

Technology Transfer:

Moving University Intellectual Property Into the Marketplace

By

William R. Rayburn, Ph.D.

Associate Provost for Research and
Dean of the Graduate School

University of Wisconsin–Milwaukee

Summary Statement

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Universities are sources of discovery and innovation in science and engineering, contributing to advances in agriculture, manufacturing, and other sectors of the economy with overall benefit to the public. Universities have fulfilled that important function for more than century. In the new knowledge-based society, universities have an even greater role to play in creating, nurturing, and deploying intellectual capital. The term university technology transfer refers to the commercialization of university discoveries and innovations. University technology transfer has taken on ever increasing importance for the U.S. economy. It is estimated that in 1998 the commercialization of academic research produced 280,000 jobs and \$33.5 billion in economic activity.

The turning point in university technology transfer activity was enactment of the Bayh-Dole Act in 1980 giving universities the right to claim title to inventions made during federally sponsored research. Prior to 1980, fewer than 250 U.S. patents were issued each year to universities. In 1998, more than 2,500 patents were issued to universities. Discovery, innovation, and the creation of new technologies are directly related to the magnitude of sponsored research conducted at universities. In 1998, academic research and development expenditures were \$25.7 billion with federal sponsorship accounting for \$15.1 billion or 59% and industry sponsorship accounting for \$1.9 billion or 7%. The 1998 licensing survey conducted by the Association of University Technology Managers found that 132 U.S. universities received 9,555 invention disclosures and filed 6,518 patent applications. Assuming that those universities accounted for approximately 80% of academic research and development expenditures, then one invention disclosure was received for approximately every \$2 million of expenditures and one patent application was filed for every \$3 million of expenditures.

Over the period of 1987 to 1997, Wisconsin's research and development expenditures grew annually by approximately 2%. Wisconsin's research and development expenditures in 1997, the most recent year for which data are available, were below those of most neighboring states in the region. Comparing research and development expenditures with gross state product can account for differences in state population, land area, and other variables. Wisconsin's 1997 R&D/GSP percent was 1.5. The neighboring states of Michigan, Minnesota, Illinois, and Indiana had R&D/GSP percentages ranging from 5.1 to 1.9. Wisconsin needs a larger investment in research and development.

University and industry relationships benefit both parties. Universities receive support for research, improvements in facilities, and learning opportunities for students. Companies receive useful research results that advance their research and development objectives. The commercialization of university technologies derived from federal and industry sponsorship of research serves the public interest. To be most effective, Wisconsin's academic institutions need policies, practices, and infrastructure that promote an entrepreneurial environment. University researchers must be knowledgeable about intellectual property and encouraged to participate in technology transfer activity.

Technology Transfer: Moving University Intellectual Property into the Marketplace

Discovery and innovation are hallmarks of the modern research university. The importance of university research and technology transfer activities to the U.S. economy has increased markedly over the past two decades as a consequence of changes in federal law. Wisconsin's public and private colleges and universities have much to contribute in the way of well-educated students for a modern workforce, the latest practical knowledge and know-how, and new technologies invented by their faculties and students. These factors need to be leveraged to build Wisconsin's economy in the twenty-first century.

Innovation and Society

Civilizations have evolved through time as a consequence of human innovation. Metal tools replaced bone and stone implements of early humans. Cultivation of grains resulted in founding of the first villages. Over time, improvements in plant cultivation and animal breeding led to the establishment of a land-based agrarian society. With reliable supplies of food, fiber, and construction materials, villages gradually expanded into small cities that became the focus of commerce.

The development of machines ushered in an industrial society that shaped a new class of workers and created greater demands for energy, transportation, and communication. Machines made possible mineral extraction on a large scale. Steam power replaced waterpower. Electrification came to the home and to the workplace, both in cities and rural areas. Development of the internal combustion engine led to fast and efficient transportation systems. Improvements in telephone and telegraph led to reliable communication systems. Factories located in population centers. Cities became transformed into centers of manufacturing as well as commerce. The migration of people from the land to the city began the process of urbanization

Important discoveries in chemistry, physics, and biology characterized the twentieth century. At the end of the twentieth century, a knowledge society commenced with the development of personal computers and the Internet. In the twenty-first century, new innovations leading to breakthrough technologies will depend upon a knowledge workforce.

Technological innovation has a broad impact on society. Innovations in the industrial society changed agricultural practices through mechanization. Along with the rapid developments in information and communication technologies, the knowledge society is impacting agriculture and manufacturing. Genetically modified organisms are replacing varieties formerly produced by breeding. Geographic information systems and global positioning devices are being employed in precision agriculture. Microprocessor controls, robotics, and machine vision are being employed in precision manufacturing on assembly lines and advanced materials are being incorporated into new products.

Transformation of society is associated with migration of people, displacement of workers, and social upheaval. Employment in agriculture and manufacturing in the U.S. continues to shrink and is now at 2.5 and 13 percent of the workforce respectively. Jobs in information technology fields are expanding rapidly and paying salaries that are well above the national average. Jobs related to international trade also have risen dramatically as information systems drive expansion of a global economy.

The agrarian society was connected to the land. The industrial society was linked with machines and manufacturing. The new knowledge society is increasingly associated with research universities where intellectual capital is created, nurtured, and deployed.

Universities and Society

The Jeffersonian philosophy of universal education created the U.S. educational system including its great public universities. The first private and public universities established in the U.S. followed the European tradition of offering classical and professional education to a small segment of the population. However, by the middle of the nineteenth century the need for a workforce with agricultural and technical education was apparent. In 1863, President Lincoln signed the Morrill Act creating a land-grant system of universities to provide practical education in agriculture and engineering.

The land-grant system of universities offered a practical education in agriculture and mechanical arts alongside the liberal arts and expanded educational opportunity to a broad segment of the U.S. population. The Hatch Act of 1887 established a federally funded agricultural experiment station program to promote research in agriculture. Passage of the Smith Lever Act in 1914 created the Cooperative Extension Service in association with the land-grant universities. The Cooperative Extension Service, jointly funded by federal and state government, transferred the innovations and discoveries derived from university agricultural research to the farm.

The triad mission of teaching, research, and service of the land-grant university, now common throughout U.S. public and private higher education, is grounded by three federal statutes, the Morrill Act, Hatch Act, and Smith-Lever Act. Historically, universities have played an integral role in the U.S. economy by educating skilled workers, contributing practical knowledge to the business community, and transferring the results of research for commercialization. Universities have evolved along with society, becoming important sources of discovery and innovation in agriculture, engineering, and science as well as in the arts and humanities. Universities are now positioned to play a critical role in advancing the new knowledge society.

Research and Development

Discovery, innovation, and the creation of new technologies are directly related to the magnitude of sponsored research conducted at research universities. In its annual licensing surveys of academic institutions, the Association of University Technology Managers (AUTM) found that one invention disclosure is made for approximately every

\$2 million of sponsored research. As academic research expenditures have grown so has the number of invention disclosures. Invention disclosures have increased remarkably every year over the 8-year history of the survey.

Academic research has an indelible impact on the U.S. economy. The 1998 AUTM licensing survey estimated that commercialization of academic research was directly attributable to 280,000 jobs and \$33.5 billion in economic activity.¹ In 1998 alone, 364 new companies were started by university-licensed technologies and some 385 new products were introduced to the marketplace. Whether starting new companies, developing new products, or contributing to an increase in productivity in large firms, innovations derived from academic research are significant contributors to the vitality of the U.S. economy.

There are approximately 660 academic institutions in the U.S. performing basic and applied research and development. University research, research infrastructure, and research training require a significant investment of resources. That demand traditionally has been met through federal, state, and industry support. In 1998, the most recent year for which data are available, expenditures budgeted specifically for academic science and engineering research were \$25.7 billion, an increase over the previous year of 6 percent.² Academic science and engineering research space totaled 143 million net assignable square feet in 1998.³

Federal sponsorship of academic research, initiated in the years following the Second World War, has grown to become the single largest source of support for academic research. The federal share of academic research expenditures in 1998 accounted for \$15.1 billion or 59 % of the total. State and local governments and industry each contributed approximately \$1.9 billion or 7 %. Institutional funds accounted for an additional \$5 billion.

Academic science and engineering research space and research expenditures are concentrated in a relatively few research universities. In 1998, the leading 100 research universities accounted for 71% of the research space and more than 80% of total research expenditures. Just 20 research universities accounted for \$8 billion or approximately one third of both total and federal academic research expenditures. The University of Wisconsin-Madison ranked fourth nationally in total expenditures with \$444 million and tenth nationally in federal expenditures with \$241 million.

Modern facilities are critical for top research performance. Universities often lack capacity in terms of the adequacy of research space as well as amount of space. The leading 100 research universities assigned 101 million square feet to research activity in 1998. Of that total, 39% was reported to be suitable for the most scientifically competitive research in the field while 24% was reported to be in need of major renovation or replacement. In 1998-99 these universities scheduled new construction for 9 million square feet of research space.

Industrial research and development expenditures in 1998 were \$169.2 billion, more than six times the total for academic institutions.⁴ Federal funding contributed \$24.2 billion or 14% to the industrial total. Academic and industrial research and development expenditures differ in character. Academic expenditures for basic research were \$17.4 billion, or 68% of the total, while applied research and development expenditures amounted to \$8.3 billion, or 32%. In comparison, product development accounted for \$125 billion or 74% of industrial expenditures, while applied research accounted for just \$30.6 billion or 18% and basic research only \$13.6 billion or 8%. The differences in character of academic and industrial research and development expenditures relate to differences in mission. Academic basic and applied research is focused on discovery and early stage technologies. Industrial research and development is directed toward later stage technology development and commercialization.

Research and development expenditures vary widely by state.⁵ The 10 highest ranking states accounted for 66% of the total U.S. research and development expenditures in 1997. California led all states with 20% of the U.S. total research and development, followed in order by Michigan, New York, New Jersey, Massachusetts, Texas, Pennsylvania, Illinois, Washington, and Maryland. Wisconsin ranked 23rd among states with \$2.26 billion for total research and development expenditures and 19th with \$1.71 billion for industrial research and development expenditures. Based on the strength of its academic research programs, Wisconsin ranked 14th among states with \$497 million of academic research expenditures.

Wisconsin's total (academic and industry) research and development expenditures were below those of neighboring states in the region including, Michigan, Illinois, Minnesota, and Indiana. Only Iowa had lower research and development expenditures. When comparing one state to another, the ratio of total research and development expenditures to gross state product (GSP) controls for differences in population, land area, and other variables. The 10 highest ranking states had R&D/GSP percentages ranging from 6.7 to 3.7. In 1997, Wisconsin's R&D/GSP percentage was 1.5. The R&D/GSP percentages for neighboring states were Michigan (5.1), Minnesota (2.4), Illinois (2.0), Indiana (1.9), and Iowa (1.2).

From 1987 to 1997, average research and development expenditures in the U.S. increased annually by 2%. Individual state research and development expenditures ranged from an increase of 14% to a decrease of 6% over that ten-year period. Wisconsin's growth was not significantly different from the U.S. average.

The federal government has instituted a number of programs to advance research and development. The Small Business Technology Transfer Program (STTR) promotes competitive joint venture opportunities between small businesses and non-profit research institutions. Five federal departments and agencies set aside funds for STTR awards to small companies. Technologies are jointly conceived, initially developed in university laboratories, and commercialized by the company partners. The Small Business Innovation Research Program (SBIR) was created in 1982 by enactment of the Small Business Innovation Development Act. Ten federal departments and agencies reserve a

portion of their research and development funds each year for the SBIR Program. Competitive awards are made to small companies that may seek the participation of university researchers in order to acquire the necessary technical expertise.

In addition to funding STTR and SBIR awards, the National Science Foundation manages several programs that bring together university and industry researchers. The NSF Grant Opportunities for Academic Liaison with Industry (GOALI) Program matches individual university researchers conducting basic high-risk/high-gain research with high-tech companies for the purpose of transferring the research results. University researchers and students are supported by a combination of NSF and company funds. The NSF Industry University Cooperative Research Centers Program builds industry consortia around university core competencies that focus on leading edge technologies in science and engineering. Funding for the research projects comes primarily from consortia members. The NSF Engineering Research Centers Program encourages academic and industry partners to focus on advances in complex engineering systems. University-based Engineering Research Centers feature long-term company partnerships that integrate research with education for undergraduate and graduate students.

States have established a variety of programs to foster university and industry relationships. The University of Wisconsin Applied Research Program is one example. Funds are awarded to faculty on a competitive basis for the conduct of research related to some aspect of the State's economy. Letters of support from a company or companies generally are appended to the proposals. The technical quality is high for the awarded projects. The Applied Research Program is well managed, but it does not adequately engage Wisconsin companies and the funds are insufficient to have a significant impact. Companies take a genuine interest in the progress and outcome of university research and development projects when they have funds invested in them and companies are more likely to invest when they have a role in proposal development. Having invested in research, companies also are more likely to pursue commercialization.

Technology Transfer and the Bayh-Dole Act of 1980

Technology transfer is the term used to describe a process by which university intellectual property in the form of innovations and discoveries is transferred from the university to a commercial entity through some form of written agreement. Innovations and discoveries of commercial value that take place in university science and engineering laboratories come about through research sponsored by the federal government and industry. Universities or their intellectual property agents (not-for-profit research foundations) protect the innovations and discoveries by patents, copyrights, or trademarks. They license rights to commercialize those innovations and discoveries to companies.

Prior to 1980, federal agencies held title to inventions created in university laboratories with federal funds. Enactment of Bayh-Dole allowed small businesses and non-profit organizations to elect title to inventions created under federally sponsored research and development. Universities claiming title to inventions were required to

undertake steps leading to the utilization of those inventions for the public good. That included filing for patent protection and preferential licensing of patents to small U.S. companies.

The success of the Bayh-Dole Act of 1980 is evident today in a growing number of U.S. universities involved in technology transfer. A small number of universities (including the University of Wisconsin-Madison and its patent and licensing agent the Wisconsin Alumni Research Foundation) were successfully engaged in technology transfer activities prior to Bayh-Dole. Now more than 200 universities are involved. Before 1980, fewer than 250 patents per year were issued to U.S. universities. Since 1993 the average number of patents issued per year to U.S. universities exceeds 1,500 with the number increasing each year.

Each year since 1991, the Association of University Technology Managers has conducted a licensing survey of its member institutions made up of U.S. universities, hospitals, and research institutes, and Canadian institutions. In 1991, 98 U.S. universities reported receiving 4,880 invention disclosures from their faculty and filing 1,335 new patent applications. Just seven years later in 1998, 132 U.S. universities reported receiving 9,555 invention disclosures and filing 6,518 new patent applications. From 1991 to 1998, U.S. universities reported a total of 58,027 invention disclosures and 22,220 new U.S. patent applications.

The Association of University Technology Managers survey began tracking the number of patents issued to its member institutions in 1993. From 1993 to 1998, 11,149 U.S. patents were issued to U.S. universities, with 2,681 U.S. patents issued in 1998 alone. U.S. universities executed 3,078 new license and option agreements with companies in 1998 and a total of 16,462 new license and option agreements from 1991 to 1998. Of that number, more than half was for the commercialization of university innovations and discoveries by small or new startup companies, thus achieving the intent of the Bayh-Dole Act.

Technology Transfer in U.S. Universities

Public and private investment in U.S. higher education is returning high tech dividends. In the two decades since the Bayh-Dole Act presented universities with a mandate to protect and commercialize the innovations and discoveries developed in their research laboratories utilizing federal sponsorship, over 200 universities have put in place some means to engage in technology transfer. The ingenuity and creativity of university researchers have been tapped as never before in the public interest. Universities have commercialized their innovations and discoveries without compromising their educational missions or sacrificing their core values.

Broadly defined, technology transfer reflects the breadth of mission of U.S. research universities, namely learning, discovery, and outreach. Having completed degrees in science and engineering, recent graduates entering the workforce take with them new knowledge and the latest ideas. Scholarly publications of all types place the

results of university research into the public domain. Outreach activities such as seminars, short courses, and workshops deliver know-how to the business community.

Universities engage in technology transfer activity for several purposes. Universities meet their obligation to contribute to the public good by the commercialization of federally funded innovations and discoveries. Universities are interested in the recruitment and retention of science and engineering faculty and students who want to see their innovations and discoveries commercialized. Such faculty and students receive tangible rewards for their inventiveness and they frequently are instrumental in establishing university-industry relations. Universities build collaborations with industry research sponsors through their ability to transfer technology. Students working on industry sponsored research often find employment with that industry on graduation. Universities promote and support research with the net income received through licensing activity. Finally, the transfer of university technologies contributes to the community through the creation of new businesses and jobs.

The management of intellectual property at research universities follows a common pattern. A researcher discloses her or his innovation or discovery to a central university office identified by various names such as an office of technology transfer or directly to the university's research foundation. A technology licensing specialist with appropriate expertise reviews the disclosure and meets with the researcher to gain an in-depth understanding of the technology. The invention is evaluated for marketability and patentability. If found to be suitably valuable, protection is sought in the form of a patent application using outside patent counsel. As a condition of employment, the researcher assigns the invention to the university or to the university's research foundation. While patent prosecution is underway, potential licensees are identified and marketing ensues. Marketing usually involves the exchange of information under terms of confidentiality. A license or option agreement is negotiated once a licensee is found and the technology is transferred. In exchange for the grant of right to the invention, the licensee agrees to commercialize the technology and to make to the university or its agent reasonable royalty payments. The royalty payments received from a licensee generally are used to cover the costs of patent filing and associated legal fees. The remaining funds are distributed to the researcher, as required by Bayh-Dole, and one or more university units. The university's share is used to support further research.

Universities enter into a variety of agreements with non-profit and commercial entities. Confidentiality agreements are used to protect the exchange of proprietary information, usually belonging to companies, which is critical to the success of sponsored research projects. Universities regularly transfer materials to other universities and companies through the use of material transfer agreements that specify the nature, ownership, and use of the material. Sharing of materials among researchers is an important condition for scientific research.

Option agreements generally are executed with companies to allow for a period of evaluation of research results originating from ongoing research projects. They are

especially useful for promising early stage technologies and technologies that require a long period of research and development before commercial potential is certain. Option agreements are usually for one year, are renewable, and offer the opportunity to negotiate for a license agreement within the option period. Option agreements often are connected with company sponsored research agreements.

Universities execute license agreements with companies in order to commercialize university technologies. Usually patents or copyrights protect the technologies. Licensees are granted the right to make, use, and sell patented technologies in exchange for license fees and royalty payments that are standard for the particular industry. The license agreement actually grants the right to exclude others from making, using, or selling the technologies. The license agreement may be exclusive or non-exclusive. Exclusive license agreements grant exclusive rights to the licensee for a specific field of use and for a particular territory (a country, a region, or the world). Exclusivity is an important consideration when a long-term research partnership exists between a university and a company, and when a company has provided significant sponsorship of the research project. Under exclusive licenses, companies often select those countries in which patent protection is sought, and pay for patent prosecution, patent maintenance, and associated legal fees. Non-exclusive license agreements may be executed with two or more licensees operating in the same territory and for the same field of use.

Certain clauses common in license agreements between universities and commercial entities reserve rights to the universities and provide legal protection. For example, universities reserve the right of their faculties to publish research results. Delays in publication are permitted only to allow time for patent applications. Universities do not permit the use of their name without prior written permission. Universities do not grant warranties for the licensed inventions. Universities require licensees to hold harmless universities and to indemnify universities against third party legal actions.

University-Industry Relationship

A university and industry relationship begins with a company sponsored research agreement. The university researcher wants funding to conduct innovative research of interest to her or him, collect data for future publications, and support a student. In return for its support, the company expects innovative research, timely completion of the project, and timely reporting of results to the company. The company wants results that advance its research and development objectives and add value to its product or service.

Companies gain access to experts in the field and can expand upon their research and development capability by funding research in university laboratories. Put differently, companies maximize their investment in research and development and reduce their risks in early stage technology development by funding creative university researchers. The needs of the university relating to student learning, innovative research, and publication are met through company sponsored research. The needs of the company in obtaining new and useful results relating to its products or services are satisfied. The

one remaining step is to protect any intellectual property coming from the research project that may have commercial value.

To protect intellectual property, university researchers must disclose new discoveries to the university's technology transfer office before any public release. By prior agreement, the technology transfer office promptly discloses the new discovery to the company sponsor and in consultation with the company decides whether or not to file a patent application. A patent application must be filed prior to publication otherwise the novelty of the discovery is lost. University of Wisconsin System policy requires that university researchers make timely disclosure of new discoveries to the appropriate university office. However, researchers are not required to assign new discoveries made with non-federal research support to the university. In this regard, the University of Wisconsin is different from most other universities.

Universities and companies have different views when it comes to placing value on the intellectual property coming from company sponsored research. Universities view new intellectual property in terms of future worth. At the beginning of research projects, ideas that form the basis of the research are difficult if not impossible to assess. The actual commercial value of new discoveries or intellectual property may not be known for some time. The university position is that payment for research covers only the cost of the sponsored research; additional license fees and royalty payments are appropriate for rights to make, use, and sell university technologies.

Companies view intellectual property in terms of cost. Companies assume that they should receive royalty free, worldwide, non-exclusive licenses as an outcome of sponsoring the research. The company position is that payment for the research also is payment for rights to new discoveries and patented technologies that come from the research. Companies ordinarily are willing to pay license fees and royalties for exclusive rights.

The difference in how universities and companies place value on intellectual property may be handled in research agreements by granting company sponsors either a first right or an exclusive right to negotiate a license agreement and sometimes upper limits are placed on royalty percentages. Company sponsors, universities, and the public should all gain when university intellectual property or technologies are commercialized.

Capitalizing on Technology Transfer

Technology transfer is not a stand-alone activity. Its significance and success are correlated with institutional policies, practices, and environment. General acceptance of an entrepreneurial environment that encourages technology transfer through recognition and a reward structure has a direct influence on the level of activity. Adequate institutional resources and infrastructure are essential and they must keep pace with the level of technology transfer activity.

University inventors need convenient access to advice and assistance offered by a knowledgeable staff in a university technology transfer office or its equivalent. The university needs access to a non-profit patent and licensing agent that will retain appropriate patent counsel for patent prosecution and effectively market the university's technologies. The University of Wisconsin-Madison and its patent and licensing agent, the Wisconsin Alumni Research Foundation (WARF), have protected and marketed university technologies for 75 years. That association generated \$16.1 million in licensing revenue in 1998, ranking UW Madison among the top 20 universities in the U.S. in technology transfer activity. The UW-Madison and WARF association is a success story. In the University of Wisconsin System, only the Madison campus has had access to a patent and licensing agent until this year. The creation this year of the WiSys Technology Foundation, a subsidiary of the WARF, provides a means for the other UW System campuses to engage in technology transfer activity.

The amount of technology transfer activity is related to the amount of sponsored research and to the size and nature of graduate degree programs. Faculty researchers and graduate students conducting research in dynamic technology fields and areas of national priority such as advanced materials and manufacturing, microelectronics and sensor technology, microelectrical mechanical systems, computer systems and software, and biotechnology make fundamental discoveries and develop technologies that may have significant commercial potential. It makes good sense to expand research in areas that are ripe for innovation. The UW-Madison campus is well positioned to engage in technology transfer activity with FY 1998 research and development expenditures of \$444 million and 110 programs offering Ph.D. degrees. For comparison, the Milwaukee campus had FY 1998 research and development expenditures of \$21 million and 17 Ph.D. degree programs. Strategic investments in new faculty and facilities at the UW Milwaukee would open opportunities for technology transfer to Wisconsin companies in the region.

Together, Marquette University, the Medical College of Wisconsin, the Milwaukee School of Engineering, and the UW-Milwaukee comprise a major higher education presence in metropolitan Milwaukee with significant size and scope of programs. A total of 43 Ph.D. degree programs are offered by three of those institutions. Marquette University, the Medical College of Wisconsin, and the Milwaukee School of Engineering have established several joint graduate degree programs. The UW-Milwaukee and Medical College of Wisconsin have entered into discussions about new joint graduate degrees. Research collaborations already exist among a number faculty at the four institutions. Research and development expenditures at the four institutions totaled \$85 million in FY 1988.⁶ Recognizing that considerable benefits may be achieved through collective action, senior officials responsible for technology transfer at the four institutions have been meeting together for more than a year to discuss common interests and strategies for cooperation.

More can be done to involve faculty in and prepare students for worthwhile and productive collaborations with commercial entities. Science and engineering faculty conducting research in areas that generate discoveries with commercial value should be encouraged to consider industry collaborations. The faculty need to have some

understanding and appreciation of the corporate culture and basic knowledge about intellectual property. The same information can be included in coursework for students, especially those students supported by company sponsored research projects. The curriculum can contain courses for future entrepreneurs on how to start and manage a business. Faculty need to be aware of the difference between technology push and technology pull. No matter how ingenious a discovery or invention, it will languish if it does not meet the need of a potential licensee. New technologies must meet real needs in the marketplace in order to be licensed. In this regard, university technology marketing managers are valuable in building university and industry linkages through outreach activities.

University technology marketing managers act as prospectors by regularly visiting and surveying companies to learn of their most important priorities and needs and bring back that information to university laboratories where faculty expertise and ingenuity can be applied. Connections between company representatives and university researchers established through such contacts may be the most important means of promoting technology transfer. A recent survey of industry licensing executives conducted by Jerry G. and Marie C. Thursby found that personal contacts with university research and development personnel was identified as by far the most important means of identifying university technologies.⁷ In descending order, presentations at professional meetings, patent searches, and journal publications were identified as less important. Least important were promotional marketing efforts by the university's technology transfer office and canvassing of university technologies by industry licensing staff.

University students and faculty should have an opportunity to expand upon their experience by working at private companies and company researchers should be able to work side by side with faculty and students in university laboratories under mutually agreed upon conditions. Students can be employed full or part time at companies, work as interns, or only conduct certain types of research at company facilities. They gain workplace experience and are better prepared to begin careers in the world of business. Faculty can spend sabbatical or unpaid leaves of absence at companies. Faculty inventors whose technical knowledge is critical to the success of small technology-based companies can be given leaves to work at those companies for specified periods, for example one or two years, with rights to return to their faculty appointments. They would return with valuable experience to pass along to colleagues and students alike.

University involvement with small technology-based companies should not end with the transfer of university technologies. Universities can lend further assistance, especially to the entrepreneurs in small companies by providing appropriate seminars, workshops, short courses, and one-on-one consultation. In addition to developing the technology, entrepreneurs in small technology-based companies often need direction in preparing business plans, analyzing markets, and developing strategies for seeking investment capital. Entrepreneurs also need help in understanding contracts and intellectual property protection. Science, engineering, business, and law students can provide some of that assistance under the supervision of faculty advisors and acquire practical experience at the same time. Business schools can organize networking

opportunities that bring together CEOs of small technology-based companies with retired executives and professionals willing to volunteer their time and talent, university inventors, and venture capitalists. Once or twice a year, business schools can host forums in which small and startup company CEOs present their business plans to the venture capital community.

Small technology-based companies are vulnerable. To succeed they need innovative and marketable technologies, sound management, and working capital. They also need a place to do business. University and community incubators and research parks can satisfy that need. Small companies must stretch their cash resources. Business incubators that offer inexpensive lease space, conference rooms, and general office support services for small companies in their early years of growth can make the difference between success and failure. Incubators can offer other critical services such as high speed Internet connections, group purchasing, and introductions to local banking, insurance, and venture capital representatives. Incubators and research parks afford an opportunity for small technology-based companies to interact, exchange ideas, and share survivor skills. University-related research parks offer an additional advantage to tenant companies by providing entry to the universities' immense store of intellectual capital.

Summary

The creation, nurturing, and deployment of university intellectual capital is a driving force in the new knowledge-based society. Academic research and development and the commercialization of university discoveries and innovations have a profound effect on the U.S. economy. Wisconsin's academic institutions can be better positioned to advance the state's economy. To be more effective, Wisconsin's academic institutions need a combination of policies, practices, infrastructure, and researchers knowledgeable about intellectual property in order to create an entrepreneurial environment conducive to technology transfer activity.

Discovery, innovation, and the creation of new university technologies are directly related to the magnitude of sponsored research. Therefore, universities, industry, and state government can and should collaborate to increase investments in university research and development that lead to technology transfer. The public interest is served by a strong economy. Strategic investments leading to commercialization of university discoveries and innovations result in economic growth and job creation. Wisconsin has a strong framework of public and private institutions of higher education poised to contribute to Wisconsin's economy. Wisconsin should capitalize on that asset.

Recommendations

- Working in unity, state government, public and private higher education institutions, and industry should develop strategies to increase Wisconsin's research and development expenditures in relation to the gross state product, including greater leveraging of federal research and development dollars.

- The State of Wisconsin and the University of Wisconsin System should provide leadership to promote more research and development collaborations between members of Wisconsin's public and private higher education community, e.g., among University of Wisconsin campuses and between Milwaukee area institutions. At the same time the State and UW System should strongly encourage collaborations between Wisconsin's companies and academic institutions that are beneficial to both parties and to the public at large.
- All University of Wisconsin institutions have for the first time, access to a patent and licensing agent. Having entered into an agreement with the WiSys Technology Foundation to provide intellectual property management for University of Wisconsin System institutions other than UW-Madison, the UW System should take all necessary steps to ensure the success of that new relationship.
- A Research and Technology Development grant program should be instituted at the UW-Milwaukee that is similar to the successful UIR grant program at the UW-Madison. The UW-Milwaukee program should employ a Wisconsin First philosophy and fully engage Wisconsin industry partners. Together with university researchers, industry representatives should participate in the preparation of proposals and the conduct of research. Industry partners should be required to match state support for all projects and agree to commercialize the results of research.
- Higher education institutions involved in research and development should incorporate information about intellectual property into course content. Business, science, and engineering curricula should contain courses that focus on entrepreneurial undertakings as well as on intellectual property. Short courses and seminars offering practical guidance and direction for developing business plans, market analysis, and securing investment capital should be made available at convenient times for entrepreneurs.
- Higher education institutions involved in research and development should examine policies, practices, and infrastructure relating to technology transfer and make changes that encourage, recognize, and reward researcher inventors and promote an entrepreneurial environment within the institution. For example, institutions should take under consideration flexible policies that allow faculty and staff to fully participate in startup companies for a period of time and then return to resume institutional responsibilities.

Author Biography

William R. Rayburn is Associate Provost for Research and Dean of the Graduate School at UWM, responsible for Research Administration, Technology Transfer, and Graduate Academic Programs. Prior to joining UWM, Rayburn was the Associate Vice Provost for Research at Washington State University. Rayburn previously served as Interim Director of both the Office Intellectual Property Administration and the Research

and Technology Park, and as President of the Washington State University Research Foundation.

Rayburn formerly held the position of Associate Director of the Washington Technology Center, an agency of the Washington State Department of Community, Trade and Economic Development, that supports research and development in the state's research universities specifically for the benefit of Washington companies. Rayburn served concurrently as the Director of the Biotechnology Group. Rayburn is a member of the Board of Directors of the Washington State University Research Foundation and previously served on the Board of Directors of the Washington Biotechnology and Biomedical Association. He holds a BA degree from Washington University in St. Louis and a Ph.D. degree from Indiana University-Bloomington.

The author may be contacted by writing to William R. Rayburn, P.O. Box 340, University of Wisconsin-Milwaukee, Milwaukee, WI 53201-0340 or by e-mail at rayburn@uwm.edu.

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² Academic R&D Spending Continues Steady Growth in FY 1998, Data Brief prepared by M. Marge Machen, National Science Foundation, Division of Science Resources Studies, August 14, 2000.

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⁴ U.S. Industrial R&D Performers Report Increased R&D in 1998, Data Brief prepared by Raymond M. Wolfe, National Science Foundation, Division of Science Resources Studies, April 28, 2000.

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