"…We are positioned to marry the intellectual capital being invested here in the research of pharmaceuticals, medical devices and biotechnology with the manufacturing expertise we have always had."

Congressman James P. McGovern

Manufacturing has a long and rich history in Central Massachusetts. Wire, textiles, machine tools, grinding wheels _ the fruits of the Industrial Revolution _ fueled the growth that made Worcester a manufacturing leader in the 19th and early 20th centuries. While the manufacturing industry has been radically transformed, that tradition provides a solid foundation for the 21st century. Worcester's abundant science and academic institutions, its accessibility and its manufacturing know-how offer it a unique opportunity to lead in a new revolution.

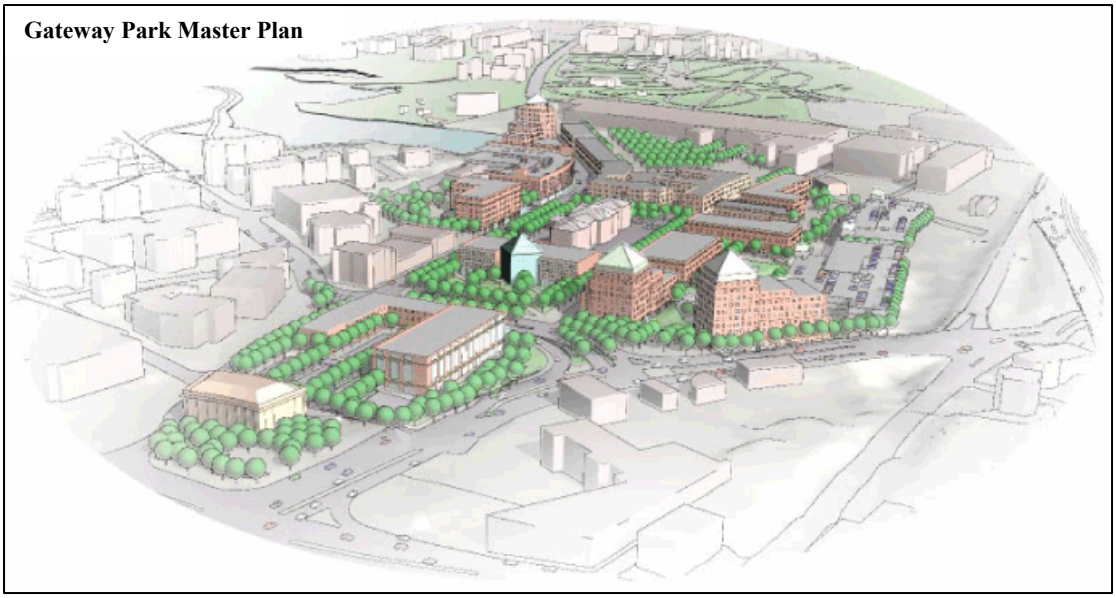
The Manufacturing Advancement Center, through its Manufacturing Our Future summits, brings together corporate, academic and business leaders to cultivate and integrate the region's varied resources to create a life science business cluster and reinvigorate the manufacturing industry. The "cluster" strategy sees interconnected businesses and institutions _ from manufacturers to universities _ as the key to a region's economic growth.

A recent study by the Massachusetts Technology Collaborative highlighted the success of the life sciences business clusters in an otherwise struggling state economy. According to the study, Massachusetts enjoys high levels of federal research and development funding, and corporate R&D funding continues to expand. The survey also revealed the state labor pool has one of the nation's highest concentrations of scientists and engineers.

The 14 colleges and universities in Greater Worcester award an annual average of more than 600 postgraduate degrees in science and engineering studies, according to the Colleges of Worcester Consortium, which includes Umass Medical School, WPI, the Massachusetts College of Pharmacy and Health Sciences, and Tufts University School of Veterinary Medicine. These academic institutions, as well as private companies such as Abbott Research Center, are developing ground-breaking technologies and have helped open a biomedical corridor between Worcester and Boston.

"As a result, we are positioned to marry the intellectual capital being invested here in the research of pharmaceuticals,

Gateway Park Master Plan



medical devices and biotechnology with the manufacturing expertise we have always had," Congressman James P. McGovern said. "The combination of these forces has placed us in the vanguard of an emerging industry and a new economy."

The MAC forum, with the help of Congressman McGovern, helped identify the potential for a biomedical industry business cluster in the area and provided the impetus for the Gateway Park project. The park, like the Biotechnology Park on the city's east side, will be anchored by research and development facilities but will also provide space for commercial and retail enterprises, as well as housing.

The project, involving WPI, the Worcester Business Development Corporation and a private business partnership, targets 55 acres north of downtown Worcester for redevelopment to create a new, vibrant gateway to the city.

Developers envision a dynamic district that includes restaurants, shops, housing

David P. Forsberg, president of WBDC

and a series of plazas and open spaces to promote pedestrian activity. The revitalized site will spark economic renewal with new business opportunities, new jobs, new housing opportunities and additional tax revenue for the City of Worcester. It will open up a link to downtown Worcester and enhance the other institutions in the area, including the Worcester Art Museum, Tuckerman Hall and the North High Condominium complex. The project is bordered by Highland Street, Salisbury Street, Humboldt Ave., Grove Street, Garden Street, I-290 and Lincoln Street.

The coalition, with the help of funding from MassDevelopment, has begun purchasing parcels, cleaning up contaminated sites and restoring some of the existing buildings. The for-profit partnership has restored a building at 85 Prescott St., which now houses the Mass. Academy of Mathematics and Science and office space. That project created 123 new jobs and added $171,200 in tax revenue.

The Bioengineering Institute's Center for Comparative NeuroImaging

The group recently purchased the New England Plating Co. building and is looking at sites at 68 and 60 Prescott St., according to David P. Forsberg, president of the WBDC, who said the group considers historic preservation an integral part of its effort to create a flourishing, modern district.

The project has progressed with support from Congressman McGovern, the City of Worcester, MassDevelopment and others, Forsberg said, but WPI created the critical mass necessary to ensure its success. The park will provide a site for the expansion of WPI's Bioengineering Institute.

Continuing its long tradition of community involvement, WPI formally formed its Bioengineering Institute (BEI) in 2002 to promote the transfer of biomedical technology from research lab to industry and fuel economic growth in the region.

The institute's mission is to identify potential biomedical technologies stemming from research by scientists and engineers at WPI, other academic and health care institutions, government labs and industry. The institute then works to translate those technologies into prototypical medical devices, developing intellectual property that can be licensed to outside companies or that can form the basis for start-up ventures.

"The tangible outcomes will range from new medical products to new companies to new knowledge and expertise," said Dr. Timothy R. Gerrity, director of BEI.

Medical devices span a wide range and include tools for prevention, diagnosis, monitoring and treatment of diseases. Advancements will require manufacturers to supply the critical components. New materials such as novel plastics and coatings, adhesives and lubricants have emerged to reduce infection with implanted devices, attach devices to internal organs, and ease the threading of tiny catheters through the blood vessels.

New manufacturing techniques are being developed to mass produce such things as diagnostic labs on a chip, laser etched microscopic identifying marks on implanted devices, and micrometer-

"The tangible outcomes will range from new medical products to new companies to new knowledge and expertise."

Dr. Timothy R. Gerrity

scaled wires for heart catheterizations and angioplasty.

Dr. Gerrity outlined the work under way at the institute's centers. The Center for Comparative NeuroImaging (CCNI) is playing a crucial role in the advancement of MRI technology. A collaboration of WPI and The University of Massachusetts Medical School, CCNI is pioneering work in high frequency RF coils and three dimensional image reconstruction and is advancing both the diagnostic power of MRI and new approaches to neuropsychiatric research.

Dr. Timothy R. Gerrity, director of the Bioengineering Institute

John Sullivan and Reinhold Ludwig of CCNI are working to combine the diagnostic features of ultrasound and MRI to produce dramatically more specific and sensitive ways of diagnosing breast cancer. They are also developing MRI methods to image animal models of human mental disease.

BEI's Center for Untethered Health Care is creating new approaches to non-invasive monitoring of human health status. Using the latest developments in reflectance photometric techniques, Yitzhak Mendelson and his team are developing non-invasive body surface sensors capable of measuring concentrations of key chemicals in the blood such as oxygen, hemoglobin and glucose.

Many of the new devices, especially implantables, will require reliable, long-lasting fuel sources, and BEI will be working with the WPI Fuel Cell Center to develop new medical device power sources, Dr. Gerrity said.

Looking to the future, Dr. Gerrity said advances in nanotechnology, photonics and micro electromechanical systems, or MEMs, will lead to devices that interact with humans on the cellular level to diagnose and treat disease.

The institute's Center for Bioprocessing and Tissue Engineering is forging a path to new methods for creating specialized cells, tissues and the biochemicals they produce. Examples of the pioneering work done by Alex DiIorio, George Pins and Terri Camesano include:

- **Development** of biopolymers for removal of heavy metals from industrial wastewater.
- **Identification** of ways to improve the design and the performance of bioengineered skin substitutes for burns and other skin injuries.
- **Measurement** of bacterial interaction forces and their relationship to bacterial adhesion, a serious problem

related to infection associated with implantable medical devices.

The institute's Center for Molecular Engineering, under the guidance of W. Grant McGimpsey, has conceived and implemented a novel strategy using nanotechnology for the modification of surfaces at the molecular level, leading to tailor-made thin films.

Of recent note, the Center for Untethered Health Care is working on new, advanced health care delivery systems that rely on telecommunications, remote sensing, informatics and artificial intelligence.

With $830,000 in new funding, thanks largely to the efforts of Congressman McGovern and Massachusetts Sen. Edward M. Kennedy, the center is designing and testing a real-time physiological status monitoring system for soldiers in the battlefield. The system involves wearable vital sign sensors, portable ultrasound imaging, wireless communications, and outdoor/indoor positioning.

In addition to military applications, such systems will soon allow the elderly and chronically ill to live more independently. Patients will be passively and actively monitored for health status while in their homes. Medical decisions will be made before early signs and symptoms progress into a major medical problem.

MBIdeas Innovation Center, 25 Winthrop St., Worcester

Chronically ill patients with diseases such as diabetes will be able to use non-invasive glucose monitors to collect information on glucose levels over days and weeks. This information can be transmitted to a health care provider to spot problems; it can also be used by the patient to learn how to better manage his/her insulin dose, diet, and exercise to maintain proper glucose levels. Artificial intelligence will augment more traditional patient care.

Among the other projects involving health care systems and telemetry, the center is working on:

- Implanted transmitters and receivers for telemetry and control of artificial organs.
- A study into the susceptibility of the common 802.11b wireless LAN technology to intentional jamming and unintentional interference.

Another effort to foster innovation is being undertaken by Massachusetts Biomedical Initiatives (MBI). Its MBIdeas Innovation Centers in Worcester provide an incubator for start-ups in the biotechnology industry. The centers offer state-of-the-art facilities and business assistance, allowing young companies to gain a critical advantage by reaching the marketplace faster and at a lower cost. With the resulting momentum and competitive

strength, the companies are much more likely to attract financing and to achieve long-term success.

Kevin O'Sullivan, vice president of development of MBI, said the goal is to become the best biomedical innovation center in the world.

Kevin O'Sullivan, MBI vice president of development

MBIdeas' facilities at 100 Barber Ave. and 25 Winthrop St. provide:

- **Accelerated startup**: MBI provides use of existing permits, a fully equipped wet lab, and shared facilities and equipment. These include a cold room, hazardous waste storage, a purified water system, autoclave, glass wash, a centrifuge, -80° freezer and flammable refrigerator.

- **Operational assistance**: Staff members handle selected business operations for startup companies, leaving the entrepreneur free to concentrate on research and development, and to implement the company's business and scientific plans.

- **Business consulting and mentoring**: MBI staff has developed the expertise to assist companies in obtaining critical resources at key points in their growth. This expertise not only saves time and money, it also helps startups avoid the pitfalls of technology entrepreneurship.

The Innovation Centers currently house 15 new biomedical companies with more than 50 employees. The newest center, on Winthrop Street in the former St. Vincent Hospital, opened Oct. 1, 2001. That facility comprises 20,000 square feet of fully outfitted and equipped wet laboratories and support office space. The $2.8 million in construction funding for the facility was provided by Economic Development Administration/ U.S. Department of Commerce matched by MBI's private fundraising campaign and MassDevelopment. Partial operating assistance is received from the Commonwealth of Massachusetts Department of Labor and Workforce Development.

The Winthrop Street facility tenants include Verax Biomedical, GlycoSolutions, Bioheart, Beckman Coulter, Sierra Informatics, Worcester Informatics Center, Hypromatrix and Avatar Pharmaceutical Services. GENE-IT and J-QUE Biologics have recently joined the facility as well. O'Sullivan said plans call for the construction of two new ground floor laboratories at the site.

The Barber Avenue facility opened in 2000 and currently is home to Antigen Express, Biomedical Research Models, DXA Resources Group, Polygenx, and Spring Bank Technologies.

These early stage biomedical companies satisfy a scientific and academic need while they create a new and expanded economic base. Investment of new dollars into the Worcester area economy with these MBIdeas companies has

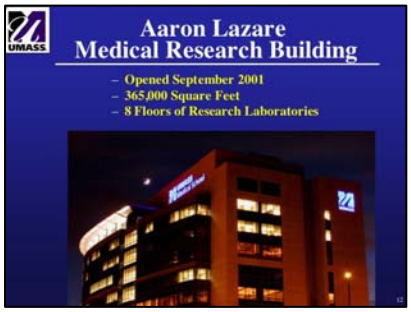
driven the biomedical industry in the region, O'Sullivan said.

Worcester County now has more than 60 biomedical companies, with an estimated 2,700 employees, generating more than $300 million in annual revenue, he said. Projections call for $1 billion in annual revenue by 2010.

Dr. John L. Sullivan, director of UMass Office of Research

O'Sullivan said MBIdeas innovation and research facilities will continue to "graduate" companies and create new ones on an ongoing basis, enhancing the state's status as a leader in the medical industry.

MBI, an independent, tax-exempt corporation, has two other programs: the Central Massachusetts Biomedical Initiative (CMBI), which promotes the biomedical industry throughout the City of Worcester and Central Massachusetts; and the Technology Commercialization Center (TCC), which offers technology transfer, commercialization, and business consulting services for academic institutions and entrepreneurs.



MBI's success has made it a national model for leveraging public sector funds with private sector investments to fuel economic development.

Anchoring the biotechnology cluster in the city is the University of Massachusetts Medical Center. Its research efforts have intensified over the last 20 years, placing it among the top 10 medical schools in the country.

In 1980, UMass received just $3 million in funding from the National Institutes of Health, according to Dr. John L. Sullivan, director of the medical school's Office of Research. In 2002, it received $95 million.

Research at UMass is rapidly expanding to keep pace with the explosion of knowledge in biology and medicine, Dr. Sullivan said.

UMass investigators Craig Mello and Phil Zamore, the discoverers of small interfering RNAs, are national leaders in gene silencing, a process that could lead to targeted medicines to fight such illnesses as cancer and AIDS.

The diabetes research program is pioneering islet cell transplantation as a cure for Type 1 diabetes and unraveling the signal transduction pathways responsible for Type 2 diabetes.

The Center for Infectious Disease and Vaccine Research is a leader in NIH-funded international research programs on emerging viral pathogens. The center's director, Dr. Francis Ennis, serves on the NIH's blue ribbon panel on bioterrorism.

The Biomedical Imaging Group is a model program for the interaction of physicists, mathematicians and

biologists to study cellular events at the molecular level, Dr. Sullivan said. The facility houses the only microscope in the world that can bring to life full 3D movements of cells in real time. Under the leadership of Kevin Fogarty, scientists are developing the next generation high-resolution microscope that will revolutionize the way living cells are studied.

Abbott Bioresearch Center

At the Aaron Lazare Medical Research Building, UMass developed new research programs in gene function and expression, proteomics and chemical biology, cancer biology, and neurosciences.

"We are poised to initiate new synergistic collaborations with university and corporate partners, which will continue to make Central Massachusetts a major player in biotechnology research," Dr. Sullivan said.

Across the street from UMass, in the Massachusetts Biotechnology Research Park, Abbott Bioresearch Center has put Worcester in the spotlight recently and bolstered its claim as a world-class biotech center. Humira, recently approved by the Food and Drug Administration to fight rheumatoid arthritis, was discovered, developed and is being manufactured at Abbott Bioresearch Center.

HUMIRA, previously known as D2E7, is the first fully human monoclonal antibody approved for reducing the symptoms and inhibiting the progression of rheumatoid arthritis in adults. The FDA's approval of HUMIRA came only nine months after simultaneous regulatory submissions in the United States and Europe.

Humira is taken as an injection every other week, making it more convenient than the other two drugs available to the more than 5 million who suffer from rheumatoid arthritis.

Abbott projects sales to reach $150 million worldwide in 2003, $500 million in 2004 and $1 billion by 2006, making Humira potentially the biggest selling drug ever produced by the state's biotech industry.

Illinois-based Abbott has begun a manufacturing expansion to meet future demand for Humira, investing $50 million for a 63,000-square-foot expansion in Worcester. When the fifth biomanufacturing suite is complete in 2004, two-thirds of Abbott's products will be manufactured in the city, Dr. Aruffo said.

The Worcester operation, which employed 330 in 2000, is expected to have more than 600 employees by the end of 2003.

Worcester has provided an ideal location for Abbott's efforts, Dr. Aruffo said.

City officials have been supportive and provided tax relief. And the area's academic institutions provide ample opportunity for collaborative research as well as a highly skilled labor pool and avenues for Abbott's advanced retraining program, Dr. Aruffo said

"Collaboration with academic institutions moves research for medical technology at a rapid pace," he said.

Dr. Alejandro Aruffo, Abbott Bioresearch Center

Worcester's central location and proximity to Cambridge and Boston only enhance its appeal, Dr. Aruffo said, providing easy access to biotechnology companies, academic institutions and more transportation options.

The strides being made in research and development place new demands on the manufacturing industry, and new workforce training programs have been created to deal with rapidly changing production technologies.

The Massachusetts Manufacturing Extension Partnership has organized a Regional Job Skills Alliance to assist small manufacturers. Congressman McGovern, in his role as co-chair for the Advanced Manufacturing Leadership Council, the policy development arm of the National Coalition for Advanced Manufacturing, announced the formation of the group in July 2002.

Training providers at WPI, Saint Gobain Abrasives and NYPRO offer key manufacturing skills to small companies through the Workforce Training Fund Express Grant Program, administered by the state Division of Employment and Training. The grant program provides matching grants to businesses with 50 or fewer employees, which represent 82 percent of the state's manufacturing firms.

MassMEP is also hoping to create a statewide network of alliances, with an eye toward establishing industry-driven standards for critical manufacturing job skills.

The state Express program has given more than $250,000 to small businesses. And McGovern said he and others are pursuing federal funding to support the alliance's mission. These programs are vital to creating a competitive advantage in Massachusetts, he said, but he warned that these efforts are being threatened by tightening federal and state budgets.

"The Commonwealth, Worcester and Central Massachusetts are well positioned to take advantage of several key economic development incentives that have been implemented during the last decade to foster advancements in new and advanced technoliges leading to the manufacturing of new and enhanced products. Incumbent worker training programs, a generous research and development tax credit, coupled with a three percent investment tax credit to encourage manufacturers to invest in

plants and equipment, supported by a tax treatment that encourages manufacturers to market their products and services both nationally and internationally offers manufacturers a significant opportunity to grow and maintain their operations here in an ever increasing competitive world market place." said Richard Lord, president and chief executive officer of Associated Industries of Massachusetts, an employer association of more than 7,500 Bay State employers and institutions.

Corporate, academic and government forces have mobilized to integrate Greater Worcester's assets: affordable housing, a skilled workforce, solid transportation infrastructure, supportive city agencies and tremendous intellectual capital. All the ingredients are in place to create a thriving center in the life sciences industry and place Worcester and Massachusetts at the forefront of a new economy.