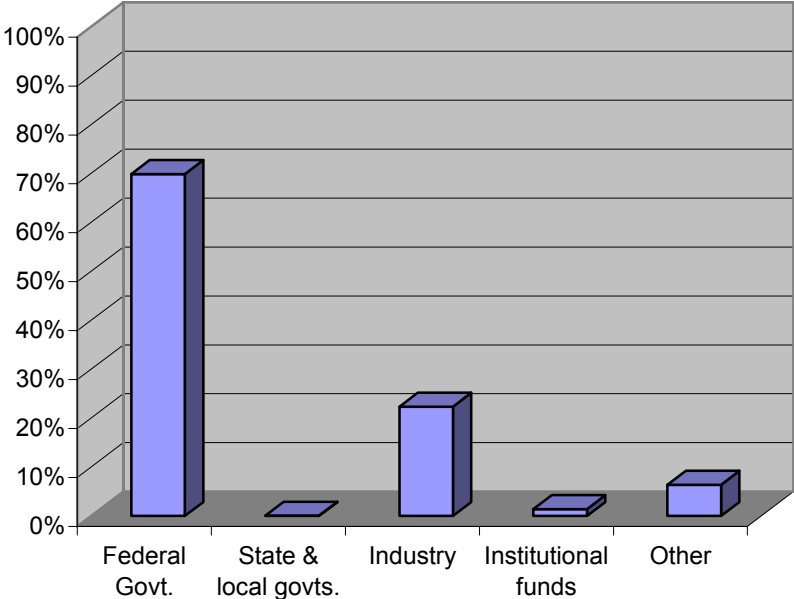


Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
Note: Total R&D Expenditures = \$306,533,000.

**Massachusetts Institute of Technology
R&D Expenditures by Science and Engineering Field: FY2001**

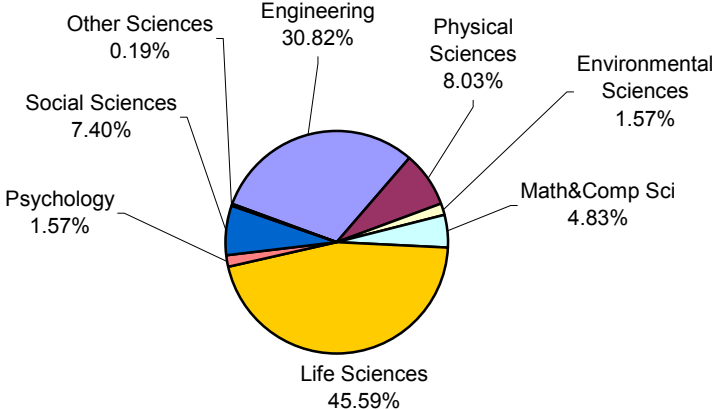


**Massachusetts Institute of Technology
R&D Expenditures by Source of Funds: FY2001**

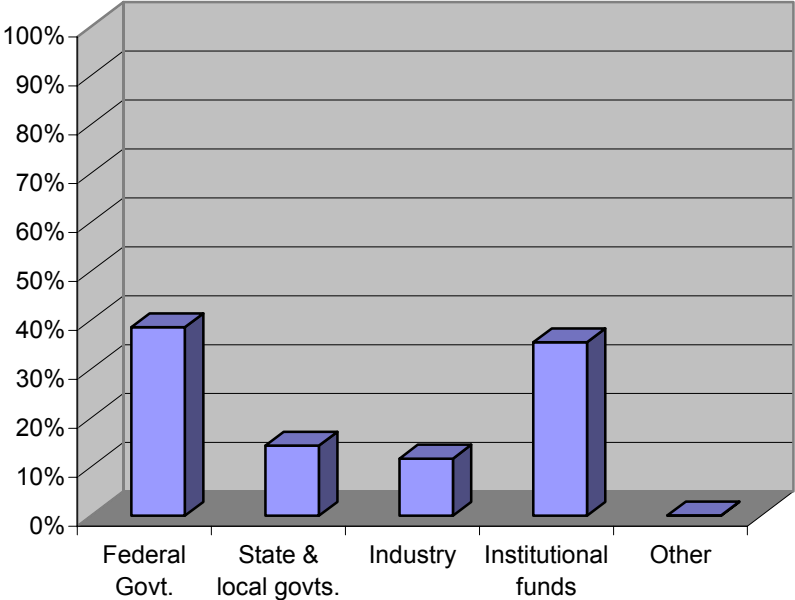


Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
Note: Total R&D Expenditures = \$435,495,000.

Purdue University R&D Expenditures by Science and Engineering Field: FY2001



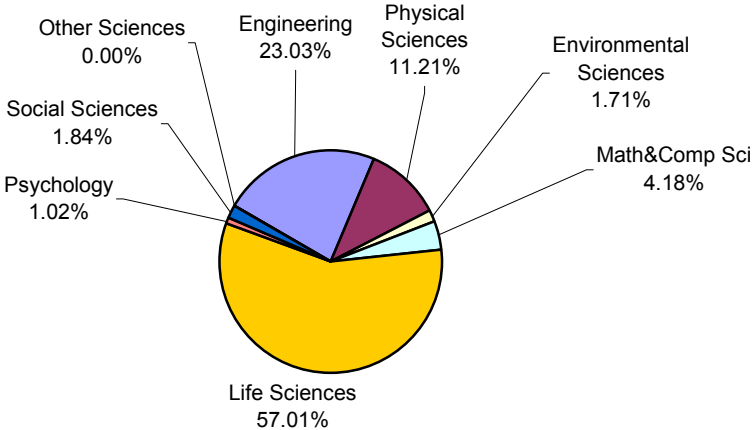
Purdue University R&D Expenditures by Source of Funds: FY2001



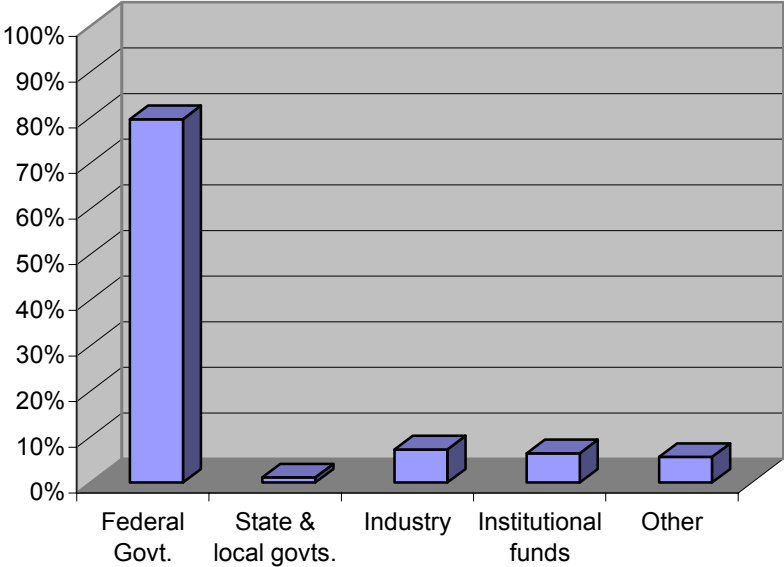
Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.

Note: Total R&D Expenditures = \$254,917,000.

Stanford University R&D Expenditures by Science and Engineering Field: FY2001



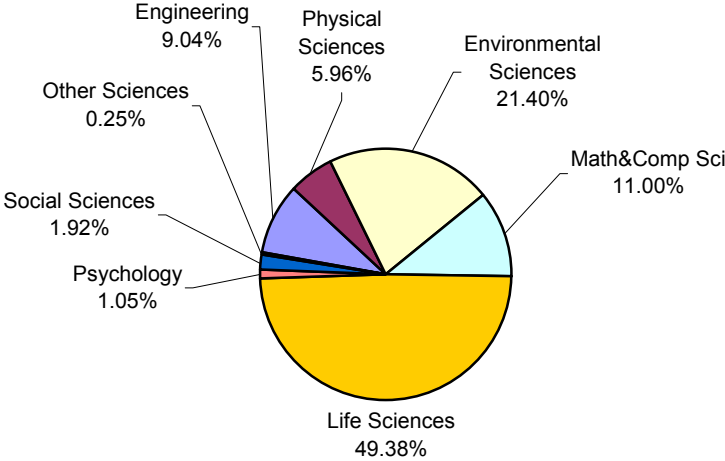
Stanford University R&D Expenditures by Source of Funds: FY2001



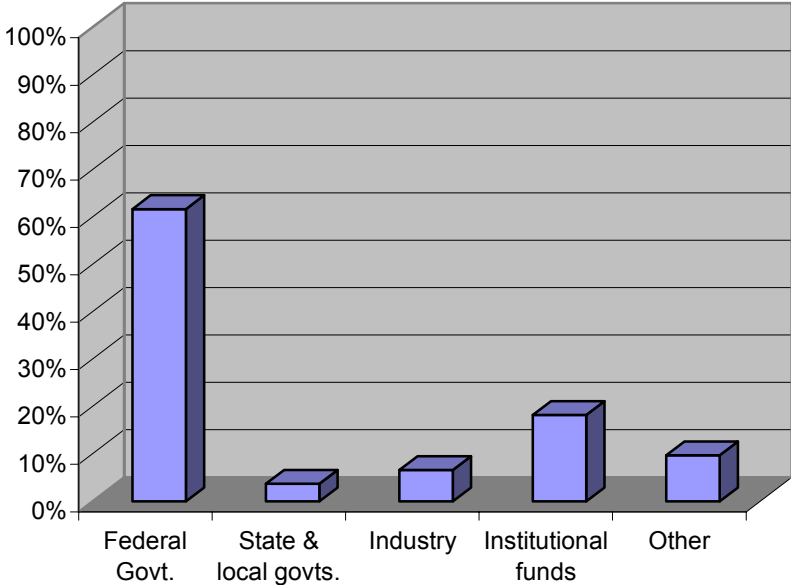
Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.

Note: Total R&D Expenditures = \$482,906,000.

University of California, San Diego R&D Expenditures by Science and Engineering Field: FY2001

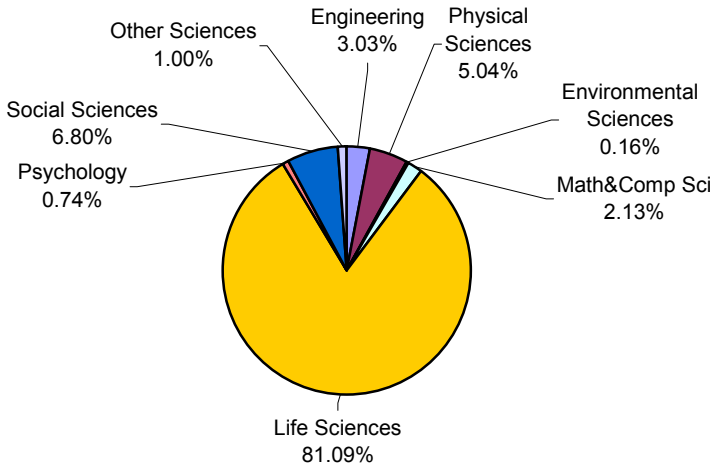


University of California, San Diego R&D Expenditures by Source of Funds: FY2001

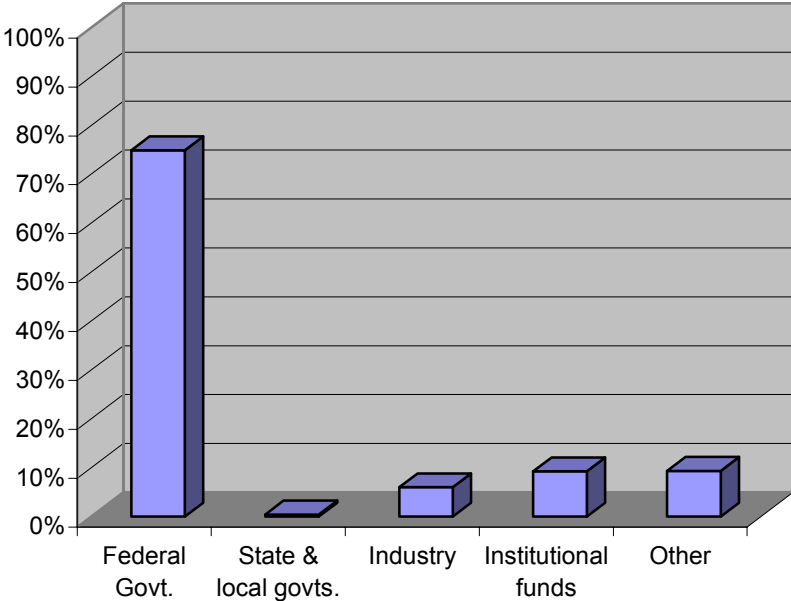


Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
Note: Total R&D Expenditures = \$556,533,000.

**University of Pennsylvania
R&D Expenditures by Science and Engineering Field: FY2001**

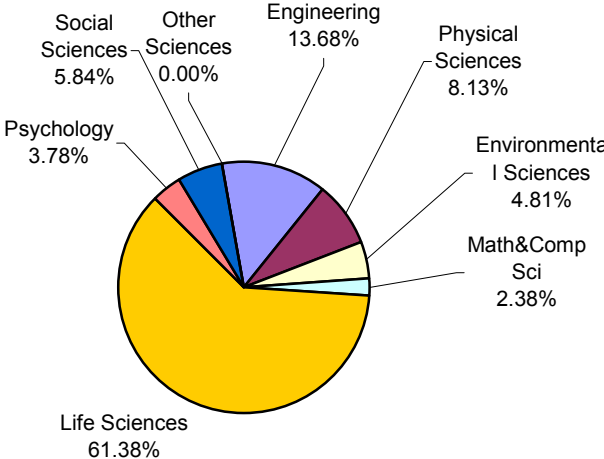


**University of Pennsylvania
R&D Expenditures by Source of Funds: FY2001**

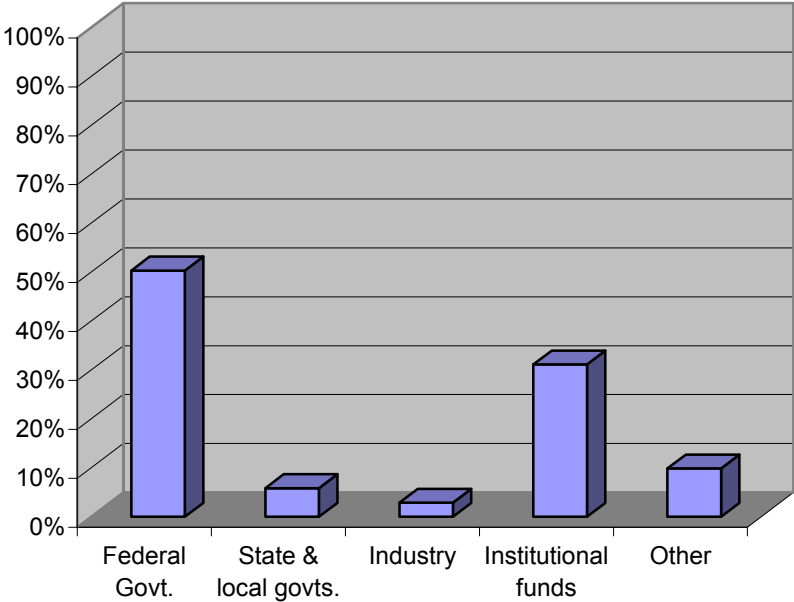


Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
Note: Total R&D Expenditures = \$469,852,000.

University of Wisconsin-Madison R&D Expenditures by Science and Engineering Field: FY2001

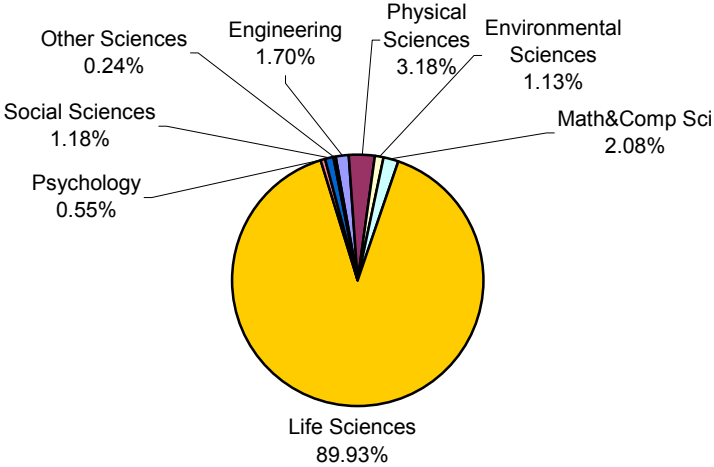


University of Wisconsin-Madison R&D Expenditures by Source of Funds: FY2001

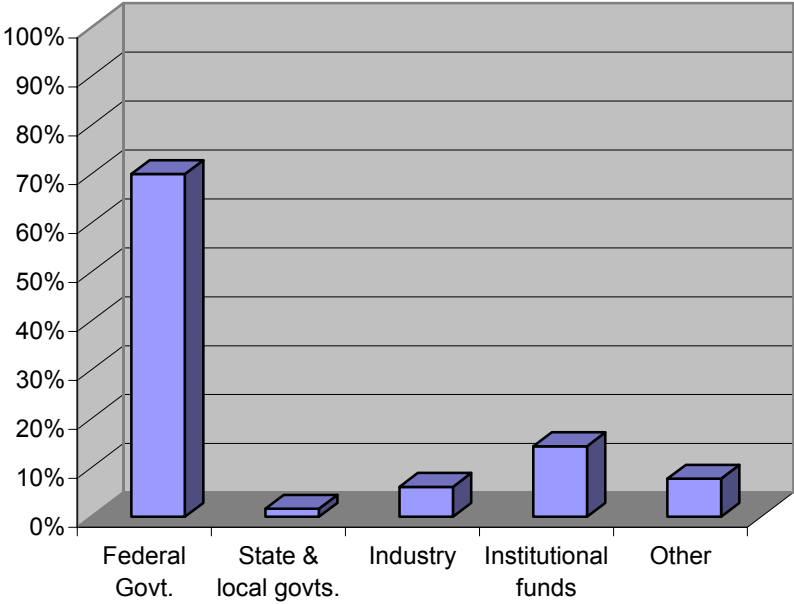


Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
 Note: Total R&D Expenditures = \$604,143,000.

**Washington University (St. Louis)
R&D Expenditures by Science and Engineering Field: FY2001**



**Washington University (St. Louis)
R&D Expenditures by Source of Funds: FY2001**



Source: Academic Research and Development Expenditures: FY 2001. Tables B-36, B-37, and B-39. National Science Foundation, 2003.
Note: Total R&D Expenditures = \$406,642,000.

APPENDIX F

**Awards to Exemplary Universities
by National Institutes of Health
FY 2003**

Rank	University	Awards (in \$k)
3	University of Pennsylvania	434,457
6	Washington University (St. Louis)	383,225
15	University of California, San Diego	288,498
16	Stanford University	271,770
21	University of Wisconsin-Madison	247,466
64	Massachusetts Institute of Technology	94,152
132	Purdue University	31,936
191	Carnegie Mellon University	16,385
205	Georgia Institute of Technology	14,901

Source: "NIH Awards to All Institutions by Rank: FY 2003", National Institutes of Health, 2004.

**Awards to Exemplary Universities
by National Science Foundation
FY 2003**

Rank	University	Awards (in \$k)
2	University of California, San Diego	95,494
3	University of Wisconsin-Madison	87,792
10	Massachusetts Institute of Technology	67,024
14	Carnegie Mellon University	55,535
15	Stanford University	54,387
21	Georgia Institute of Technology	46,934
33	Purdue University	36,229
51	University of Pennsylvania	23,426
73	Washington University (St. Louis)	15,063

Source: "Award Summary: Top 200 Institutions FY 2003", National Science Foundation, 2004.