

Carnegie Mellon University

Research Development Report

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Commercial Development of Research

Carnegie Mellon University (CMU) has an excellent reputation for technology transfer, particularly in life sciences. CMU currently:

- Ranks #1 among U.S. universities without medical schools in the number of start-up companies created (2007);
- Ranks #1 among peer research universities in the number of startup companies on a per federal dollar invested basis, making it one of the most productive generators of innovation in the world (2005-2007);
- Ranks #2 among all Pennsylvania universities in royalties received from patents, a close second to the much-larger University of Pennsylvania (2004-2007), and the only university in the top five without a medical school.

Table 1 shows total transactions in life sciences over the past seven fiscal years. Table 2 shows technology transfer activities normalized to yield actions per \$10M of sponsored research. These are standard metrics used by the Association of University Technology Managers (AUTM). Carnegie Mellon consistently compares favorably with other universities in technology transfer activities. Importantly, our commercialization of life sciences research through start-up company formation is especially strong, nearly six times the AUTM average.

Table 1: CMU life sciences commercialization efforts in past six fiscal years (FY03-FY09)

<i>Indicator</i>	<i>#</i>
patent applications	167
patents issued	38
licenses/options executed	41
start-up companies formed	17

Table 2: Comparison of CMU life sciences commercialization performance metrics to AUTM averages

<i>Actions per \$10M of sponsored research*</i>	<i>CMU life sciences (FY03-09)</i>	<i>CMU all (FY03-09)</i>	<i>AUTM data (FY07)</i>
patents issued	1.40	1.87	1.83
licenses/options executed	1.51	1.09	1.05
start-up companies formed	0.63	0.34	0.11

Carnegie Mellon's technology commercialization efforts are spearheaded by our Center for Technology Transfer and Enterprise Creation (CTTEC), which serves all faculty, staff and students. The CTTEC proactively identifies new research discoveries, legally protects those research discoveries, connects inventors with potential licensees and investors and negotiates licensing agreements to transfer those research discoveries to commercial entities.

Our policies and practices for technology transfer and intellectual property are straightforward and inventor-friendly. For example:

- The CTTEC must assess new discoveries and reach a decision whether to pursue or not pursue a patent within 120 working days from submission of the invention disclosure.
- In the event that the university decides not to pursue a patent, the ownership rights may revert to the faculty inventor (provided any government source of funding has not opted to elect title), though the CTTEC will still provide the inventors with commercialization assistance if requested.
- Equity positions in CMU spin-off companies are consistent and spelled out: 6% for exclusive licensing and 5% for non-exclusive licensing, retained through the first raising of \$2 million in funding or more. Additional equity percentages are taken in exchange for additional services, e.g., 1% for patent services and 1% for each of up to two years of laboratory use to incubate the start-up company.

Much of our life science research and development is done through collaborations, particularly with faculty of the University of Pittsburgh and clinicians with the University of Pittsburgh Medical Center (UPMC). CTTEC works with those institutions to commercialize the results of collaborative projects, often taking the lead if all parties agree that CTTEC's expertise, experience and connections position the team for highest likelihood of success.

Research Licensing Agreements

Carnegie Mellon has in place standard agreements for technology licensing, as well as guidelines for start-up company formation. The latter features provisions that clearly delineate the university's expectations for granting licenses to a start-up, the university's equity position for both exclusive and non-exclusive licenses to the start-up, terms for royalty payments based on milestones and capitalization of the company, and allowable roles in the company for founders who are Carnegie Mellon employees.

Training Students and Health Professionals

As a post-secondary institution, we directly educate and train students and health professionals. On our own campus, we have courses and offer degrees in traditional areas including biology, chemistry and biomedical engineering. In addition we have specialized programs that offer degrees and/or certificates, including computational biology, the neural basis of cognition, biotechnology management, health business practices, and medical management. Representative programs are highlighted below.

For students

- *Biological Sciences*—The Department of Biological Sciences' areas of emphasis include biochemistry, biophysics, and structural biology; biotechnology; cell biology; computational biology and bioinformatics; developmental biology; genomics, proteomics, and systems biology; molecular biology and genetics; and neuroscience. It grants degrees at the Bachelor's, Master's and Doctoral levels. Biological Sciences is a rising star; it's rank has improved to #34 from #54 in FY05.
- *Biomedical Engineering*—The Department of Biomedical Engineering (BME) provides training and grants degrees at the Bachelor's, Master's and Doctoral levels. Though established as a department in only 2002, it is now ranked 24th in the country. BME is also a partner with the University of Pittsburgh School of Medicine in the Medical Scientist Training Program, an MD-PhD degree program. Research within BME is concentrated in five foci: biomedical imaging (including the Center for Bioimage Informatics), computational biomechanics and medical devices, medical robotics, molecular and cellular biotechnology and regenerative medicine (including the Bone Tissue Engineering Center).
- *Computational Biology*—Through a generous donation, the Ray and Stephanie Lane Center for Computational Biology was established in September 2007. Key facets of the center are fellowships for visiting professors and post-doctoral fellows. Carnegie Mellon established an undergraduate computational biology program in 1987 and a Master of Science degree program in 1999. In the fall of 2005, we established a computational biology PhD program jointly with the University of Pittsburgh. The Center now has department status within CMU's School of Computer Science.
- *Master of Science in Health Policy and Management (HCPM)*—The HCPM program teaches students how to think strategically about the economic, political, and financial environment in which health care is delivered. It provides an understanding of how to manage and lead organizations through the sea of changes sweeping across health care, and equips students with the technical and analytic tools-including IT-that will help them work smarter and more efficiently. This program can be completed on a part-time basis.

For health professionals:

- *Master of Medical Management (MMM)*—The MMM program offers management and leadership training to physician executives who wish to lead today's health care organizations and to shape the future of tomorrow's health care industry in a rapidly changing environment. Our curriculum builds upon and extends the skills and knowledge that physicians acquire in the American College of Physician Executives' Graduate Program in Medical Management.
- *Quality of Life Technology (QoLT)*—The QoLT Center, a joint Carnegie Mellon/University of Pittsburgh center funded by the National Science Foundation is developing and applying intelligent assistive technologies for older adults and people with disabilities. Faculty, staff and students in QoLT Center regularly address groups of

clinicians and other health professionals through seminars and targeted outreach activities.

Commercial Research Development Training

A cluster of projects and programs, involving faculty, staff, and trustees, forms a productive environment or ecosystem for innovation. These programs are especially focused on the critical early stages of the move from the university to the marketplace. These projects each function independently but also interact and interconnect across the campus. They include:

The Center for Technology Transfer and Enterprise Creation (CTTEC)

CTTEC is a resource for any individual or group interested in commercial activity around Carnegie Mellon research. CTTEC staff help faculty inventors through the various stages of commercialization; they assist in writing patent applications, finding venture funding, developing marketing strategies, and negotiating license agreements.

The Don Jones Center for Entrepreneurship

Based at the Tepper School of Business, the Jones Center provides education and training in writing business plans, securing financing, and devising winning market strategies for start-up firms. More than 10 percent of Carnegie Mellon undergraduates, including students from every college, are involved in the Jones Center's programs or classes each year. The Center holds an international business plan competition annually, attracting world wide attention to Pittsburgh, and Carnegie Mellon MBA students often win top honors at this and other competitions. MBA students frequently turn to Carnegie Mellon engineers, computer scientists, chemists, or biologists for potential new-business ideas.

Project Olympus

Project Olympus, under the leadership of Computer Science Professor Lenore Blum, provides start-up advice, micro-grants, and incubator space to support faculty as they refine their ideas for the marketplace. Olympus also creates new connections between faculty and investors and regional and national resources. The project funds and mentors faculty in order to move basic research further along in the development and business cycles, and stays with these faculty members as they work their ideas through the proof-of-concept stage to prepare projects for licensing, spin-offs, start-ups, or other corporate collaboration. Olympus aims to build an infrastructure and foster a culture, climate, and community that will nurture talent and ideas by:

- Injecting an entrepreneurial culture into the earliest stages of the value-creation chain of the university's technology commercialization initiatives, helping more people to "think like entrepreneurs"
- Assisting students and faculty in exploring the commercial potential of their research by providing education, advice and connections; and
- Developing collaborations that bring together the expertise and resources of the university with the innovation development sector in the region and in the nation.

Quality of Life Technology (QoLT) Foundry

The QoLT Foundry is led by an Executive-in-Residence, a veteran medical device entrepreneur. He brings the experience of technology management, business operations and investment; regional connectivity; and convergent knowledge of science, technology, business, and markets to the QoLT Foundry. He has personal relationships with the local economic development agencies, as well as industry, entrepreneurs and investors. This connectivity is the linkage and leverage required to rapidly advance the ERC's innovative technologies as funded companies. He is assisted by additional Entrepreneurs-in-Residence, EIR's, and teams of interns – business, law and innovation management students from CMU and other local universities to perform early due diligence, industry and market analysis and develop a preliminary business model and plan. These efforts are then put through additional screenings by potential investors, industry advisors and domain experts. The EIR's are consultants with time-limited contracts to discover and nurture a spin-off company he/she champions and founds. Each EIR owns the QoLT Foundry's initial due diligence process for a few technologies, focusing on the business side; the primary selection criterion for EIR's is, in fact, their business acumen and domain experience. Because they have a defined window of opportunity, they also have a vested interest in getting the company moving quickly. The QoLT Foundry's due diligence and the EIR's provide business credibility that complements the ERC researchers' technical credibility.

A key differentiator of the QoLT Foundry is that the EIR's actively 'ferret out' promising research technology from within the university and then become their champions. The QoLT Foundry leverages a large aggregate network of seasoned advisors and thought leaders, experienced investors, and industrial partners.

Team Tartan Connection

This new initiative, led by CMU's VP for Research, enlists investors and business leaders from among the university's alumni and friends around the world, to give advice and counsel to fledgling enterprises. These mentors meet with faculty members about specific issues, concerns, and bottlenecks, and work with them to move forward on promising projects.

Other programs

Our newest program is a Master of Science in Biotechnology and Management (MSBTM) which is a collaborative program of our Heinz College, our Mellon College of Science and our Tepper School of Business. The MSBTM program is the first of its kind in the US. It is being led by a former biotechnology executive whose experience includes being a VP at Johnson & Johnson and running his own durable medical equipment company.

The Tepper School also offers a Biotechnology MBA for students seeking to combine technical and scientific expertise with strategic business leadership skills. Students who select this Track are preparing for leadership at the intersection of business and life sciences where both breadth and depth in managing regulatory, management, scientific and marketplace issues are required. The interdisciplinary program leverages expertise across the university: science, robotics, computer science, business management and biomedical engineering. Many students enrolled in this track belong to the Tepper School's Biopharma Business Student Club, the membership of which includes nearly 20% of the MBA student population.

Outreach to Businesses Regarding Recent Research Developments

CTTEC personnel have numerous meetings with prospective funders (local technology-based economic development organizations, angel investors and venture capitalists) and local companies regarding Carnegie Mellon technologies and spin-offs. The CTTEC Director and staff routinely make presentations to audiences consisting of faculty, regional companies or both on topics such as technology transfer, intellectual property, patenting and company formation.

Carnegie Mellon's Corporate Relations group and Alumni Relations group also play important roles in connecting prospective licensees with technologies available for licensing. Indeed, it is typical a company visiting the university will meet with representatives of those groups and CTTEC. Similarly, Corporate and Alumni Relations often collaborate to produce events outside of Pittsburgh to inform companies and university alumni about recent developments and technology transfer opportunities. Such events are often held in conjunction with major conferences and expositions, e.g., the annual Biotechnology Industry Association meeting.

Part of the charter from the National Science Foundation to our Quality of Life Technology (QoLT) Center is to significantly contribute to the creation of products such as personal robots to assist with household chores and personal hygiene, personal electronic coaches for physical therapy, cognitive aids, and customizable driver interfaces to automobiles that will enable people with disabilities and older adults to live more independently. As such the Center is expected to be an instrument of economic development. In February 2008 we launched the "QoLT Foundry," a pilot program whose goal is commercialization of the Center's research and development through licensing and creation of new companies. A team of business, law, entrepreneurship and policy students led by a former medical devices executive, qualifies market need and potential of new product concepts. It explores those concepts in terms of technical feasibility and development time, market size and competition, time-to-market, regulatory constraints, and other factors. After this preliminary due diligence, product concepts are presented to local economic development organizations, investors and companies affiliated with the Center in "Product Opportunity" meetings. Since its launch, the QoLT Foundry has held three such Product Opportunity meetings, two of which were in the past fiscal year.

Research Development Collaboration

Close collaborations between biomedical researchers, lab scientists, computer and data mining specialists, and engineers are needed to develop technologies that exploit the potential of the second wave of biotechnology development. Such collaborations have been taking place successfully between Carnegie Mellon University and the University of Pittsburgh for well over a decade. The following programs are all formal, sustaining CMU/Pitt collaborations.

- *Biomedical Security Institute*—This program is devoted to bioterrorism and public health readiness and response and combines Carnegie Mellon expertise in data mining and search algorithms with Pitt expertise in medicine and public health. Its research develops computer-based surveillance, analysis and communication capabilities that provide early warning of naturally occurring disease outbreaks and bioterrorist attacks by using real-

time data mining and analysis of selected data streams for detecting patterns consistent with an abnormal or hostile public health event.

- *Bone Tissue Engineering Center*—The center’s mission is to develop technologies that will translate into safe and effective bone and cartilage clinical therapies. These therapies will treat developmental deformities, ablative injuries, degenerative changes, tendon and ligament healing, hypoplastic fat, and vascular insufficiencies. The center’s participants include molecular and cell biologists, polymer chemists, clinicians and engineers drawn from Carnegie Mellon's School of Engineering, Mellon College of Sciences, and Robotics Institute, along with the University of Pittsburgh Medical Center, the University of Pittsburgh, Children's Hospital and Duquesne University.
- *Center for Bioimage Informatics*—Members use advanced signal processing tools and machine learning tools to automate the generation of biological knowledge from cellular and tissue images. The initial focus has been on fluorescence microscope imaging; this will grow to include all major biomedical imaging modalities. This center was founded as a result of a \$9.4 million, five-year, multi-institution Information Technology Research grant from the National Science Foundation; Carnegie Mellon and the University of California, Santa Barbara are co-leading institutions on this grant award.
- *Center for Cognitive Brain Imaging*—Conducts functional magnetic resonance imaging (fMRI) studies to investigate high-level cognition, such as language comprehension, decision-making, and problem solving, using state-of-the-art scanners and techniques. Investigations also include other approaches used in conjunction with fMRI, most notably behavioral studies, computational modeling, eye fixation studies, and therapy studies of people with brain damage. It is one of the world’s leading centers for imaging normal human brain function during thought processes, as well as imaging the effects of brain damage, therapy, and recovery on these processes.
- *Center for the Neural Basis of Cognition*—Studies the neural basis of cognitive processes, including learning and memory, language and thought, perception, attention, and planning. Promotes the application of research results to artificial intelligence, technology, and medicine. Many projects combine one or more of the following methodologies: computational modeling, behavioral analysis of normal behavior and effects of brain disorders on behavior, functional neuroimaging, and electrophysiological recording of neuronal activity. The CNBC’s external advisory board recently identified the Center as one of the top three centers of Cognitive Neuroscience in the world.
- *Medical Scientist Training Program*—This program is designed to produce dual degree graduates. The University of Pittsburgh School of Medicine confers the M.D. degree; the Ph.D. may be conferred either by the University of Pittsburgh Graduate School or by Carnegie Mellon. Over the past several years, many of these students have enrolled in Carnegie Mellon’s Biomedical Engineering Department and are doing research in the Healthcare Robotics Center.
- *Pittsburgh Mind-Body Center (PMBC)*—Established by the University of Pittsburgh and Carnegie Mellon University and funded by the National Institutes of Health, PMBC is dedicated to the scientific study of mind-body interactions in health. During its initial five years of funding, PMBC’s major objective was to understand how the mind

influences the development of and recovery from diverse diseases, including infectious disease, osteoarthritis, early cardiovascular disease, and breast cancer. This objective has evolved into the current emphasis of PMBC to provide an infrastructure of common resources to facilitate the conduct of research and to cultivate new scholars and ideas. The premise of the Center's research rests on the growing realization that many of the ideas about mind/body relationships may be similar across diseases and knowledge learned about one disease may help understand another. In addition, the Center provides training through summer institutes for health care professionals and researchers; offers lectures; and provides small grants to stimulate new research projects.

- *Pittsburgh NMR Center for Biomedical Research*—An NIH-supported national Biomedical Technology Resource Center, bringing together scientists and clinical investigators in a concerted research program focusing on applications of magnetic resonance imaging (MRI) and spectroscopy (MRS) to biomedical sciences using animal models. Center facilities are available to other academic, medical, and industrial researchers. It is a national leader in the field. One of the research projects undertaken by the NMRI Center is the development of a non-invasive methodology to detect the early signs of graft rejection in organ transplantation by MRI using rodent models (supported by a major NIH grant of over \$3 million for five years), if successful, will replace the traditional invasive “biopsy” method to detect graft rejection in transplant patients and reduce healthcare costs. Magnetic resonance imaging (MRI) has also long been a strength and used variously to identify aberrant cell clusters to recognition of aberrant mental processing.
- *Pittsburgh Supercomputing Center (PSC)*—PSC provides state-of-the-art advanced computing resources to national scientists and engineering research communities; educates researchers in the use of supercomputers; introduces industrial firms to the benefit of supercomputing; and serves as a catalyst for campus-based research to advance computational science and techniques. The PSC has been the prime NIH supercomputing resource for biologic efforts for more than a decade. Multiple sequence alignment through supercomputing power will become more important with more genomes sequenced. Structural biology uses still greater processing power.
- *Quality of Life Technology Center*—This Carnegie Mellon/University of Pittsburgh collaboration is a prestigious National Science Foundation Engineering Research Center. Its goal is to allow two populations—older adults and people with disabilities—to live more independently by overcoming cognitive, perceptual and physical disabilities with information technologies and robotics. The team includes researchers in CMU computer science, robotics, engineering, social science and public policy departments and Pitt rehabilitation, engineering, geriatrics and nursing.
- *Technology Center for Networks and Pathways (TCNP)*—This new effort was enabled by and will build upon research conducted through CURE Formula grants that Carnegie Mellon received in FY2002 and FY2004. The center is a partnership of Carnegie Mellon and the University of Pittsburgh. It will create a powerful toolbox of intracellular fluorescent labels and biosensors that can be used to study many, if not all, the proteins in pathways and networks of living cells. Its fluorescent probe development program will blend genetics, protein structure, nucleic acid structure and fluorescent dye chemistry.

The probes will be genetically expressible so that exogenous macromolecules will not have to be transported into the living cells to be studied. Probe technologies will be augmented with imaging and informatics to create tools that help other researchers obtain and manage large amounts of spatial and temporal information about pathways in living cells. The magnitude and duration of the NIH funding will allow us to make these technologies robust so that they can be disseminated to a wide range of investigators in academic research, pharmaceutical drug discovery, and biotechnology.