FINAL REPORT

TARGETING GROWTH OPPORTUNITIES AROUND BALTIMORE'S BIOSCIENCE RESEARCH ANCHORS

AN ASSESSMENT FOR APPROACHING THE DEVELOPMENT OF THE EAST BALTIMORE LIFE SCIENCES AND TECHNOLOGY PARK AND ADDRESSING BROADER REGIONAL BIOSCIENCES DEVELOPMENT

PREPARED FOR:
East Baltimore Development Incorporated
in collaboration with
Maryland Department of Business and Economic Development, Maryland Technology Development Corporation,
Greater Baltimore Committee and
Baltimore Development Corporation

PREPARED BY:
Technology Partnership Practice
Battelle Memorial Institute

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Targeting Growth Opportunities around Baltimore's Bioscience Research Anchors

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Executive Summary

Assessing the approach to developing East Baltimore's Life Sciences and Technology Park has brought together the East Baltimore Development, Inc. (EDBI), in collaboration with Maryland's Department of Business and Economic Development (DBED), the Maryland Technology Economic Development Corporation (TEDCO), the Greater Baltimore Committee and the Baltimore Development Corporation. These organizations recognize that going from the ideal of a research park anchor to tailoring a specific approach for the Baltimore region requires a better understanding of how the region's strengths and capabilities in the biosciences can best be translated into targets of opportunity for bioscience economic development.

So, this analysis, while focused on identifying specific targeted growth opportunities for the East Baltimore Life Sciences and Technology Park, also speaks to the broader positioning of biosciences development in the Baltimore region and other key anchor projects being developed.

Project Methodology

The project methodology includes a comprehensive and integrated set of analyses, including:

- **Competitive benchmarking analysis** that involves analysis of Baltimore position across measures of industry, innovation, workforce and research activity.
- **Best practices benchmarking** examining the experience of leading regions in research park development, particularly focused on insights into the pace of development, key design features, role of incubation and new venture development, and specific mechanism supporting their success.
- **Research core competency analysis** to explore areas of research focus based on publications and grant activities and extensive interviewing at the academic health centers.
- **Target opportunity identification** based on the tangible and specific possibilities for near-term development that represent the intersection of research and industry activities.
- **Assessment of key support mechanisms and activities needed** to translate bioscience growth opportunities into realized development.

A steering group of industry, academic and community stakeholders was organized by East Baltimore Development, Inc. to guide the analysis and project results. This steering group came together to guide and review the analysis performed by the Battelle Technology Partnership Practice, which was engaged to develop an analysis of the region's position in biosciences development and identify targets of opportunity for future development.

Vision of Success

The vision of success starts with the understanding that regions compete with other regions, and the development of locations within regions promote strength and development momentum that is complementary and contributes to growth across the region.

With this in mind, it is critical for East Baltimore's bioscience development that it be linked to a broader regional focus, while at the same time pursue specific targets of opportunity for its

development, leveraging the strengths of Johns Hopkins University (JHU) medical complex and building partnerships with other research drivers.

Region-wide Vision: The Baltimore region will establish one of the world's premiere biomedical districts linking together its world-class hospitals and medical schools, with a robust commercial bioscience research and diagnostic services cluster to create a high value-added environment for fostering new bioscience ventures and attracting leading biotechnology, medical device and pharmaceutical companies to the Baltimore region.

East Baltimore Vision: East Baltimore's Biotech Research Park will be a key anchor and driver for the region's growing bioscience industry cluster by:

- Serving as a hub for the region's commercial research services cluster
- Offering an entry point into JHU from advancing broader relationships with bioscience industry to enhancing the ability to generate new bioscience ventures
- Enabling emerging bioscience companies and initial operations of existing bioscience companies to gain a foothold in the region
- Providing educational and training facilities with a strong outreach to minority community and existing workers seeking careers in the biosciences and upgraded skills
- Addressing, in partnership with the community, ways to improve public health in the East Baltimore area

SITUATIONAL ANALYSIS

The Baltimore region is at an important crossroads in the development of its biosciences cluster. On one hand, biosciences are a key asset for the Baltimore region. The region is among the national leaders in biomedical research and clinical care. Baltimore City is ranked 4th among all cities in the total amount of research funding from the National Institutes of Health (NIH) to its research universities and hospitals, and is also home to NIH's intramural research programs for the National Institute on Aging and National Institute on Drug Abuse. Baltimore is also a leading center for innovative clinical care with its two leading academic health institutions, Johns Hopkins University and the University of Maryland, Baltimore (UMB) and their associated teaching hospitals, being nationally ranked among the best hospitals in the nation.

More problematic is that while the bioscience research base in the Baltimore region continues to enjoy strong growth, the biosciences industry base has been flat and has failed to keep pace with national growth and existing and emerging regional competitors.

Across the broad bioscience sectors of hospitals and medical labs, drugs, medical devices, commercial research and testing, and agricultural chemicals and biotech, total biosciences employment in the Baltimore region reaches 68,608 across 724 establishments through the first quarter of 2003, according to Dun & Bradstreet's *Marketplace* survey. As a share of total employment, the Baltimore region stands 27 percent higher in its presence of bioscience employment compared to the national average.

But the pace of development of the biosciences industry in the Baltimore region is lagging. Dun & Bradstreet's *MarketPlace* survey reports that total biosciences employment in the Baltimore

region has been flat over recent years, while growing by 11 percent nationally from 1st quarter 1998 to 1st quarter 2003 and recording strong gains in leading competitor regions, such as Boston and San Francisco.

So, despite the size and breadth of the biosciences in the Baltimore region, there is a concern that the Baltimore region has not yet realized the substantial commercial potential of its biosciences base. At the same time, the last ten years have witnessed the rise of a new set of commercial bioscience national hotspots, including San Diego, Research Triangle, and Seattle, while nearby regions of Suburban Washington, Richmond and Philadelphia have made great strides.

The need for new anchor developments to better leverage the strengths of the growing biomedical research base and catalyze biosciences industry growth in the Baltimore region has never been greater.

TARGET GROWTH APPROACHES

To realize this vision, the Baltimore region needs a diversified growth strategy that can leverage the assets and address the weaknesses and gaps found in the region relating to biosciences development.

Four key growth opportunities should be pursued with a near term focus on growing a robust commercial research business cluster complemented by an ongoing, sustained effort in promoting active relationships with leading national bioscience firms to gain a stronger presence in the Baltimore region, fostering a new generation of leading therapeutic and medical device companies in the Baltimore region and generating the talent pools to support broader biosciences development.

These targeted market opportunities translate into a conceptual plan for the development of the East Baltimore Life Sciences and Technology Park. Specifically, the East Baltimore Life Sciences and Technology Park can become within the context of a broader regional development:

- A hub for the region's commercial research and diagnostic services cluster
- An entry point for biosciences industry into the JHU environment with a strong focus on advancing broader R&D relationships with bioscience industry
- Enhancing the ability to generate new bioscience ventures leveraging the major research programs found at JHU
- Providing educational and training facilities with a strong outreach to minority community and existing workers seeking careers in the biosciences and upgraded skills

Another key role that the East Baltimore Life Sciences and Technology Park can serve is to advance public health interventions and community-based public health enterprises by addressing, in partnership with the community, ways to improve public health in the East Baltimore area. This additional activity can clearly demonstrate the Park's recognition of the need to improve the quality of life in East Baltimore, not only in generating jobs and skills development for residents, but in broader community impacts.

A range of specific opportunities for the East Baltimore Life Sciences and Technology Park have been identified that are aligned with the overall targeted growth opportunities for Baltimore. In addition, a number of critically important mechanisms and resources are needed to ensure the success of the East Baltimore Life Sciences and Technology Park. Three particular mechanisms stand out:

Summary of Baltimore's Bioscience Position:
A Strengths, Weakness, Opportunities & Threats Analysis

The intelligence gathered through the competitive positioning analysis of Baltimore and specific capabilities found in the Baltimore region, can be organized into a comprehensive analysis of the overall strengths, weaknesses, opportunities, and threats (SWOT) facing the region in developing its biosciences base. This SWOT analysis reveals the situational analysis confronting the Baltimore region and helps point towards strategic course of action that can be pursued to ensure success for the proposed East Baltimore Biotech Park, as well as the broader region.

Strengths

- The Baltimore region is a national leader in biomedical research with two major academic health centers and the presence of other university and non-profit research drivers.
- Cluster analysis of NIH grant awards including all regional institutions finds not only strengths in particular disease areas of the biosciences, but a particular depth—led by JHU—in basic biological research tools, techniques and understandings cutting across diseases.
- Growing base of industry support for research both at JHU and UMB.
- Presence of leading hospitals generating substantial employment and a regional specialization.
- A largely overlooked sector in Baltimore is bioscience commercial research and testing. With 102 establishments and an employment base of over 1,500, it stands 25% more concentrated than the nation.
- Growing levels of NIH funded SBIR activity in Baltimore.

Weaknesses

- Lack of critical mass of bioscience industry.
- No tradition of sustained collaborations among institutions across Baltimore.
- Gaps in translating biological targets into new therapeutics seen as big deficient at JHU.
- Generally a poor performance in region in fostering bioscience commercial innovations.
- Lack of affordable research laboratory space.
- Perception by small and emerging bioscience companies that academic health centers are not receptive partners, nor interested in assisting companies.
- Biosciences community in Baltimore not well-organized and networked.
- JHU viewed by venture capitalists as not ripe for technology commercialization, despite the quality of the research.
- Baltimore seen as missing in managerial talent, venture capital and management support.

Opportunities

- Strong brand name of The Johns Hopkins University.
- Promote collaborations across Baltimore bioscience institutions, particularly in drug discovery and development and biomedical device development.
- Changing the paradigm from technology transfer to technology commercialization.
- Proximity of Baltimore to major pharma and biotech firm concentrations.
- Presence of post-docs and graduate students.
- Broad base of bioscience employment opportunities.
- Biomedical device potential found in the region.
- Opportunity for leadership to make a major difference

Threats

- Other regions may continue to move ahead, creating wider gaps between Baltimore and leading regions and making it more difficult to create a robust bioscience industry cluster.
- Competition from suburban areas is strong, and inner city research park locations will need to address more than just industry-university relationships and opportunities.
- The ability to attract quality and star faculty to Baltimore—a key to the past successes of the region in the bioscience—may be compromised by lack of entrepreneurial environment.

- Addressing the ability to create affordable wet-lab space on an ongoing basis;
- Establishing an industry liaison that functions both strategically and day-to-day to advance collaborations with industry;
- Forming a technology commercialization entity tailored to the needs of the Baltimore region to advance the formation of new start-up ventures, while also tackling the broad entrepreneurial culture of the region.

The following chart summarizes the specific opportunities identified for East Baltimore and the key incentives and program activities required.

Table 1: Opportunities Identified for East Baltimore

Targets for Growth	East Baltimore Opportunities	Key Incentives and Program Activities
Grow a robust commercial-oriented bioscience research services cluster	• JHU genomic core labs, including gene sequencing, cell culture, and new genotyping • Transgenics facilities operated by commercial operator • Bio-informatics core facilities as a partnership between JHU and leading information technology companies	• Affordable space, possibly with incentives for build out and initial attraction.
Promoting active R&D relationships with existing bioscience firms	• Attracting satellite R&D activities	• One stop industry liaison activities • Innovative approaches for shared use of post-docs • Advancing broader programs that link basic research and clinical research
Foster a new generation of leading therapeutic and medical device companies in the Baltimore region through a comprehensive bioscience technology commercialization effort.	• Key targets of opportunity: • Advancing drug discovery and development • Biomedical device, instrument and diagnostic development • Co-location of incubator facilities	• Funding support for development of proto-typing and incubator space development • One stop industry liaison activities. • Support of a technology commercialization initiative as a partnership between TEDCO, EBDI, City of Baltimore and universities. • Entrepreneurial development programs—like Limbach Enterpreneurial Center, build off Biotech Network

Table 1: Opportunities Identified for East Baltimore (cont.)

Targets for Growth	East Baltimore Opportunities	Key Incentives and Program Activities
Supporting the growth and attraction of bioscience businesses through the region's ability to generate talent pool of bioscience workers at all levels	• Expanded home for BTI • Training for entry level bioscience lab technicians • Skill upgrading for bioscience lab workers • Augmenting and integrating with Dunbar High School and pursuing other specialized life science schools • Strong outreach and technical assistance programs to K–12 for Baltimore region in conjunction with UMBI	• Need for state, federal, local, and foundation funding support
Advancing public health interventions and business opportunities	• Location of Morgan State public health program • Support establishment of community-based businesses for health services	• State funding for new Morgan State facility • Partner with Open Society

Staging the Development of the East Baltimore Life Sciences and Technology Park

The development of the East Baltimore Life Sciences and Technology Park is a long-term project. Similarly, the integration of the proposed development activities also should be viewed over distinct time periods.

It is proposed that the East Baltimore Life Sciences and Technology Park be staged in three periods:

- Stage 1 – Anchoring the Park
- Stage 2 – Developing the Park
- Stage 3 – Maturing the Park

Stage 1 – Anchoring the Park

In this first stage, it is critical to show development activity that reflects the value proposition of the Park as set out in its vision statement. It is important that the Park not be set apart from the community as an unfriendly and unknown place where people go to work. Rather it must be a place that also offers services to the community for education and training as well as public health.

Five specific activities are proposed to anchor the park:

- Establishing a hub facility for bioscience commercial research activities. This would include the development of a multi-tenant wet-lab enhanced facility to house the laboratories of the JHU Genetic Resource Core Facility, as well as possibly a centralized pathology laboratory,

and an informatics core with server farms and grid access. A specialized wing or adjacent facility might also be developed for transgenics animal models.

- Design and launch the technology commercialization and entrepreneurial development initiatives, including incubator and prototyping space for targeted development in medical device and drug development as part of a BioCollaboratory. This can be incorporated into the commercial research hub facility or if sufficient funding is available for facility and operating support as its own facility.
- Establish the industry liaison function – addressing region's value proposition to industry – and ensure availability of a small amount of space (15,000 to 25,000 sq. ft.) in the commercial hub and/or biocollaboratory facility for potential satellite research offices, post-incubator companies and commercial research companies.
- Educational and training facility that would be anchored by housing the BioTechnical Institute of Maryland, Inc. (BTI) and would also be the home for expanded K-12 bioscience offerings expanding on Dunbar High School, reaching out to lower grades and offering shared lab space for students at other schools. Many of BTI's classes for its current programs with young adults moving into bioscience careers and continuing skill upgrading for existing bioscience workers would be held in the evening so laboratory and classrooms could be shared between the ongoing BTI activities and the charter school. It is suggested that separate entrances, office and open meeting space be constructed, so as to maintain the identities of the separate programs. It is expected that many of the laboratory technician positions needed by the hub commercial research facility will be filled by those going through the BTI training program, and that workers at the hub facility would be taking skill upgrading programs at the education and training facility through BTI.
- A new facility for the Morgan State Public Health Program be developed. This facility might also offer some swing space for other Morgan State researchers to have close labs to JHU, as well as dedicated space for outreach education and training geared for the community.

This initial anchoring stage could take up to two years.

Stage 2 – Developing the Park

The second stage in the development of the park will be focused on realizing the fruits of the pro-active outreach marketing effort and the technology commercialization program put in place as part of the first stage of activities.

The types of developments anticipated are primarily multi-tenant facilities, with key anchor tenants helping to advance specific multi-tenant facilities.

A full scale BioCollaboratory incubator and prototyping facility should be developed if not already in place with appropriate state, local, federal, private foundation and other support.

It is expected that this stage of activity in developing the park will take another two to three years.

Stage 3 – Maturing the Park

As the park emerges from its second stage, a steady program of space development will be required to ensure that there is always available at least 25,000 to 35,000 sq. ft. of absorbable space. Without this continual development stream, the momentum of development can be stalled.

This focus on sustained development must be factored into the development mechanisms for the park.

It is also likely that build to suit facilities for individual tenants will occur as the park matures, if not earlier.

CONCLUSION

The East Baltimore Life Sciences and Technology Park is an important anchor not only for the redevelopment of the East Baltimore area, but for the overall regional biosciences development of the Baltimore Region. The park can help lead growth in the targeted opportunities identified for the Baltimore region. The analysis identifies specific opportunities for carrying out the initial start-up of the research park, as well as key development mechanisms that need to be put in place to ensure ongoing development in the future. Ultimately, the success of the research park as well as the region's efforts to broaden its bioscience cluster with a strong commercial bioscience business base will depend on the leadership from universities, government, industry, and foundations in the region.

I. Introduction

The development of East Baltimore's Life Sciences and Technology Park has brought together a number of leading economic and technology development organizations interested in assessing the Baltimore region's position and identifying targeted growth opportunities around its bioscience research anchors.

These organizations recognize that going from the ideal of a research park anchor to tailoring a specific approach for the Baltimore region requires a better understanding of how the region's strengths and capabilities in the biosciences can best be translated into targets of opportunity for bioscience economic development.

This analysis, while focused on identifying specific targeted growth opportunities for the East Baltimore Life Sciences and Technology Park, also speaks to the broader positioning of biosciences development in the Baltimore region and other key anchor projects being developed.

Organizations Supporting Analysis of Targeted Growth Opportunities for Baltimore

East Baltimore Development, Inc., in collaboration with:

- Maryland Department of Business and Economic Development (DBED)
- Maryland Technology Economic Development Corporation (TEDCO)
- Greater Baltimore Committee
- Baltimore Development Corporation

The Opportunity and Challenge of Biosciences Development in the Baltimore Region

Biosciences are a key asset for the Baltimore region. The region is among the national leaders in biomedical research and clinical care. Baltimore City is ranked 4th among all cities in the total amount of research funding from the National Institute of Health (NIH) to its research universities and hospitals, and is also home to NIH's intramural research programs for the National Institute on Aging and National Institute on Drug Abuse. Baltimore is also a leading center for innovative clinical care with its two leading academic health institutions, Johns Hopkins University (JHU) and the University of Maryland, Baltimore (UMB) and their associated teaching hospitals, being nationally ranked among the best hospitals in the nation.

Not surprisingly, the biosciences also represent a major base of employment in the Baltimore region. Across the broad bioscience sectors of hospitals and medical labs, drugs, medical devices, commercial research and testing, and agricultural chemicals and biotech, total biosciences employment in the Baltimore region reaches 68,608 across 724 establishments

Leading Bioscience Research Drivers in the Baltimore Region

- Johns Hopkins University
- University of Maryland, Baltimore
- NIDA & NIA
- University of Maryland Biotechnology Institute
- University of Maryland, Baltimore County
- Aberdeen Proving Ground

through the first quarter of 2003, according to Dun & Bradstreet's *Marketplace* survey. As a share of total employment, the Baltimore region stands 27 percent higher in its presence of bioscience employment compared to the national average.

But the pace of development of the biosciences industry in the Baltimore region is lagging. Dun & Bradstreet's *MarketPlace* survey reports that total biosciences employment in the Baltimore region has been flat over recent years, while growing by 11 percent nationally from 1st quarter 1998 to 1st quarter 2003 and recording strong gains in leading competitor regions, such as Boston and San Francisco.

So, despite the size and breadth of the biosciences in the Baltimore region, there is a concern that the Baltimore region has not yet realized the substantial commercial potential of its biosciences base. At the same time, the last ten years have witnessed the rise of a new set of commercial bioscience national hotspots, including San Diego, Research Triangle, and Seattle, while nearby regions of Suburban Washington, Richmond and Philadelphia have made great strides.

ADVANCING NEW BIOSCIENCE-FOCUSED RESEARCH PARKS AS ANCHORS FOR FUTURE BIOSCIENCE DEVELOPMENT

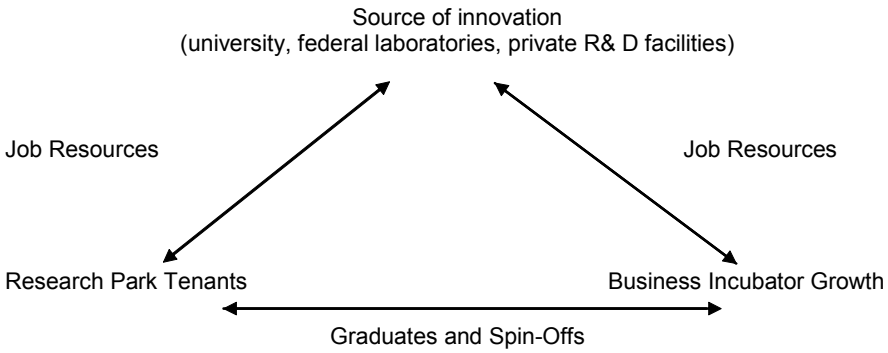
The Baltimore region can not afford to stand still in the face of this national and regional competition for biosciences development, particularly commercially oriented biosciences development. Fortunately for the Baltimore region, a range of anchor developments are going forward to support biosciences development, including two new research park developments in Baltimore City.

- On the east side of Baltimore City, the East Baltimore Development, Inc. is pursuing a major biotech research park, as part of a comprehensive redevelopment strategy for that area of Baltimore City, which includes the Johns Hopkins University medical complex.
- While on the west side of Baltimore City, the University of Maryland is pursuing a smaller scale technology park across from its campus along Martin Luther King Boulevard.

These new research park developments are complemented by other recent research park and incubator developments in the region, such as the University of Maryland Baltimore County (UMBC) research park and the Battelle Eastern Technology Center in Aberdeen, as well as the development of a new incubator at the Eastern High School site in Baltimore City and the presence of the UMBC emerging technology center just off of Interstate I-95.

The value of these bioscience-focused research parks goes beyond their physical facilities to the roles they can play as a catalyst for development bringing together the assets of a region's research institutions, hospitals and industry base. Research parks can create an environment that fosters collaboration and innovation and promotes the development, transfer and commercialization of technology by providing a location in which researchers and companies operate in close proximity. The concept behind the value added of research parks is set out in Figure 1. Research parks are seen as enablers of idea flow between the technology generators (universities, public and private research laboratories) and the companies located in the research park. In addition, the innovations, technology, and knowledge generated by the companies and research institutions lead to attracting units of established research organizations and the creation of new start-up companies.

Figure 1
Research Park Concept



Adapted from: "Positioning Research Parks for Success", Guy T. Mascari. *Economic Development Commerntary*, Vol. 23, No. 4, Winter 2000, p. 38.

Research parks can play a particularly important role for biosciences development:

- **First, the close linkages between bioscience product and venture development and research activities makes proximity offered by research parks a particularly important competitive advantage.** Unlike other technology fields, product development in the biosciences draw more frequently on advances in basic sciences generated by research institutions, such as for advances in new drug targets, advances in biomedical instrumentation for imaging or diagnostics, and identification of improved medical approaches for treating diseases. Moreover, because of the strict regulatory environment surrounding the introduction of new therapies and devices for medical treatment, bioscience research institutions are critical in undertaking clinical research. So having physical locations with close ties to bioscience research organizations can provide an important competitive advantage of proximity.
- **Access to specialized lab space is another key need in biosciences development that biosciences-focused research parks can address.** Bioscience development also requires highly specialized lab space providing wet lab facilities that meet key clean room requirements for sterility. This specialized lab space is expensive to construct and is not adequately supported by the commercial real estate market because of its perceived specialized use. So bioscience-focused research parks by offering available wet lab space can be an important resource for attracting and supporting commercial biosciences development.
- **Home for incubation of new bioscience start-ups.** Combining the proximity to research drivers with the availability of bioscience wet lab space can enable effective biosciences incubation programs that assist in moving high commercial potential research discoveries into the marketplace with a variety of new venture formation assistance from market analysis to proof-of-concept to business planning to recruiting management teams to attracting venture financing.
- **Access to talent.** An important ingredient in the success of a region in the biosciences is having an environment that generates, attracts and retains talent pools of specialized workers in the biosciences. Research parks can serve as an important intersection of complementary talents, from bioscience researchers to bioscience company management to technicians. More directly, research parks can leverage students for internships and coop programs

creating new relationships, and increasingly research parks are also becoming sites for advanced training programs and specialized educational programs in the biosciences. Finally through its innovation support activities from incubators to testing and applied research facilities, research parks can be a place where more senior faculty and post-graduate researchers can effectively interface with bioscience entrepreneurs and existing and emerging companies.

- **Creating a focus and image of the biosciences in a region.** One key element for advancing a region's biosciences base is creating a sense of place. Even regions with significant bioscience activity can fail to recognize its presence because so much of biosciences activities occur behind the formidable walls of major institutions, such as medical schools, research universities and hospitals, or are scattered across a region in individual bioscience venture locations. Research parks can serve to create a sense of focus and momentum for a bioscience community by serving as a key meeting place and outreach point for the different sectors of a bioscience cluster.

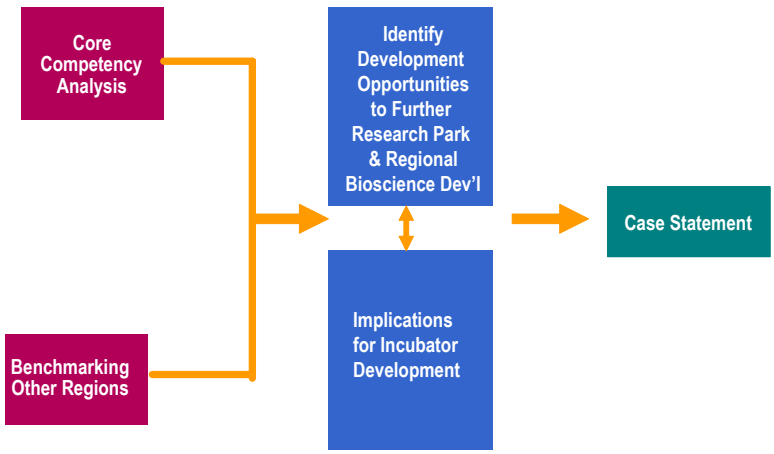
While there are lessons of effective best practice in bioscience research parks, there is not a one-size fits all approach. Instead each community must inventory its assets and determine how best to target growth and development. That is the focus of the remainder of this analysis.

Approach to Assessing Baltimore's Position and Targeted Growth Opportunities for Biosciences Development

The East Baltimore Development, Inc., in collaboration with Maryland's Department of Business and Economic Development (DBED), the Maryland Technology Economic Development Corporation (TEDCO), the Greater Baltimore Committee and the Baltimore Development Corporation, engaged the services of the Battelle Technology Partnership Practice to develop an analysis of the region's position in biosciences development and identify targets of opportunity for future development.

The Battelle Memorial Institute is one of the world's largest non-profit research and development organizations. Battelle's Technology Partnership Practice is a leading technology-based economic development consulting group. The Battelle Technology Partnership Practice brings a strong understanding of the dynamics and requirements for growing a bioscience cluster, along with proven expertise in research park development, including work in such states and regions as St. Louis, Pittsburgh, Arizona, Colorado, Georgia and Memphis. Battelle brings a well-grounded understanding of the bioscience industry and research base found in Baltimore and Maryland, with its senior staff having worked

Figure 2: Opportunity Assessment Approach



extensively in Maryland on biosciences development in previous positions.

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- **Research core competency analysis** to explore areas of research focus based on publications and grant activities and extensive interviewing at the academic health centers.
- **Target opportunity identification** based on the tangible and specific possibilities for near-term development that represent the intersection of research and industry activities.
- **Assessment of key support mechanisms and activities needed** to translate bioscience growth opportunities into realized development.

As part of this effort, an extensive number of interviews were undertaken involving key officials in industry, higher education and academic health centers, and economic development. Altogether, more than 40 interviews were undertaken.

The result is the development of a business case statement that presents Baltimore's opportunity to advance its bioscience cluster around major niches and opportunities. This case statement can be used to help develop a consensus on the region's brand and image in the biosciences and to help mobilize the private and public sectors for needed actions.

The organization of this business case statement is in three parts:

- First, the Baltimore region's position in biosciences, which brings together both the competitive benchmarking analysis and the core competency analysis, is considered. This positioning analysis is summarized in a strengths, weaknesses, opportunities and threats analysis.
- Next, the experiences and lessons from other leading regions to help inform the proposed efforts in East Baltimore and across the Baltimore region are examined.
- Finally, a vision and specific details regarding targets of opportunity for biosciences development is offered that discusses key mechanisms and investments needed to seize the potential of these targeted opportunities.

II. Position of Baltimore's Bioscience Base

To assess the Baltimore region's position in the biosciences, it is important to consider four critical drivers for biosciences development, namely:

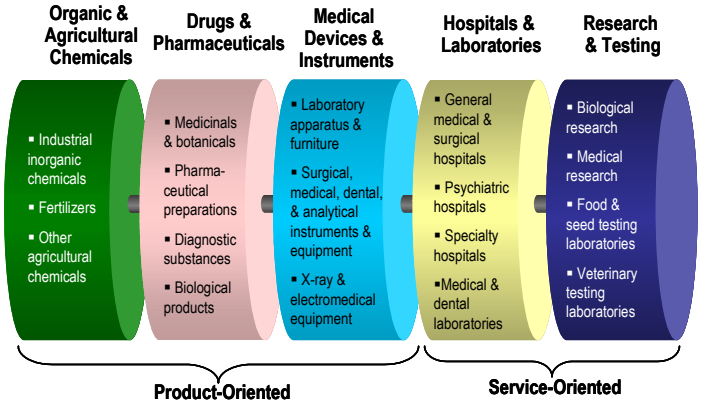
- Bioscience research base
- Bioscience industry base
- Innovation activity
- Talent generation

Here's why these drivers are particularly important for biosciences development:

Bioscience research base. Unlike other industries—even many high tech clusters—product and new venture development in the biosciences have strong links to basic and clinical research activities. Part of this is due to the emerging nature of biosciences research where new fields are being pioneered, and part is due to the need to conduct research on patients in which medical schools and teaching hospitals offer significant access. But even in medical devices, bioscience research institutions play a key role in identifying key needs, developing innovative solutions and helping to test and refine new innovations. But it is not just the size of the research activity, but how smartly it is developed and applied. Those regions able to bridge from basic to clinical research and impact on the development of new advances in medical care and other bioscience tools and products in what is referred to as "translational research" are able to leverage their research bases as a direct driver for new economic opportunity.

Bioscience industry base. Ultimately the way to judge success or standings of bioscience development is the extent that it has translated into growing bioscience-related industries. One key feature that marks the biosciences is the extensiveness of the industry opportunities it offers, ranging across manufacturing, services and research activities as well as broad market areas from drugs and pharmaceuticals to medical devices to commercial research and testing to hospitals and laboratories to agricultural biotech, and many new arenas such as industrial biotech and environmental biotech. The common factor across these industries is the application of biological knowledge and processes. Together, just the sectors of health care, drugs, medical devices and agricultural chemicals represent nearly 6.5 million jobs and more than $600 billion of output across the nation. It is also a growth sector. Over the past seven years, bioscience industries have grown by 11 percent, adding nearly 650,000 jobs nationally. Based on the latest Bureau of Labor Statistics industry employment projections covering the ten year period

Figure 3: Illustration of Range of Bioscience Industry Sectors



ending 2010, the broad non-clinical bioscience industries—including medical devices, drugs, agricultural chemicals and research and testing—will average annual increases of 2.9 percent nearly double the overall employment growth rate of 1.6 percent annually.[1] The aging of our population and growing life spans are key market forces driving growth across many bioscience industries.

Innovation activity. Clusters are not simply creatures of past experience, but can be grown from investments in new capacities and translating assets into development. Key to growing a region's biosciences cluster beyond where it stands today is the ability of a region to foster bioscience innovations, particularly to leverage its research base. Given the close connection of the biosciences research discoveries to new product innovations and new venture development, a region that excels at translating its basic research to clinical advances in new drug therapies, devices or medical practices can give root to major bioscience industry development.

Bioscience workforce and educational capacity. Like other technology fields, a region's capacity to support the growth and development of the biosciences depends upon having a skilled workforce and generating graduates in bioscience-related fields. The popular vision of the life sciences industries are jobs dominated by PhDs and medical doctors. But in fact the largest occupations are those found in production occupations for drugs, agricultural chemicals and medical devices. Leading occupations include laboratory technicians, manufacturing technicians, quality control and regulatory affairs workers. For hospitals, the leading field is health care practitioners, though they only comprise about one-half of the total jobs in hospitals. Among the health care practitioners, doctors are not the dominant occupation, comprising under three percent of all hospital workers, rather it is registered nurses and nurses aides, who combined represent nearly one-third of hospital workers. Looking to the future, bioscience workforce will need to be an increasingly multi-disciplinary workforce integrating computer science, engineering disciplines, nanotechnology and other physical sciences to advance discoveries, develop products and deliver services.

These four drivers of biosciences development are highly linked and interdependent. For instance, bioscience workforce and educational capacity is closely linked with the level of development of its bioscience research base and in turn the bioscience research base depends upon the ability to attract, retain and develop top flight researchers and associated research technicians. Meanwhile, the capacity to advance innovations reflects both the quality and depth of the local research base as well as the presence of bioscience industry, with its associated expertise in management, product development, marketing and other key requirements to support new and emerging bioscience ventures. And finally, the bioscience industry base is advanced by the region's innovative capacity to start and grow bioscience ventures, draws upon the availability of skilled workforce, and is enhanced by collaborations with research drivers.

In considering Baltimore's position across these four drivers of bioscience development, two points of view are considered:

- One is how the Baltimore region compares to other leading regions along a range of key quantitative dimensions of bioscience development to learn how Baltimore is different from other regions.
-

[1] U.S. Department of Labor, "Industry Output and Employment Projections to 2010," November 2001, calculations of biosciences by Battelle.

- The second approach is to examine specific strengths and capabilities found in the Baltimore region that can offer possibilities for targeting development initiatives.

For the quantitative benchmarking analysis, a broad set of ten regions was identified in consultation with members of the Steering Committee. These include regions that are national leaders (Boston, San Francisco and Research Triangle), regions with strong bioscience research bases (New Haven, Philadelphia, Chicago, Pittsburgh), and regions with successful research parks associated with academic health centers (Worcester, MA, Richmond, and Newark).

The examination of specific strengths and capabilities found in the Baltimore region, meanwhile, involves specialized data analysis and was the focus of interviews with academic researchers and officials and industry executives in the Baltimore region.

HIGHLIGHTS OF BALTIMORE'S POSITION IN BIOSCIENCE RESEARCH

As already noted, Baltimore stands as one of the nation's leading regions in biosciences research.

A closer look at the trends in bioscience research funding shows that the Baltimore region continues to be making strong gains in biosciences research. The Baltimore region outpaced the nation and all of the benchmark regions in the growth of university-related bioscience research, growing at 50.3 percent compared to 38.8 percent. In NIH funding, where Baltimore City ranks 4th in the nation, the region enjoyed strong growth of 57.4 percent from FY 1997 to 2001, though slightly below the total NIH growth in extramural funding of 63.2 percent.

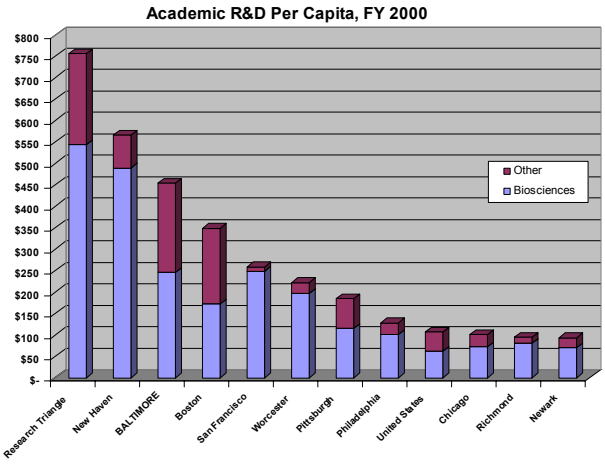
A major new driver for research funding at Baltimore research institutions is industry sponsored research, which now reaches a combined $100 million between The Johns Hopkins University Medical School and the University of Maryland, Baltimore Medical School. In the case of JHU School of Medicine, industry sponsored research stood at only $1.5 million in 1986 and now has risen to $55 million in 2002. The lion share of industry-sponsored research goes for clinical research activities, involving clinical trials, but important pre-clinical research relationships are also present.

- For JHU, cancer and general medicine are the leading areas of industry support (clinical trials, pre-clinical, sponsored research, licenses, etc).
- Cancer research, focused on head and neck, brain, prostate, lung, lymphoma, and breast cancer, is the highest area of industry funding, and 2nd highest in total number of industry supported projects. JHU has been particularly successful in gaining large numbers of National Cancer Institute (NCI) funded Special Programs of Research Excellence (SPOREs), which provide important resources for advancing specialized multi-disciplinary resources and enabling a more value-added collaboration for industry, particularly in moving industry clinical trials forward with NCI review processes.
- Medicine, led by asthma and allergies, represents the 2nd highest level of industry funding, and highest in number of total projects—another leading area of clinical research.
- The University of Maryland, Baltimore is active in both clinical trials activities with industry as well as a number of key research relationships. Examples of key industry activities include:
- Substantial clinical trials activities with industry in the area of new cancer treatments.

- There is an extensive corporate relationship between the Maryland Psychiatric Research Center and Novartis.
- A significant ongoing research relationship on innovative drug delivery technologies is in place with ALZA.
- Model for establishing industry relationships in other areas of psychiatric disorders.

What also stands out about the Baltimore region is that its overall university research base is more diversified than other regions. Only Boston and Research Triangle, among the benchmark regions, have as much non-bioscience research activity ongoing as the Baltimore region in its university base.

Figure 4: Academic R&D Per Capita, FY 2000



The importance of technology convergence is found across the biosciences from the development of bioinformatics, which integrates advanced information technologies particularly data mining, large scale database management and scientific computing to advance the biological fields of genomics and proteomics, to bioengineering which applies the principles and methods from engineering to understand, define, and solve problems in medicine, physiology, and biology and is critical for advancing new medical equipment and devices from imaging to implants to new organs. NIH's recently advanced roadmap—the first ever—promotes more specialized centers of inter-disciplinary research as well as specific centers for bioinformatics and bio-nanotechnology.

Basic biological research is a key strength of ongoing research enterprise in Baltimore. It represents the leading cluster area of NIH grant activity as well as a major area of excellence in publications.

- Using a data mining software program to group NIH grants based upon textual similarities in each of the grants' abstracts identified basic biological research as the largest and most diverse cluster area, spanning 566 grants across six clusters. It involved a broad range of activities from the genetic basis of diseases to immunology to protein analysis to mice models. What makes these activities "basic" in orientation is that the clustering was cross-cutting in disease areas and specific institutes at NIH funding the research.
- Moreover, in publications research the Baltimore region stands well above the national average in citations per publication—a key measure of research excellence.

Table 2: Publication Citation Rate by Field

Field	Higher Citation Rate Per Publication than Nationally for Field
Neurosciences and Behavior	47%
Cell and Developmental Biology	59%
Molecular Biology and Genetics	52%
Microbiology	77%
Biochemistry and Biophysics	43%
Biotechnology and Applied Microbiology	76%

- The leading driver of basic biological research is found at The Johns Hopkins University. JHU not only accounts for 366 NIH grants in the basic bioscience research clusters, it is among the top ten universities in the nation in total citations (reflects both number of publications and how often publications cited) across a wide range of biological sciences, including 2nd in neurosciences and microbiology, 3rd in molecular biology and genetics as well as in biochemistry and biophysics, 4th in immunology and 8th in cell and developmental biology.
- Across other bioscience research institutions, there are also clear areas of strength in basic biological research including microbiology at University of Maryland Baltimore, where it ranks among the top institutions in total citations, structural biology and protein analysis at University of Maryland, Baltimore County, and marine biotechnology and virology at the University of Maryland Biotechnology Institute.
- A key outgrowth of the strong focus on basic biological research at JHU is the development of leading core research facilities, which offer an important asset for future biosciences development in the region. At JHU these core facilities provide high end cell culture analysis and genetic sequencing, and in the past year added high throughput genotyping. An important shift in focus is that JHU is now open to having its core facilities be available to serve the broader biomedical community from NIH, other research institutions and industry. JHU is also interested in partnering with specialized companies to pursue better approaches for animal modeling/handling—major strength, but not efficient and for bio-informatics and perhaps even the banking of biological samples.

Public health is another key area of research focus in the Baltimore region. It represents the second largest cluster grouping of active NIH grant awards, reaching 329 grants across two clusters. These activities include disease intervention and prevention activities, epidemiology studies of diseases in the population and ways to improve medical practice.

- A number of institutions were identified across the region as having activities, though JHU and UMB dominated the overall grants in public health.
- The Baltimore region is also a leader in national publications in public health, recording a 40 percent higher citation rate than the nation.

More specific disease related research focus areas also emerged from the cluster and publications analysis:

- **Brain and neurological research** is a major grouping with 274 grants across four clusters involving research into brain mechanisms, imaging and cognitive processes, pain, neural cell death and neural receptors. This area is one where there is more parity between JHU and University of Maryland. In publications analysis, neurology, psychiatry and neurosciences and behavior are fields of excellence for the region with higher citation rates than the national average of 95 percent, 37 percent and 47 percent and a share of all citations that exceeds three percent.

Table 3: Areas of Disease Publications Strengths

Areas of Disease Specific Publications Strengths in the Baltimore Region Relating to NIH Cluster Analysis, FY 1997-2001

Field	% of All Institutions Citations	Percent Higher Citation Rate Than National Average
Cardiovascular & Respiratory Systems	1.8%	61%
Cardiovascular & Hematology	2.0%	34%
Clin Immunol & Infect Dis	4.9%	53%
Environmt Med & Public Hlth	4.1%	35%
Neurology	3.8%	95%
Neurosciences & Behavior	3.0%	47%
Oncogenesis & Cancer Res	4.0%	114%
Psychiatry	3.2%	37%
Public Hlth & Hlth Care Sci	4.0%	41%

Source: Institute for Scientific Information

- **Vascular and cardiovascular research** spans 211 grants across four clusters and involves cell signaling, stroke and rehabilitation, and vascular cell biology. While cardiovascular research in the Baltimore region is not a high share of national citations, the Baltimore region shows excellence as measured by the citations per publication, where Baltimore stands 61 percent higher in cardiovascular and respiratory systems research and 34 percent higher in cardiovascular and hematology research. The Johns Hopkins University in particular stands out in the area of cardiovascular and respiratory systems, ranking 5th in the nation of all institutions in total citations.
- **HIV research** is well entrenched in the Baltimore region with 127 active NIH grants across four cluster areas. These clusters range from research into HIV interventions to HIV-related dementia and central nervous system impacts to HIV and drug abuse to HIV infections and clinical research. Publications data does not enable a refined analysis by HIV, but it is important to note that in clinical immunology and infectious diseases, which encompasses much of HIV research, the Baltimore region accounts for nearly five percent of all citations and enjoys a 53 percent higher citation rate per publication than the national average. Moreover, the Baltimore region is significantly more concentrated in clinical immunology and infectious diseases than any other bioscience field, representing 11 percent of all bioscience-related publications in the Baltimore region and only six percent of bioscience-related publications nationally.
- **Cancer research** involves 121 active NIH grants across three clusters focusing on prostate cancer, breast cancer, cancer tumor cells and cancer clinical research. In cancer research publications, the Baltimore region is a major player, with four percent of all national citations and a hefty citation rate per publication that exceeds the national average by 114 percent.
- **Drug abuse** involves 86 active NIH grants across two cluster areas focusing on drug abuse interventions, treatment and use of brain imaging. No publication data falls into drug abuse,

though the field is highly related to neurology and neurosciences and behavior, key research strengths in Baltimore.

HIGHLIGHTS OF BALTIMORE'S BIOSCIENCE INDUSTRY BASE

Baltimore's bioscience industry base stands at an important transitional juncture. As noted in the Introduction, the biosciences industry in Baltimore is a major sector with 68,000 jobs, and stands at a regional specialization with a 27 percent higher concentration in the biosciences than the nation. But employment trends reveal a flat performance for the Baltimore region in recent years, while the nation recorded healthy employment gains of 11 percent from 1998 to 2003.

Nearly all benchmark regions with the exception of Chicago and Richmond are more specialized in biosciences research, and six out of the 10 benchmark regions also outpace national employment growth, and so their performance falls into a "star" rating. Figure 5 depicts how the Baltimore region stacks up with other region's on the basis of its overall bioscience industry base, bringing together specialization along the vertical y-axis and relative growth along the horizontal x-axis.

In comparing bioscience industry performance across regions we examine the specialization and relative growth of the biosciences industry sectors in each region.

- Specialization measures the employment concentration in the biosciences relative to the national average, also referred to as the location quotient. A location quotient above 1.0 indicates a higher level of bioscience employment in a region than found in the nation, while an employment concentration below 1.0 indicates a smaller share of employment in the region than the nation. Typically, we consider location quotients of above 1.20 or 20% higher employment concentration than the nation to indicate a level of specialization.
- Relative growth judges the recent employment growth trends of a region compared to the growth rate to that for the nation. In this way, we isolate whether a region is outpacing or falling behind the nation in its growth of bioscience activity.

Figure 6 sets out the performance of each of the regions across the major bioscience industry sectors of hospitals and labs, commercial research and testing, drugs and pharmaceuticals and medical devices. It is interesting to note that no region is a "star" in all sectors. The Baltimore region, however, is the only region which fails to reach the "star" quadrant in any of the industry sectors.

Figure 5: Baltimore Region vs. Other Regions, Bioscience Industry Base

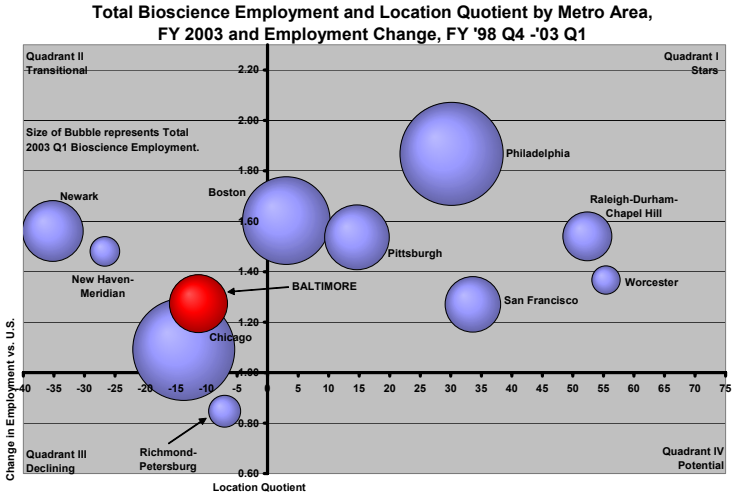
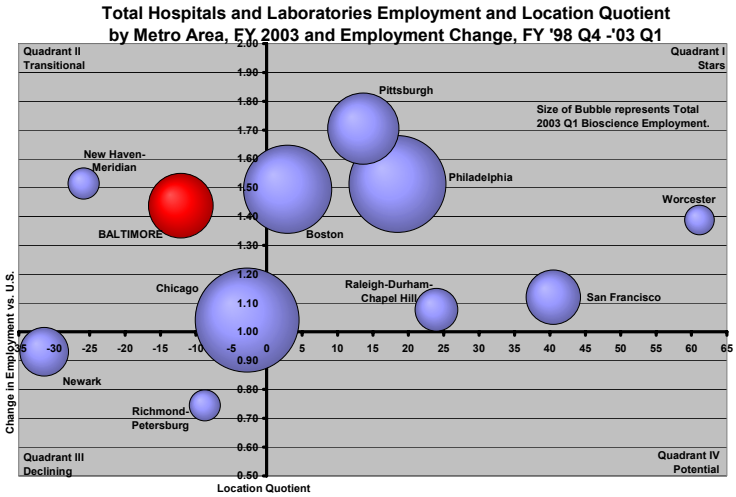
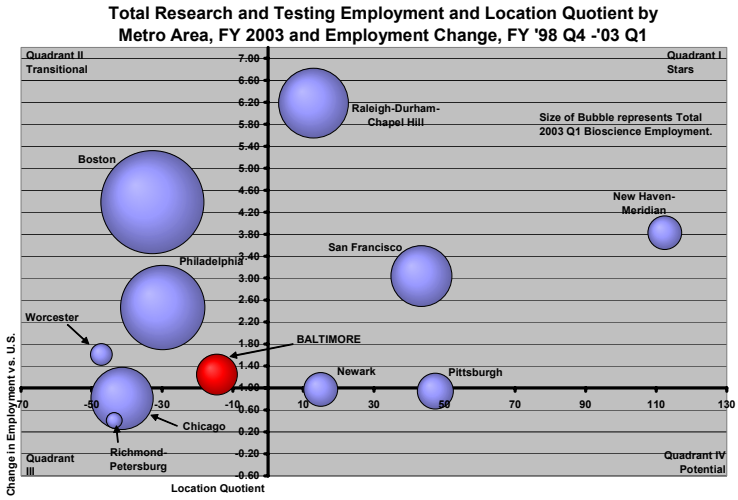
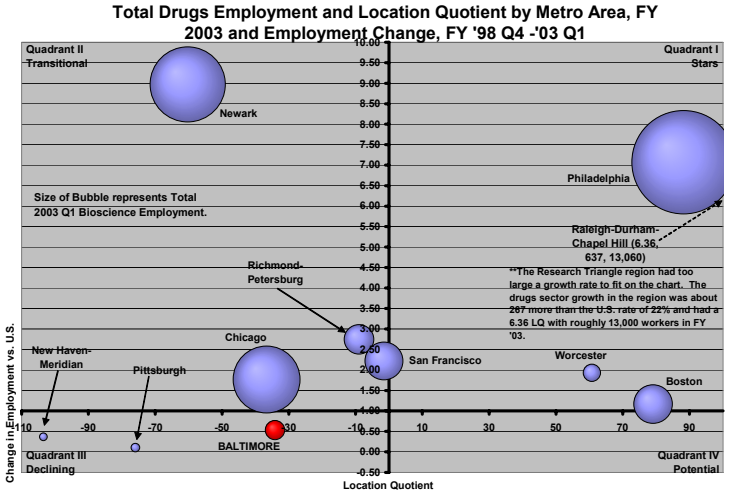
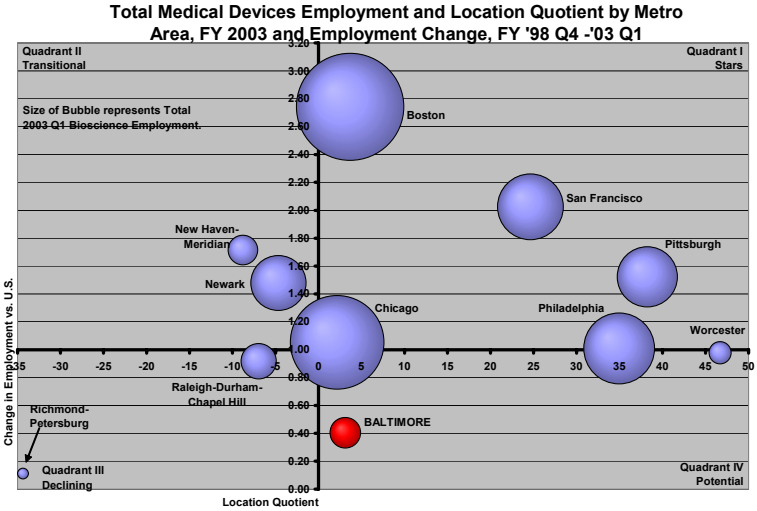


Figure 6: Bubble Charts on Performance of Baltimore and Benchmark Regions by Major Bioscience Industry Sectors—Hospitals and Labs, Commercial Research and Testing, Drugs and Pharmaceuticals and Medical Devices









Guide to Interpreting a Four Quadrant Bubble Chart

Examining specialization and performance in this manner provides a four quadrant picture.

- The upper right hand quadrant is for those regions that have an employment concentration above the national average and are outpacing national employment growth. We consider regions falling into this quadrant "top performers" or "stars."
- The bottom right hand quadrant is for those regions outpacing national growth but not yet specialized in bioscience employment. These regions are termed "emerging."
- The upper left hand quadrant is for those regions that are more specialized in bioscience employment than the nation, but are not faring as well in employment growth. These regions can be thought of as in "transition" because their past successes still gives them a strong presence of bioscience activity, but recent trends suggests that they are slipping.
- The bottom left hand quadrant is for those regions that are less specialized in employment concentration and failing to keep pace with national employment trends. These regions are "declining" regions in bioscience industry development and do not have strong prospects.

A more detailed examination by bioscience industry sector suggests that the strengths in the biosciences industry in Baltimore are found in two principal sectors—hospitals and medical labs and commercial research and testing.

- Hospitals and medical labs in the Baltimore region have a 44 percent higher employment concentration than the nation—and in Baltimore City that level of concentration rises to 200 percent higher than the nation. But employment was flat, similar to the overall bioscience sector in the Baltimore region.
- A closer look at the teaching hospitals associated with either Johns Hopkins University or the University of Maryland Medical System—which are more likely to serve outside residents and be a source of competitive economic strength—indicates a more mixed picture with teaching hospitals growing by 39 percent, while non-teaching hospitals declining by 11 percent. While part of this growth may be associated with hospital acquisition by academic hospitals, it suggests that there is an important growth segment in the hospital and medical sector.
- Commercial research and testing, comprised of firms engaged in biological and medical research often providing specific contract services to pharmaceutical, biotechnology, medical device and other bioscience companies as well as firms advancing their own research projects for future commercialization, stand 25 percent more concentrated in employment than the nation. Unlike the overall biosciences industry sector, commercial research and testing is growing a healthy 9.8 percent rate from 1998 to 2003, but still falls behind the national average of 24 percent. Table 4 (on the following page) highlights a number of the commercial research and testing companies found in the Baltimore region. Generally this is a highly fragmented industry, with many small to mid sized firms, often offering a niche service.

Other sectors in the Baltimore region have only a weak presence, with location quotients for drugs and pharmaceuticals, medical devices and organic chemicals ranging from only 0.19 to 0.53—or well below the national average concentration in employment.

Nevertheless, there are significant firms across the biosciences found in the Baltimore region in drugs and pharmaceuticals and medical devices. Among the leading bioscience firms with a national profile based in the Baltimore region are Guilford Pharmaceuticals, a developer of biopharmaceuticals for neurological diseases and conditions and brain cancer; Martek Biosciences, specializing in products derived from algae for functional foods, infant formula and other nutritional products, as well as fluorescent markers for use in drug discovery; Becton Dickinson, a leading biomedical device company specializing in diagnostic products at its Baltimore regional facilities; and Alpharma, Inc. a manufacturer of pharmaceuticals and over the counter products.

Table 4: Data on Baltimore Regional Bioscience Sectors (1998 and 2003)

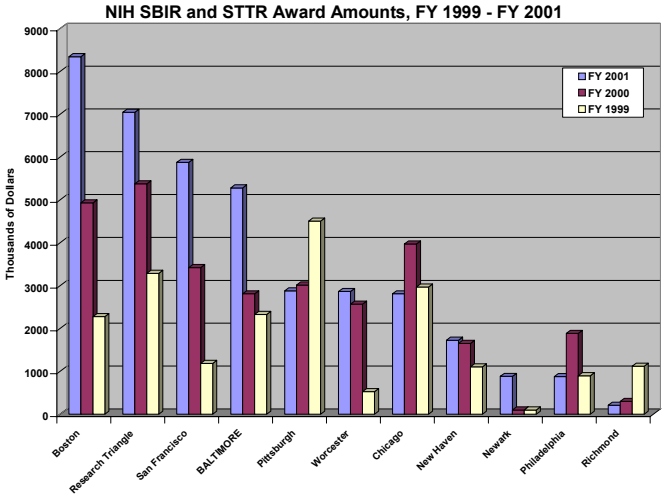
Baltimore Region	Drugs	Org. and Agric. Chemicals	Med. Devices and Instr.	Hospitals and Labs	Res. and Testing	Total
Establishments, 2003	63	14	68	477	102	**724**
Employment, 2003	1,865.0	243.0	1,497.0	63,649.0	1,518.0	**68,608.0**
Employment Growth '98-'03						
Baltimore Region	-11.8%	37.3%	0.4%	-0.3%	9.8%	**-0.3%**
National Average	22.3%	-8.0%	-2.7%	11.9%	24.3%	**11.0%**
Employment location quotient, 2002	0.53	0.19	0.40	1.44	1.25	**1.27**

Data source: Battelle calculations from Dun & Bradstreet *MarketPlace* survey.

KEY FINDINGS ON BALTIMORE'S POSITION ON COMMERCIAL INNOVATION ACTIVITY IN THE BIOSCIENCES

Having a strong and growing bioscience research base is a key asset. Being able to translate that base into intellectual property and early stage investments is a promising sign for growing a full-fledged bioscience cluster.

Figure 7: NIH SBIR and STTR Award Amounts, FY 1999–2001



Baltimore fares well in generating federal research grants for small business innovations, often referred to as SBIR and STTR (involves joint industry-university collaboration). These grants suggest a base of small business activity involved in innovative life sciences activity.

But in bioscience patent and bioscience venture capital activity—more broad based indicators of technology commercialization—the Baltimore region lags other regions of the nation.

- In venture capital financing for bioscience activities, Baltimore totaled $213 million from 1996 to 2002 (3rd quarter). This stands approximately one-third of the level of bioscience venture financing for Philadelphia and Research Triangle, North Carolina and well behind the Boston and San Francisco regions. Over half the venture funding in the Baltimore region went for healthcare services, well exceeding that for biotechnology or pharmaceuticals.
- In bioscience patent activities, the Baltimore region had 891 bioscience patents issued from 1995 to 1999, compared with 4291 for Boston, 3109 for Philadelphia, 2166 for Chicago and 1,570 for San Francisco. Baltimore trails not only these top regions, but many smaller regions in bioscience patent activities, including Newark and New Haven.

In technology transfer activity—a more direct measure of university performance in translating its research base into commercial innovation—JHU and UMB generally rank average or below average after standardizing for the size of their research budget.

- In new start-up activity, JHU rates well in the total number compared to other institutions with 17 from 1999 and 2000, but only six remained in Maryland. UMB started up three companies in that same timeframe.

Table 5: Technology Transfer Performance of Baltimore-based Research Universities

Metrics	Johns Hopkins University	University of Maryland-Baltimore	University of Maryland-Baltimore County	AUTM Median For Universities	AUTM Top Quartile for Universities
Sponsored Research Expenditures	$1,033,801,604	$189,553,966	$26,044,000	$114,566,899	$223,960,364
Invention Disclosures Received	355	65	25	43	106
Patent Applications Filed	331	60	18	32	72
Patents Issued	106	20	3	13	27
Licenses & Options Executed	127	6	1	10	28
Licenses Generating Income	166	13	4	22	47
Gross License Income	$14,606,510	$215,285	$52,426	$1,116,784	$4,250,353
Startups	10	1	0	1	3
Disclosures per $10 M Sponsored R&D	3.43	3.43	9.60	3.87	5.72
Patents Issued per $10 M Sponsored R&D	1.03	1.06	1.15	1.17	1.63
Licenses Executed per $10 M Sponsored R&D	1.23	0.32	0.38	1.11	1.67
License Income per $10 M Sponsored R&D	$141,289	$11,357	$20,130	$81,899	$251,796
Average Revenue per License	$87,991	$16,560	$13,107	$41,571	$87,476
Startups per $10 M Sponsored R&D	0.10	0.05	0.00	0.10	0.21
Startups per License Executed	0.08	0.17	0.00	0.08	0.20

Source: AUTM
All Dollars are Nominal

The perception of venture capitalists interviewed is that JHU, in particular, is a very difficult institution to deal with in technology transfer. The issue seems to be that JHU is a very complex organization and hard for a venture capitalist to work with. While the technology transfer staff is seen as professional, they are not always seen as being the clearinghouse for technology at JHU with many specific fiefdoms in place.

But perhaps the most difficult issue facing Baltimore in advancing new venture development is having experienced management teams. Venture capitalists see the Baltimore region as not having in place the quality management teams to advance new bioscience ventures. This is viewed as a chicken and egg problem. Interestingly, though, the Suburban Maryland area, just 30 miles down the road, seems not to have this management problem.

Interviews identified an untapped potential for the Baltimore region in the area of medical instrumentation and devices. Baltimore boasts strong research competencies in biomedical devices, ranging from radiology/imaging to biomaterials to research instrumentation to biological sensors to systems engineering. Even the Applied Physics Lab is actively engaged in biomedical devices with 16 percent of its invention portfolio falling into the broad category of biomedical devices.

Another key opportunity for the region is addressing the significant gap that exists in drug discovery and development at JHU. There is a concern that the research discoveries in Baltimore are too early stage or basic in nature to be commercially viable. The Baltimore region does not have a strong drug discovery and development capability to match its basic research capacity.

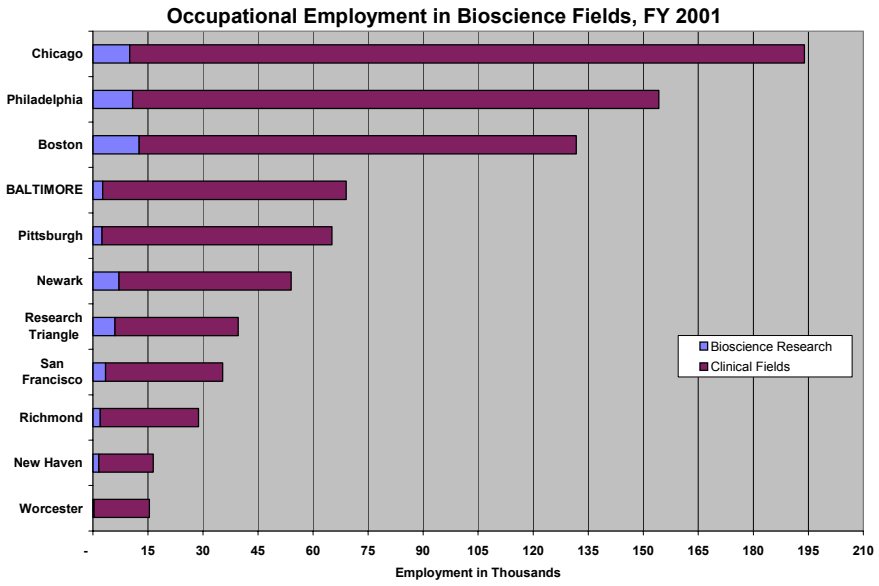
JHU, in particular, does very well in generating biological targets, but has a serious gap in translating those insights into new drug opportunities. UMB has a capacity in drug discovery and development at its School of Pharmacy, but it is just forging linkages at the UMB Medical School and is not well linked to JHU. JHU is establishing a new chemcore to do high throughput screening against various libraries of chemical agents to identify potential drug candidates, but this effort will be limited in size and is only an initial step in a lengthy drug discovery and development process.

KEY FINDINGS ON BALTIMORE'S POSITION IN BIOSCIENCE TALENT GENERATION AND WORKFORCE DEVELOPMENT

Across a broad range of bioscience occupations, from clinical care providers to research scientists to laboratory technicians, the Baltimore region employs just over 69,000 workers in bioscience occupations. This total is smaller than the overall number of workers employed by bioscience organizations, because many workers are involved in non-bioscience occupations in these firms from back office operations to marketing/sales to manufacturing activities.

Of the 69,000 workers in bioscience occupations in the Baltimore region, 66,450 or approximately 96 percent are employed in clinical positions. In fact, despite the significant size of the bioscience research activities found in Baltimore, employment in bioscience research occupations is much lower relative to the overall bioscience occupational base than in most of the benchmark regions. While bioscience research occupations comprise just under four percent of all employment in bioscience occupations, in Boston it stands at 9.6 percent, San Francisco 9.7 percent, Philadelphia seven percent and Research Triangle 15.2 percent.

Figure 8: Occupational Employment in Bioscience Fields, FY 2001



Baltimore fares much stronger in the generation of biomedical and medical sciences graduates, with nearly 5,000 graduates in 2001. This is among the leaders, being greater than seven of the 10 benchmarks, and surpassed only by Boston, Philadelphia and Chicago, which have larger base of post-secondary schools.

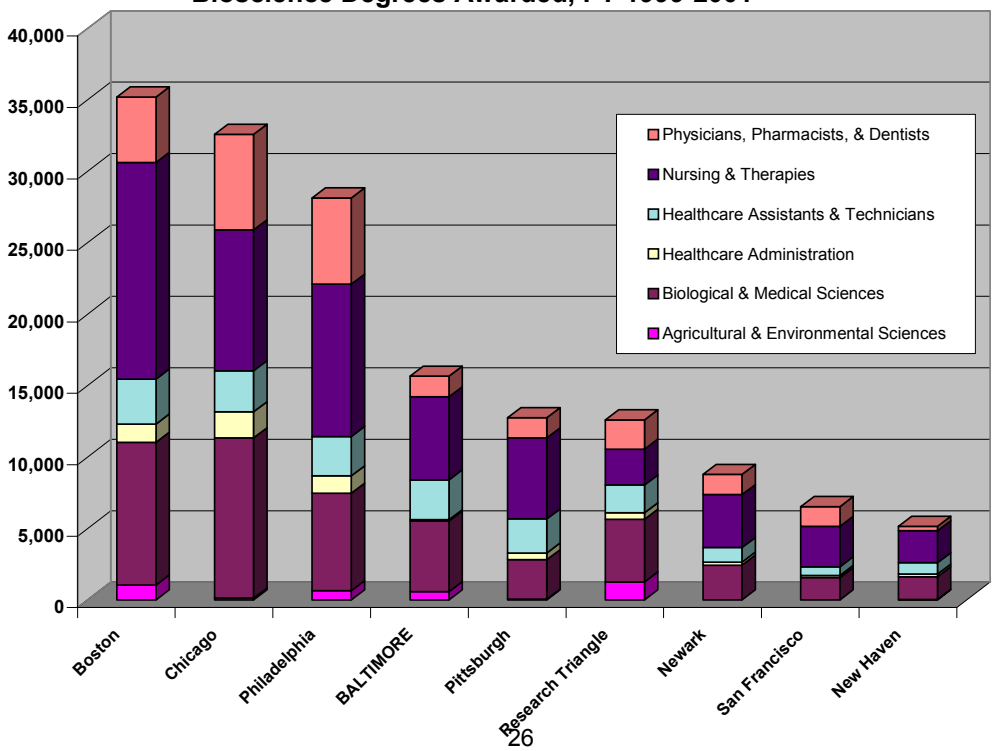
In clinical care graduates, Baltimore particularly stands out in healthcare assistants and technicians being roughly on par with the two leading regions—Boston and Chicago. In nursing

and therapists, the Baltimore region is above average, while in physicians the Baltimore region is in the middle of the pack.

Baltimore does stand out in innovative education and training programs in the biosciences.

- Dunbar High School offers an innovative curriculum in the biosciences and health sciences.
- Baltimore is home to the BioTechnical Institute of Maryland, which has been successful in training young adults with just a high school education for entry level laboratory technician positions, with placements at JHU research labs as well as nearly two dozen other bioscience organizations.
- The STEP program in Baltimore is another innovative program that has established a consortium of hospitals to train non-bioscience workers at these hospitals for a range of clinical occupations, with the training taking place during work hours while the workers are still being paid for their jobs.
- Towson State has established an innovative, specialized bachelor's program emphasizing hands-on bioscience laboratory skills, which articulates well with community college biotechnology programs.
- University of Maryland Baltimore has developed a number of career tracks in its medical technician program, positioning this program to be a key source of good laboratory practices technologists for the region. UMB has also developed a one year master's program for bachelor graduates to enter specific fields of laboratory tech.
- University of Maryland Baltimore County has established an outstanding bachelor, graduate and continuing education program in bioprocessing and scale-up through its chemical engineering department.

Figure 9:
Bioscience Degrees Awarded, FY 1999-2001



SUMMARY OF BALTIMORE'S BIOSCIENCE POSITION: A STRENGTHS, WEAKNESS, OPPORTUNITIES AND THREATS ANALYSIS

The intelligence gathered through the competitive positioning analysis of Baltimore and specific capabilities found in the Baltimore region, can be organized into a comprehensive analysis of the overall strengths, weaknesses, opportunities, and threats (SWOT) facing the region in developing its biosciences base. This SWOT analysis reveals the situational analysis confronting the Baltimore region.and helps point towards strategic course of action that can be pursued to ensure success for the proposed East Baltimore Biotech Park, as well as the broader region.

This SWOT analysis is much like a business planning process. In preparing its business plans, a company undertakes a similar SWOT analysis, identifying its internal strengths and weaknesses, and taking account and addressing external factors, including markets and opportunities and adverse events and threats. The Baltimore region, for this analysis, is examined much as a business would examine itself.

It should be noted that in some cases perceptions are included in this SWOT, whether accurate or not, since they reflect the climate within which progress can be made in building a bioscience base.

Strengths

- **The Baltimore region is a national leader in biomedical research with two major academic health centers and the presence of other university and non-profit research drivers.**
- **Cluster analysis of NIH grant awards including all regional institutions finds not only strengths in particular disease areas of the biosciences, but a particular depth—led by JHU—in basic biological research tools, techniques and understandings cutting across diseases.** Basic research strength involves understanding the genetic basis of diseases, cell biology, protein analysis, animal models and sophisticated immunological disease interactions.

  Other key clusters of activities identified include:

  - Brain research, neurological conditions and psychiatric disorders. Major centers in schizophrenia and Alzheimer's disease present in the region
  - HIV, infectious diseases and vaccine development
  - Cancer, particularly prostate, neck and head, brain, breast, lymphoma, and lung. Key area for clinical research
  - Vascular, stroke and cardiovascular research
  - Drug abuse
  - Public health
- **Growing base of industry support for research both at JHU and UMB.** Focusing on East Baltimore, JHU Medical School has grown its industry support for research (including clinical research and trials) from $1.5 million in 1986 to $55 million in 2002. Key areas of

industry support for JHU are cancer and asthma and allergies, followed by cardiology, neurology, ophthalmology, radiology and pathology.

- **Presence of leading hospitals generating substantial employment.** Hospital and medical lab employment stands 44 percent more concentrated in Baltimore, and is a major specialization for Baltimore City.
- **A largely overlooked sector in Baltimore is bioscience commercial research and testing.** With 102 establishments and an employment base of over 1,500, it stands 25 percent more concentrated in the nation than the nation.
- **Growing levels of NIH funded SBIR activity in Baltimore.** These product development awards from NIH to small companies in the Baltimore region have been increasing in recent years from approximately $1 million in FY 1999 to over $5 million in FY 2001.

Weaknesses

- **Critical mass of bioscience industry.** While Baltimore enjoys the presence of key companies across the broad bioscience spectrum, its overall bioscience industry cluster is thin. There is not a strong demand for incubators. Earlier studies show private sector absorption of bioscience space low.
- **Lack of deep and sustained collaborations among institutions across Baltimore.** There is not a strong element of collaboration across the biomedical research institutions in Baltimore. Where in other regions there is a high level of collaboration, especially among principal investigators and at times in pursuing major research centers, that does not appear to be the case in Baltimore.
- **Lack of ability to translate biological targets into new therapeutics seen as big deficient at JHU.** An acknowledged problem at JHU is a lack of capacity in medicinal chemistry and other disciplines to translate promising biological targets into chemical agents as well as into vaccines. This is seen as making discoveries too early stage for licensing or company spin-off.
- **Generally a poor performance in region in fostering bioscience commercial innovations.** While technology transfer performance at JHU and UMB rate at or slightly above the median levels of universities, levels of bioscience patents and bioscience-related venture capital investments are well below leading regions.
- **Lack of affordable research laboratory space.** A common concern raised by small and emerging bioscience companies is the lack of affordable laboratory space in the region.
- **Perception by small and emerging bioscience companies that academic health centers are not receptive partners, nor interested in assisting companies.** Among the small and emerging bioscience companies that access to core lab facilities, specialized equipment as well as technology being generated at academic health centers is difficult. For example, companies interviewed raised an inability to access facilities for bacterial culture and mammalian cell facilities, virology facilities, and NMR facilities. Even among other universities in the region, issue of access to specialized facilities raised, such as gene sequencing. In particular, many companies see JHU as difficult to work with, hard to enter into subcontracts with, and they have concerns about follow-through.

- **Biosciences community in Baltimore not well-organized and networked.** Many of the bioscience companies thought that there has been a sense of loss of camaraderie and shared purpose across the bioscience industry community. Folks tend to be focused on issues and developments for their own companies. Need for a strong catalyzing force to bring the local biosciences community together.
- **JHU viewed by venture capitalists as not ripe for technology commercialization.** Despite the quality of the research, JHU is not seen as a sure bet for technology commercialization. JHU is viewed as having little experience in spinning out companies, its faculty as being isolated from biomedical community and not possessing a strong entrepreneurial bent and technology transfer hindered by fiefdoms and Byzantine processes and lacking a true one stop shop and clearninghouse.
- **Baltimore seen as missing in managerial talent, venture capital and management support.** Particularly in comparison with nearby regions, Baltimore is seen as sorely lacking in management talent, core network of professional business advisors and even lead venture capital. Makes locating a high-flying start-up in Baltimore a hard sell from a business point of view. Truly is a chicken and egg problem that others have addressed successfully from San Diego to Montgomery County, and now new rising bioscience cluster regions are having notable successes, such as St. Louis and Pittsburgh.

Opportunities

- **Strong brand name of The Johns Hopkins University.** Despite ongoing concerns about the difficulty of partnering or commercializing technologies from JHU, there is still a strong sense that JHU will be taken seriously and can open doors. Example: faculty at JHU will always get a hearing from venture capitalists.
- **Promote collaborations across Baltimore bioscience institutions, particularly in drug discovery and development and biomedical device development.** Baltimore seems to have the ingredients to address specific areas of shortcoming in moving technology towards commercialization. For instance, there appears to be an opportunity to bridge collaborations for advancing new therapeutic development, leveraging the presence of a School of Pharmacy at UMB and vaccine development capabilities at UMB as well as biochemistry strengths at UMBC and JHU Homewood Campus. Similarly, in the area of biomedical devices broader collaborations can be envisioned for JHU Medical School and UMB with the JHU Applied Physics Lab and UMBC.
- **Changing the paradigm from technology transfer to technology commercialization.** A major emphasis at the research universities in Baltimore has been upgrading its technology transfer activities, but a more focused effort on generating new company formation in Baltimore is needed which requires broader range of services beyond the disclosure, patenting, and marketing of new technologies and research disclosures.
- **Proximity of Baltimore to major pharma and biotech firm concentrations.** Baltimore's strategic location between the major pharmaceutical concentrations found in the Pennsylvania and New Jersey region and the major concentration of federal R&D in the Washington, D.C. region can be of strategic value as the region puts in place its new anchor research park developments.

- **Presence of post-docs and graduate students.** The high concentration of graduate students is a notable finding of Baltimore's talent pool generation. Similarly, the region possesses many "best and brightest" post-docs engaged in scientific research. Their presence presents the region with a major opportunity to have the necessary talent to support a growing commercial bioscience base.
- **Broad base of bioscience employment opportunities.** As Baltimore broadens its commercial biosciences base it can avoid a chicken and egg situation as region builds up bioscience base—also several innovative bioscience education and training efforts found in Baltimore (BTI, STEP, UMBI biotech master's, UMB medical technology, etc).
- **Broad research base found in Baltimore region,** which suggests the Baltimore regionn has an opportunity to expand its biosciences beyond pure play biological related development to increasingly important interface of biology with other disciplines, particularly engineering, material sciences, information technology, etc.
- **Biomedical device potential found in the region.** While not a strong industry sector in the Baltimore region, the development of medical devices is a strength across the research drivers, including JHU Medical School/Homewood Campus, JHU Applied Physics Lab, Morgan State.
- **Opportunity for leadership to make a major difference.**

Threats

- **Other regions may continue to move ahead, creating wider gaps between Baltimore and leading regions and making it more difficult to create a robust bioscience industry cluster.** Across the nation, many regions are putting in place the needed investments to grow their bioscience base. While the Baltimore region has a clear advantage given the depth of its research and clinical base, these are not sufficient to ensure that the region becomes a premier bioscience cluster with a thriving commercial bioscience sector.
- **Competition from suburban areas is strong, and inner city research park locations will need to address more than just industry-university relationships and opportunities.** Industry and venture capitalists voiced concerns about the amenities, parking and crime at the East Baltimore location. Biotech research park will not succeed without comprehensive effort.
- **The ability to attract quality and star faculty to Baltimore—a key to the past successes of the region in the bioscience—may be compromised by lack of entrepreneurial environment.** Today's younger faculty are often very interested in settling in a location where they can not only do top research and teaching, but have the potential to move their research into commercial development. Regions that lack this potential risk not attracting leading faculty as well as potentially losing faculty to more developed bioscience regions.

III. Benchmarking Analysis of Research Park Developments

Purpose of Benchmarking Practices

Benchmarking practices of leading areas, which is commonly undertaken in the corporate and financial communities as a way of improving efficiency and calibrating performance, is just as important in planning for technology-led economic development. Practice-related benchmarking allows one to identify, analyze, and draw useful lessons from the efforts of regions and institutions that are generally comparable along relevant strategic dimensions.

Practices benchmarking can help in:

Identifying the competition. Benchmarking forces a community or institution to identify clearly those other regions against which it competes for business investment in the targeted technology sectors. Benchmarking forces planners to examine in a broad, qualitative way who is pursuing similar strategies and how they are succeeding or failing. This may yield important insights into how the competitive landscape looks to those in business who are making decisions on where to place research partnerships or make locational investments.

Isolate the strategic issues. To design a strategy for technology-led economic development, any region or institution must understand what its key choices are and how various potential uses of resources trade against each other. Examining how competing entities have positioned themselves can give insight into what strategic choices must be made in view of the home region/institution's strengths and weaknesses, and the opportunities and threats posed by the broader marketplace for business engagement.

Figure out what works. There is no point in reinventing the wheel. Strategies and initiatives that have worked in other regions/organizations facing similar challenges can often be adapted to local conditions, avoiding the risks of investing in entirely untried approaches unless the situation explicitly requires that.

How the Benchmarks Were Selected

In early discussion with Battelle, members of the Steering Committee identified several factors it considered important to be addressed in the benchmarking exercise:

- Regions with large or fast-growing bioscience clusters. While there are certainly challenges posed by the spatial distribution of biosciences companies within Maryland (see below), the EBDI research park initiative is lucky indeed to function in the context of a state that has in the last 15 years grown its bioscience sector so rapidly that Maryland now routinely ranks just after Boston and the San Francisco Bay area in measures of bioscience vigor. Therefore, the peer set needs to encompass some of the very top bio-pharma regions in the nation.
- Research parks coupled to major academic medical centers. Johns Hopkins University is a powerful knowledge generator in many fields other than the biosciences, but since its physical-science and engineering research is split between the Homewood and APL campuses, and since the research park is inherently part of the vision for East Baltimore's

development, the focus of this project rests squarely on Johns Hopkins Medicine. Therefore, the benchmarks should focus where possible on analogous relationships between other research parks and their mostly closely associated academic medical centers.

- Cities with more than one research park or bioscience hub in town. EBDI's initiative is just one of two under way in Baltimore City. A similar effort is unfolding at the downtown medical campus of the University of Maryland, Baltimore, and its medical center. The benchmarking therefore needs to include at least some regions where there are multiple research-park initiatives, so that some insight can be gained into how more than one such effort can be coordinated and supported at a time.
- Neighborhood challenges similar to those faced by East Baltimore and its residents. Like many academic medical centers, Johns Hopkins Medicine remains in the setting where it began more than a century ago, and one which is now at the heart of an area of concentrated poverty and significant de facto segregation. To enjoy the support of its neighbors, the research park needs to be seen as one element of a comprehensive and fair revitalization effort that improves the lives of existing residents and also attracts new investment, but with the minimal necessary displacement. The benchmark set needs to include urban research-park initiatives that have faced analogous challenges.
- Cities facing bioscience challenges from regional suburbs. EBDI faces the very difficult challenge of competing to establish an urban presence for the bioscience industry in a state whose large and thriving bioscience cluster is already identified closely with a thriving suburban corridor. Even worse, the Bethesda/Rockville/Gaithersburg corridor is remote from Baltimore City, and really a suburb of Washington, D.C. The benchmark set needs to provide insight into how developers of urban research parks position them with respect to private-sector developments that attempt to meet the perceived demand for "corporate campus" settings far from the urban center.

Of course, not all these criteria can be met by a single set of benchmarks:

- Not all the leading bioscience regions can trace their success to university related-research parks.
- Only a few of the top academic medical centers are closely associated with research parks.
- Some of the best analogues to East Baltimore are in cities smaller than Baltimore or associated with academic medical centers smaller or less well funded than Hopkins (see tables below at right for the peers of Hopkins/Baltimore, not all of which have even a single recognized research park).
- Good benchmarks may be at a wide range of maturity; some will be well established, while others are just getting started.

Cities with the most total funding from NIH

- Boston
- New York
- San Diego
- Philadelphia
- **Baltimore**
- Seattle
- Los Angeles
- Houston
- San Francisco
- Chicago
- St. Louis
- Pittsburgh

Benchmark Selections

Battelle presented a range of 12 possible benchmarks spanning the range of all the important dimensions, and asked the steering committee to chose the subset that best met their needs. The

initial 12 benchmark regions included Atlanta, Boston, Chicago, New Haven, New York, Newark, New Jersey, Oklahoma City, Philadelphia, Research Triangle, Richmond, Winston-Salem, and Worcester, Mass.

Following discussion of these criteria, EBDI and Battelle agreed on the following benchmarks, whose capsule descriptions are presented below:

- **New Haven.** Science Park at Yale is a 20-year-old brownfield redevelopment with a history of financial troubles and too-high expectations, but which has recently found its groove through a narrowed focus on the biosciences, a near-complete privatization, and a clear alignment with Yale's new strategy for community economic development based on spin-off formation and capture. There is competition both within the city and with its suburbs. Although New Haven is a much smaller city than Baltimore, neighborhoods that border Science Park face challenges analogous to those of East Baltimore.
- **Philadelphia.** The Science Center is a 40-year-old consortial attempt at urban renewal, which faced heavy neighborhood opposition at first, but has steadied itself as its closest neighbor, the University of Pennsylvania, gradually learned to engage the surrounding communities more effectively. Relying heavily on institutional rentals of surge space, the Science Center has "incubated" many bioscience companies over the decades but only recently established a formal incubator. The Center faces intense competition from private development in Philadelphia's western and northern suburbs, but its only research park competitors are those in which it has served as partner or consultant.
- **Pittsburgh.** During the last 20 years, Pittsburgh's research park efforts have been diffused over five separate developments,[2] two of which are university-affiliated (one each by Pitt and Carnegie Mellon), two owned by a City agency and redeveloped in opportunistic fashion by private builders, and one more that is being driven by the community of regional philanthropic foundations, driven in part by exasperation with the City. While Pittsburgh has some overall economic and social similarities to Baltimore, these five projects could be seen more as a cautionary story than a model for emulation.
- **Research Triangle Park.** This 50-year-old project is, rightly or wrongly, now regarded around the world as the canonical standard for a research park, and it has had strong success in the biopharmaceutical sector. Research Triangle Park (RTP) has the reputation of close university involvement, but in fact more closely reflects the determination of the state and the business community to "brand" North Carolina as an acceptable location for multinational R&D laboratories, and thereby provide local employment opportunities for university graduates. In fact, RTP operates at some physical and cultural distance from the three universities of the Triangle and their host cities.
- **Raleigh.** North Carolina State University's (NCSU) Centennial Campus is a 15-year-old attempt to design the "campus of the future" as a dual-use entity, with both academic and industrial tenants sited side by side and sometimes in the same buildings. It is situated within the City of Raleigh, not downtown but adjacent to the main NC State campus, on what was once farmland surrounding a reservoir on a former state mental-health campus. Centennial's

[2] Pitt's UPARC; CMU's Panther Hollow Research Park; Pittsburgh Technology Center; South Side Works; and Hazelwood/LTV site.

record in the biosciences is not yet strong, but it presents a uniquely important model for research parks built on partnership with the associated university.

- **Worcester/Boston.** The main focus of the benchmark is the Massachusetts Biotechnology Research Park, a now-mature, 20-year-long effort to redevelop another former state mental-health campus as the heart of a "center of excellence" in biotechnology surrounding the University of Massachusetts Medical Center in this declining manufacturing town. However, for contrast, we also examine the recent BioSquare development at Boston University, and the privately developed University Research Park at MIT. Both Worcester and Boston University (BU) must face intense competition from the City of Cambridge and increasingly from Route 128 landlords.

Table 6 below summarizes the selected benchmarks along the strategic dimensions identified above and Table 7 provides a concise summary of the size, scope and maturity of the selected benchmark parks. More detailed case studies for each of the selected benchmark parks can be found in the appendix to this report.

Table 6: Selected Benchmarks

Region/park	Top bioscience area?	Associated academic medical center	Med school NIH rank	More than one in town?	Neighbor-hood challenges	Suburban competition?
New Haven—Science Park at Yale	N	Yale	5	Y	Y	Y
Philadelphia—Science Center	Y	University of Pennsylvania	2	N	Y	Y
Pittsburgh—multiple parks	N	University of Pittsburgh	12	Y	Y	N
Research Triangle—RTP	Y	Duke, University of North Carolina	8 (Duke)	N	N	Some
Raleigh—NCSU Centennial Campus	Y	None	N/A	N	N	Y (RTP)
Worcester/Boston—multiple parks	Y	Harvard, Partners, BU UMass	Combined Harvard/ Partners in top 10	Y	Y	Y

Table 7: Summary of Size/Scope/Maturity of Selected Best Practice Lessons

Park	Square feet built	Square feet potential	Other measures of scope	Comment on status
New Haven—Science Park	<1 million	>2 million	80 acres	Entering rapid growth phase
Philadelphia—Science Center	~1.5 million	>2 million	17 acres	Resuming growth after pause; nearly mature
Pittsburgh—Pitt's UPARC			55 buildings (incl. small pilot plants)	Mature
Pittsburgh—Carnegie Mellon University's Panther Hollow	125,000	500,000		Growth rate uncertain
Pittsburgh—Pittsburgh Technology Center	750,000	2 lots left	48 acres	Nearly mature
Pittsburgh—South Side Works	~800,000[3]		130 acres	Nearly mature
Pittsburgh—Hazelwood/LTV site	None	Large potential[4]	138 acres	Just beginning
Raleigh—NCSU Centennial	17 bldgs	150 bldgs	1,334 acres	Rapid growth phase
RTP	18 million		7,000 acres	Developing last sector of the park to receive water/sewer service from the county
Worcester—Mass. Biotech Research Park	~1 million	Built out	105 acres	Mature
Boston—BU's BioSquare	400,000	2.5 million	14 acres	Early stages
Cambridge—University Research park at MIT	2.3 million	Built out	27 acres	Mature

[3] However, including substantial non-technology space, despite original plan for 1 million square feet of it.
[4] But only a limited component will be technology space.

LESSONS LEARNED

Based on discussions with interviewees at many of the benchmark parks, several interrelated lessons emerge on:

- Broader community issues are compatible with the mission, vision and purpose of many research parks and can be successfully addressed.
- Variety of development models with no one approach fitting all regions or remaining in place forever.
- Need for a portfolio approach to types of tenants to focus on.
- Suburban competition is typical and featuring the advantages of proximity is key to success.
- Incubation is an important driver of growth, but not always the initial anchor.
- Patience is critical and managing turning points essential for success.

Broader community issues are compatible with the mission, vision and purpose of many research parks and can be successfully addressed.

Across the selected research parks, only those in more isolating, self-contained settings—Research Triangle Park and Worcester's Massachusetts Biotechnology Park—have not had to address community issues in a significant manner.

In fact, for many research parks, their mission, vision and purpose strongly embraces addressing community development issues.

Table 8: Mission, Vision and Purpose

Mission/Vision	Benchmark communities/parks interested in this outcome
Attract R&D partners to the anchor academic institution	Centennial; Panther Hollow; Mass. Biotech
Adaptively re-use underutilized state-owned property	Centennial; Mass. Biotech
Redevelop contaminated urban brownfields	Science Park; Pittsburgh (three of five projects)
Replace jobs lost in manufacturing shut-downs	Science Park; Pittsburgh (all projects); University Research Park at MIT
Advance neighborhood-revitalization agenda	Science Park; Science Center; Hazelwood/LTV; University Research Park at MIT
Fight brain drain by providing jobs for college grads	RTP, Pittsburgh
Financial motivation	Pitt's acceptance of Gulf donation of UPARC MIT's investment in Cambridge real estate for endowment purposes

Examples of specific community development activities pursued by research parks abound and cut across housing, employment and more specific activities for their cities.

Table 9: Community Activities Associated with the Research Parks

Region/Park	Housing	Employment	Other
New Haven—Science Park	450 affordable housing units financed at same time as last park bailout, but separately managed by independent community development corporations	Private developer remains committed to recruit light-manufacturing employers to support neighborhood jobs	Yale's overall economic development strategy involves also a downtown business improvement district; a home-ownership grant program for faculty/staff; efforts to improve public schools; and overall marketing program for NH
Philadelphia—Science Center	Acreage yielded back for housing development in the 1970s/80s West Philadelphia Partnership community development corporation is one of the city's most active		Penn's strategy for economic development includes a "voluntary business improvement district"; community outreach center; home ownership grant program and mortgage subsidy for faculty/staff; adoption of urban agenda university wide; and cooperation with school district on development of new K-8 school and relocation of city's science high
Pittsburgh	Oakland neighborhood has a CDC South Side Works has market-rate and subsidized housing Hazelwood/LTV site will include large housing initiative	Hazelwood plan explicitly calls for generation of jobs that can be held by residents of surrounding neighborhood	Universities participate in a community council and Pitt hosts an outreach center, but less progress achieved than in Philadelphia. Large debate under way over transportation modes that will best connect neighborhoods to employment opportunities in parks—highway vs. transit debate.
Raleigh—NCSU Centennial	Market rate housing only		
RTP	No housing in park; some now being built outside		
Worcester—Mass. Biotech Research Park	No housing		
Boston—BU BioSquare	No housing		BioSquare one of three major development projects in Cross Town area, a key transition point between Roxbury, Dorchester, South Boston and institutional district
Cambridge—University Research Park at MIT	Extensive commitment to affordable "middle class" housing was required as part of approved master zoning plan; additional market-rate housing developed	Employment opportunity was part of the concept, but has not been emphasized in practice	As plan evolved, developer decided to open a supermarket to give Park more of a neighborhood feel and connection

Development Approach: No one approach fits all or remains in place forever

Across the research park developments in the selected regions, there is a significant diversity in how development was pursued, both in the specific efforts for research development and in the more programmatic relationships with university research drivers.

For those regions that have strong commercial real estate development, such as in Cambridge, Massachusetts, private developer approaches have worked effectively. In more challenging environments—which is the majority for the regions selected—various alternatives to having a private commercial developer have been pursued. Often a more public agency will play a role, typically selling parcels to private developers, as is the case at Research Triangle Park, Pittsburgh's Technology Center and South Side Works. For some of the region's, the university driver is the developer, such as at Boston University, or a specialized development entity will take the lead such as the Worcester Development Corporation or the New Haven Science Park Corporation.

It is also important to recognize that no one model lasts forever. For instance, Worcester began by trying to work with a private developer, then shifted for most of its build-out to a quasi-public corporation and then sold its property to a commercial real estate developer. Philadelphia started by having its University Science Center being the master developer and now moving to more equity partnerships with private developers. New Haven's Science Park initially served as the developer and now has entered into a long term arrangement with a private developer.

Another key dimension to recognize is the relationship between the research park development and activities and the university driver's associated with the research park. Again, there is wide variety, and no clear recipe, except on the importance of having established relationships.

Table 10: Summary of Development Model and Linkages with Research Driver found Across Selected Regions

Region/Park	Development Model	Nature of linkages with associated university and/or academic medical center
New Haven—Science Park	• Originally by Science Park corp. itself • Now, as properties are donated to Science Park by Olin, 65-year land leases are made to Lyme Properties LLC	• Science Park was formerly the billing intermediary for extensive services, including health care, but Yale took little interest • Now, tenants negotiate with Yale directly for all but library services, which are provided through the developer, and Yale is much more engaged
Philadelphia—Science Center	• Originally by Science Center itself based on fund-raising (institutional shareowners have no capital invested in the Center) • Then, equity partnerships with private developers on a lot-by-lot basis, levering the credit rating of institutional tenants	• No formal affiliation agreement because of consortial ownership structure, but Science Center is now positioning itself as "portal" (industrial liaison) to services offered by Penn and other shareholders, including animal care
Pittsburgh—Pitt UPARC	• N/A	• No special linkages except at UPARC, which is a university facility
Pittsburgh—Carnegie Mellon University Panther Hollow	• Development by Regional Industrial Development Corp., guided by a community-based nonprofit, and with state subsidy where available	
Pittsburgh—Pittsburgh Technology Center and South Side Works	• Sale or land lease by city Redevelopment Authority to private developers on either a master or lot-by-lot basis, often requiring subsidy from state or third parties such as a nonprofit "Strategic Investment Fund"	
Pittsburgh—Hazelwood/LTV Site	• The foundation-backed partnership that bought the land has issued an RFP for a master-developer.	
Raleigh—NCSU Centennial	• Originally by the university itself, starting with academic and multifunction buildings, and recently moving to single-use commercial buildings (either wet-lab or office) • Then by 99-year land leases to private developers, starting with clusters of lots and now on a lot-by-lot basis. Starting with office buildings, now expanded to wet labs	• Heavy emphasis on a tenants and subtenants signing a "partnership agreement" specifying ways they will interact, and extensive list of affiliation benefits

Table 10: Summary of Development Model and Linkages with Research Driver found Across Selected Regions (cont.)

Region/Park	Development Model	Nature of linkages with associated university and/or academic medical center
RTP	• Foundation acts as landbank that can sell cheaply, originally only to owner-occupiers, but now including speculative developers provided they agree to build quickly	• Contrary to popular image, few formal linkages with Duke, University of North Carolina or North Carolina State University, though park attempts to facilitate the hiring of grads, students and faculty consultants
Worcester—Mass. Biotech Research Park	• Originally by the nonprofit Worcester Business Development Corp (WBDC) • Now, WBDC has recapitalized by selling several buildings to Alexandria REIT.	• No formal linkages, but Worcester-area universities (UMass, WPI, and Tufts Veterinary) have been heavily involved in park development
Boston—BU BioSquare	• Direct development by BU's facilities office, using commercial condo model to separate facilities that can be financed by tax-exempt bonds from those that cannot	• BU offers BioSquare tenants reimbursement-based access to full range of university labs and services. Technically any company could have same deal, but proximity gives BioSquare tenants advantage.
Cambridge—University Research Park at MIT	• 20-year master development agreement with Forest City Enterprises, specifying 75-year land leases	• No special arrangements by MIT.

Tenants: Take a Portfolio Approach

It is certainly possible for a research park to attract large, multinational companies as anchor tenants, but only in certain settings (typically those in the suburbs). For example, attraction of the R&D labs of multinational companies was exactly the vision held by the founders of Research Triangle Park. With hard work, subsequent generations of park managers were able to achieve the vision, since the park was quite literally a greenfield development that could be designed, built out, and marketed in a way that appealed very precisely to the desired target market. Only a very few urban parks have matched this success with large companies, at least at the outset. One exception is Worcester, which did successfully recruit BASF's pharmaceutical operations (now part of Abbott Laboratories). However, in most urban locations large companies have actually followed and not led development of the research park. Even in the relatively gentrified Cambridge, Novartis moved a large-scale laboratory into town only after Genzyme and other MIT spin-outs had demonstrated the viability of the location, and Merck came to Boston even later than that.

For places that have not yet demonstrated a track record at building bioscience-based enterprises, it is probably best to start by exposing large companies to the university research base through small "listening posts" comprising specialized laboratory research units. Indeed, this is the approach being taken by NC State's Centennial Campus (which hosts several outposts of companies whose larger regional or North American headquarters are actually in RTP) and by the Panther Hollow Research Park at the University of Pittsburgh. It should also be noted that any significant focus on corporate R&D requires special attention to the kind of housing required by the professional, technical and managerial workforce. Large companies cannot locate on the

whim of a founding entrepreneur, and must pay closer attention to the issues that allow them to recruit reliable levels of highly qualified workers. The focus must be on both modern, suburban housing within an easy commute of the research park and revitalized urban settings, with careful attention to school options in both cases.

Table 11: Range of Tenants in Selected Region's Research Parks

Region/Park	Example Tenants and Trends
New Haven—Science Park	• Historical manufacturing and service tenants (Winchester Arms, Cyclone Microsystems, SNET, Kodak Scientific Imaging) being counterweighted by growing emphasis on Yale bioscience spin-outs (Genaissance, Vion, PhytoCeutica, etc.)
Philadelphia—Science Center	• Wide variety of tenants including Monell Chemical Senses Institute, Institute for Scientific Information, Kulgian Engineering, National Board of Medical Examiners, and a Phillips subsidiary. But providing stability across the Center are a range of UPenn offices.
Pittsburgh—Pitt UPARC	• Facilities manager for pilot plants; university programs; and multiple small users of wet-lab space.
Pittsburgh—Carnegie Mellon University Panther Hollow	• In construction—likely use as listening posts by large companies in software, electronics, robotics, etc.
Pittsburgh—Pittsburgh Technology Center and South Side Works	• Mixture of non-high-technology tenants (Union Switch & Signal, Metaltech, Aristech) and university-related research and back office sites, including Pitt and Carnegie Mellon University bioengineering labs and Pitt sports medicine.
Pittsburgh—Hazelwood/LTV Site	• In planning.
Raleigh—North Carolina State University Centennial	• Anchored by university facilities, such as the Engineering Graduate Research Center. Many large companies have satellites linked to larger locations at RTP. Specific companies in single-tenant buildings (ABB, Red Hat).
RTP	• Large corporate R&D labs (IBM, Glaxo) and major federal labs (NIEHS, EPA) and anchor nonprofit intermediaries (RTI, NC Biotech Center, MCNC)
Worcester—Mass. Biotech Research Park	• Anchored by UMass facilities (and in the early stages by an incubator, now moved out). Attracted BASF (now Abbott) in standalone facility. Over time moved toward multitenant buildings with mostly bioscience tenants.
Boston—BU BioSquare	• Anchored by university core research facilities and multi-use "condo" building with mix of bioscience companies, university-affiliated institutes, and now a formal business incubator.
Cambridge—University Research Park at MIT	• First buildings were aimed at mix of firms across software/IT, defense and biotech. Over time, radically transformed by growth of MIT-related firms like Millennium and Genzyme, and now 90 percent biotech.

Suburban Competition: Emphasize Proximity

In competing against suburban flex space owned by private developers who can unshell it for wet-lab use as demand materializes, urban research parks face several important challenges:

- Taxes and other costs that are usually higher;
- Parking that is usually not free;
- Perceived safety concerns; and
- Occasional community tensions over failure of R&D jobs to replace lost manufacturing jobs.

Nonetheless, some urban parks have been able to differentiate themselves by emphasizing their immediate proximity to knowledge generators. That is the central difference, for example, between RTP and Centennial Campus. While RTP promotes the overall academic milieu of the Triangle, Centennial requires all tenants and subtenants to sign a partnership agreement specifying exactly how they will interact with the university, either through sponsored research or hiring of students and graduates. Likewise, Science Park at Yale will compete effectively against suburban Branford because it is just minutes from the Yale medical center, the source of intellectual property and leadership for many regional start-ups. At the Science Center in Philadelphia, serving as a "portal" to university resources (in effect, as an industrial liaison) became one of the key functions of internal staff once the center absorbed the functions of a formerly standalone business incubator. Virtually all urban parks emphasize that proximity conveys real benefits when trying to reach and interact with key faculty, or to use key infrastructure elements such as core laboratories and instruments, highly regulated animal-care facilities, and in-house services such as hazardous-waste disposal and radiation-safety management.

In this way, as observed by the Science Center in Philadelphia, urban parks can segment the market. They do not bother competing for those firms which by corporate culture or preference of their managers and investors are cost-sensitive. Rather, they target those companies that place the highest value on interaction with knowledge-generators and then make the financial "fit" as close and comfortable as possible through whatever subsidy programs are available. Even more important than financial subsidy, though, is close collaboration among all stakeholders that conveys to potential tenants the unambiguous message that the community is "hungry" for their investment and will make them welcome in every way possible, both material and social.

Table 12: Types of Competition Faced by Selected Research Parks in Town and Suburban

Region/Park	In-town competition	Regional/suburban competition
New Haven—Science Park	300 George St., adaptive re-use by a private developer of a telco building near the med school	Suburban Branford, where developers are unshelling flex buildings in 30,000 square foot increments for wet-lab tenants
Philadelphia—Science Center	None	Entire Route 202 corridor, totaling tens of millions of square feet of flex space owned by REITS or private developers, and its own partner park in Newark, Delaware
Pittsburgh	4 parks within city limits, 1 more close by	Very little suburban space suitable for wet labs, though considerable for IT or other hard technology uses
Raleigh—NCSU Centennial	None in town	RTP and private space elsewhere in the Triangle
RTP	RTP is its own zip code	Some "outside the gates" developers
Worcester—Mass. Biotech Research Park	None in town; a partner park in nearby Grafton	Cambridge and, increasingly, Route 128
Boston—BU BioSquare	Little in Boston, since Longwood Medical and Academic Area is heavily built out and almost all institutional	Cambridge and Route 128
Cambridge—University Research Park at MIT	Heavy competition in Cambridge itself from other MIT endowment investments, and infill development by multiple REITs and private developers	As Cambridge approaches full build out, new space on Route 128 will come on line

Incubation: Important driver of growth, but not always an initial anchor for research park development

Attracting startup ventures can be important but is not always necessary to getting development of a research park under way. Some cities, such as Worcester, emphasized this aspect from the outset and provided a business incubator that was tightly integrated with a venture fund to make sure that it happened. But in many other communities, incubation was not a major focus at first, possibly due to lack of resources or necessary expertise, or a suspicion that many startup ventures are cost sensitive and will flow naturally to suburban locations, or an inability to meet the tight deadlines involved in venture formation. However, once Cambridge had begun to demonstrate the power of university bioscience spin-outs to reverse the fortunes of a sagging IT-oriented urban research park, attention focused again on the power of new-venture development.

In the last several years, Research Triangle Park went from no incubators to four (counting both state-sponsored and corporate versions), and both Philadelphia and Pittsburgh saw the creation of their first formal, wet-lab business incubators. These additions often correspond with an underlying change of attitude and approach by the university office for technology transfer or

licensing. Both Yale and Penn, for example, went from royalty-oriented licensing operations to offices committed to spin-off formation and building value for the university through its equity holdings. At Yale, this commitment is joined to a second and more powerful one to make sure that spin-offs stay local and contribute to the economic development of New Haven. Indeed, this is what permits Lyme Properties to position Science Park at Yale as a steady, fast-turnaround, and reliable source of high-quality, nearby wet-lab space.

Table 13: Role of Emerging Business/Incubation in Selected Research Parks

Region/Park	Incubators	Role of spin-outs	Other factors
New Haven—Science Park	Science Park itself was once conceived as an incubator as well as the developer, but that mission was abandoned. Private developer willing to consider an incubator as a tenant if the funding stream is secure	Capturing Yale spin-outs now forms the core of the developer's strategy, and availability of space is critical to Yale's intent to keep spin-outs local	Extensive overlap between tenants, Yale spin-offs, and portfolio of Connecticut Innovations seed fund
Philadelphia—Science Center	Center claims credit for "incubating" 200 businesses, but with no formal incubator. During IT boom, Center was able to raise funding for an incubator with both IT and wet-lab space	Center's ability to open a formal incubator coincided with Penn's revitalization of its tech transfer function to newly emphasize spin-offs, but many are still going elsewhere	Minimal overlap among incubator tenants, Yale spin-off portfolio, and Ben Franklin seed fund portfolio, but starting to see overlap with Life Science Greenhouse venture portfolio
Pittsburgh	The first formal wet-lab incubator has just opened as a subtenant of a biotech firm at PTC	Carnegie Mellon University has strong spin-off record in IT, but Pittsburgh has just started in biosciences	Not enough data available to assess overlap between Pittsburgh spin-offs, incubator tenants, and Ben Franklin and/or Life Science Greenhouse spin-offs
Raleigh—North Carolina State University Centennial	Centennial buildings (one institutional, one private) host two incubators (one wet lab) sponsored by a separate nonprofit	Incubation is so critical to NCSU's plans to boost spin-off formation that they will take over these incubators if funding fails. However incubator grads cannot always be accommodated quickly given present supply of multitenant space	Not enough data available to assess overlap between NCSU spin-offs, incubator tenants, and NCTDA seed fund portfolios

Table 13: Role of Emerging Business/Incubation in Selected Research Parks (cont.)

Region/Park	Incubators	Role of spin-outs	Other factors
RTP	Incubation is only a recent interest after decades of focus on multinationals. However the park now has two wet-lab incubators sponsored by nonprofit (one outside the gates) and two privately owned buildings positioned as incubators	Incubators are starting to see some Duke and UNC bioscience spinouts, though some may be better served by privately renovated space in downtown Durham	Not enough data available to assess overlap among incubator tenants, Duke and UNC spin-offs, and NCTDA seed fund portfolio.
Worcester—Mass. Biotech Research Park	Originally state-sponsored MBI operated incubator in the park. Now moved to elsewhere in Worcester.	Originally the park depended heavily on UMass spin-outs and other startups mentored by MBI.	Minimal current overlap between incubator tenants and MTDC biomedical portfolio and BioVenture portfolio
Boston—BU BioSquare	Operated informally as an incubator, but no includes formal suite of shared laboratory and office spaces as an incubator	BU's Community Technology Fund is heavily oriented to spin-off formation, though until now few have stayed local	Not enough data to assess overlap between incubator tenants and BU spinoffs and MTDC or BioVenture portfolios
Cambridge—University Research Park at MIT	No incubator	Of 60 bioscience companies in Cambridge, 21 have licensed MIT technology or were founded by alumni or faculty	Note that Millennium is now Cambridge's largest private-sector employer, with 2,000 workers followed by Biogen with 1,400. Both formed by MIT faculty.

Time Frames: Patience is Key and Managing Turning Points is Critical

Most of the benchmark communities have had research park initiatives in place for 20 or 30 years or more. Some have succeeded and catalyzed spillover development outside park boundaries, but others are still struggling. Focus needs to be maintained over a very long time frame, with stakeholder consensus on what outcomes should be and what funding streams are required. Furthermore, creation of a steady stream of university spin-outs (particularly where the institutional technology transfer office has not been accustomed to functioning on this model) can take many years, and ample support from state, nonprofit and for-profit funding streams. Overall, the reputation of any region or any neighborhood can take decades, but can then change with surprising rapidity, sometimes virtually overnight, so that one rarely remembers that a thriving park was on pastureland or an abandoned brownfield just two generations ago.

Table 14: Key Turning Points for Selected Research Parks

Region/Park	Key turning points
New Haven—Science Park	• Following repeated financial bailouts, decision by new board leadership of Science Park to privatize the development process because it would always be undercapitalized in the nonprofit context relative to needs • Yale's turn toward an economic-development strategy that focused on use of bioscience and other spin-offs to help revitalize the city and the university's surroundings
Philadelphia—Science Center	• Understanding by the neighboring institutions (Penn, its health system, etc.) of their role in stabilizing development by renting surge space and helping recruit anchor tenants • Resolution of outstanding tensions with neighbors through development of subsidized housing (by a third party) on land yielded back from original urban renewal clearance • Recent move toward professional real-estate staffing, but combined with commitment to retain university-related mission • Penn's renewed commitment to neighborhood commercial development (see below under community issues)
Pittsburgh	• Involvement of the foundation community through the Strategic Investment Fund of the Allegheny Conference (which helped develop PTC sites) and the assembly of the partnership that bought the Hazelwood/LTV site
Raleigh	• NCSU's success at winning state appropriations to move key academic "anchors" to Centennial, especially the Engineering Graduate Research Center
RTP	• Recruitment of anchors that gave the park legitimacy in the eyes of corporate decision-makers, especially NIEHS and IBM in 1965 and the first two multinational pharma companies in the 1970s.
Worcester/Boston	• No clear turning points—steady buildout

IV. Approach to Pursuing Biosciences Development Linking East Baltimore and the Broader Baltimore Region

The Baltimore region is at an important crossroads in the development of its biosciences cluster. It is clearly a leader in biomedical research, but its research success is not matched by its bioscience industry development.

More problematic is that while the bioscience research base in the Baltimore region continues to enjoy strong growth, the biosciences industry base has been flat and has failed to keep pace with national growth and existing and emerging regional competitors.

The need for new anchor developments to better leverage the strengths of the growing biomedical research base and catalyze biosciences industry growth in the Baltimore region has never been greater.

VISION OF SUCCESS

Our vision of success starts with the understanding that regions compete with other regions, and the development of locations within regions promote strength and development momentum that is complementary and contributes to growth across the region.

With this in mind, it is critical for East Baltimore's bioscience development that it be linked to a broader regional focus, while at the same time pursue specific targets of opportunity for its development, leveraging the strengths of Johns Hopkins University medical complex and building partnerships with other research drivers.

Region-wide Vision: The Baltimore region will establish one of the world's premier biomedical districts linking together its world-class hospitals and medical schools, with a robust commercial bioscience research and diagnostic services cluster to create a high value-added environment for fostering new bioscience ventures and attracting leading biotechnology, medical device and pharmaceutical companies to the Baltimore region.

East Baltimore Vision: East Baltimore's Biotech Research Park will be a key anchor and driver for the region's growing bioscience industry cluster by:

- Serving as a hub for the region's commercial research services cluster
- Offering an entry point into JHU from advancing broader relationships with bioscience industry to enhancing the ability to generate new bioscience ventures
- Enabling start-up and emerging bioscience companies and initial operations of existing bioscience companies to gain a foothold in the region
- Providing educational and training facilities with a strong outreach to minority community and existing workers seeking careers in the biosciences and upgraded skills
- Addressing in partnership with the community ways to improve public health in the East Baltimore area

TARGET GROWTH APPROACHES

To realize this vision, the Baltimore region needs a diversified growth strategy that can leverage the assets and address the weaknesses and gaps found in the region relating to biosciences development.

One key element of this growth strategy is to focus on recruitment of commercial bioscience activity to the region. The realization of a critical mass of leading biotechnology, medical device or pharmaceutical companies operating in the Baltimore region can be achieved over time, with a pro-active and sustained outreach effort and a near term focus on creating a strong presence of commercial bioscience research and diagnostic activities to serve as a foundation for offering high value environment to operate a bioscience company. Baltimore needs to be recognized as a welcoming location where innovative, advanced biosciences products and services can leverage the best thinking of academia and high quality support resources for biomedical product development and pre-clinical and clinical testing needed to launch a successful product.

Entrepreneurship is another key focus for building a future base of commercial bioscience activity in the Baltimore region. The fast pace of new discoveries and the broad breadth of market opportunities found in the biosciences makes it ripe for new business start-ups. Baltimore needs to invest in building a culture of entrepreneurship that can seize those commercial opportunities generated by its world-class biomedical research organizations into forming new ventures, and capture those new ventures in the region by having the incubation and new venture support tools in place to be a competitive location for new bioscience business start-ups.

The Baltimore region must invest in supportive resources that generate benefits from pursuing biosciences development to the broad community. Commercial biosciences activities can offer good quality jobs across a range of skill levels, and in turn the growth of these commercial bioscience activities depends upon having a range of qualified workers. Advancing educational and training for research, clinical and biomanufacturing technicians can translate the promise of the biosciences to a broad range of workers and students who are not going to pursue medical or graduate science degrees. And linking advancements in the biosciences towards improving a communities public health system, through activities such as prevention and access to advanced treatments, can raise the quality of life of communities.

This focus on a comprehensive and balanced growth approach for biosciences development of recruitment, entrepreneurship and supportive resources translates into a set of targeted growth opportunities for the Baltimore region, with specific implications for the development of the East Baltimore Life Sciences and Technology Park:

- Growing a robust commercial-oriented bioscience research cluster
- Promoting active relationships with leading national bioscience firms
- Fostering a new generation of leading therapeutic and medical device companies in the Baltimore region through a comprehensive bioscience technology commercialization effort
- Generating a talent pool of bioscience workers at all levels to support the growth and attraction of bioscience businesses

For each of these targeted growth opportunities we set out an “opportunity statement” that:

- Gives a context to the growth opportunity including market potentials;

- Sets out the strengths and opportunities that the Baltimore region can build upon; and
- Identifies key challenges facing the Baltimore region to be successful.

Opportunity Statement: Grow a robust commercial bioscience research-oriented business cluster

Overview and Market Potential

Commercial bioscience research and diagnostic related companies are the backbone for medical care, pharmaceutical and biotechnology industry activities. They provide a range of contract research services for bioscience research institutions, pharmaceutical and biotechnology companies, such as high throughput genomic and proteomic analysis, biological testing services, pre-clinical animal models, drug development and clinical trials. As biotechnology advances move from the research lab into clinical care, these services are also having a growing impact on the diagnosis and treatment of diseases, and helping to usher in a new era of personalized medicine.

This major bioscience sector is often overlooked because it is not comprised of high-flying biotech or pharmaceutical companies developing new blockbuster drugs. Nevertheless it is a significant sector, with healthy growth prospects.

Nationally, this bioscience sector has grown in employment by 24 percent from 1998 to 2003, reaching 146,000 workers across 6,500 establishments. This industry is marked by being highly fragmented with many specialized niches and a broad range of companies involved from equipment makers, suppliers of key biological products and service products.

A key growth driver for commercial bioscience research is the move towards contract drug development services for both pharmaceutical and biotechnology companies. For pharmaceutical companies, the use of contract drug development reflects ongoing consolidation and cost-cutting, while biotechnology companies are often seeking skill sets outside of their specific domains to move from promising targets through to commercialization of new therapies.

One key component of the commercial bioscience research sector is biomolecular research and development supporting drug discovery. The total market for products and services for drug discovery, including genomics, was estimated to be $5.3 billion in 1998 and growing at 15 percent per year by High Tech Business Decisions. These commercial biomolecular research and development activities involve a range of market niches, such as:[5]

- High throughput screening for drug discovery is estimated to generate demand for outside services in excess of $1.5 billion.
- Cell analysis technologies used for clinical diagnosis and monitoring as well as research. Increasingly as genomic approaches expand the number of cell type specific targets, cell analysis techniques are growing in importance in assessing drug-target interactions.
- Transgenics involving animal models for studying diseases is expected to exceed $1 billion.

Once a potential chemical agent has been validated then a broad set of preclinical activities are undertaken—involving drug safety, preclinical R&D, drug disposition, drug evaluation and

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[5] Estimates of bioscience market size reported from Dorland's Biomedical, Medical Healthcare Marketplace Guide, 2002-2003

toxicology. This is another large niche activity, expected to reach 15 percent of $50 billion global pharmaceutical R&D effort.

A growing service for many emerging biotechnology companies pursuing more large molecule protein therapies and other biologic therapies as opposed to traditional small molecule chemical agents is the rise of biopharmaceutical contract manufacturing. Advances in biotechnology research are resulting in a growing number of new drug therapies produced by live, genetically-modified microbial or animal cells, referred to as biologics. Genetic Engineering News (August 2002) reports that the current total pharma market is $390 billion, of which biologics accounts for seven percent, or $27 billion. By 2006, the total pharma market is expected to increase to $550 billion of which biologics will account for $70 billion—implying a growth rate for biologics of 15 to 20 percent per annum. Moreover, approximately one-third of the entire new drug pipeline are now biologics.

A major market for the future of commercial research and testing may be in "predictive medicine" involving the use of genetic-based diagnostics with pharmaceutical treatment. Clinica Reports explains that "predictive medicine" or what is also referred to as theranostics can help identify which patients would be most suited to a particular drug therapy or could be used to provide feedback on how well a drug is working and help tailor medical treatments.

The Baltimore Advantage

The Baltimore region seems to be well positioned to grow its base of commercial research and diagnostic services.

- **First, even without a targeted development effort, the base of commercial research services in the Baltimore region is growing and becoming a regional specialization in the biosciences.** The commercial bioscience research services sector in the Baltimore region is a growing sector—recording a 9.8 percent increase in employment from 1998 to 2003—and today stands at 102 establishments, employing 1,518 workers. This translates into the Baltimore region having a 25 percent higher share of private sector employment than the nation for commercial biosciences research services. These positive developments suggest that Baltimore, if it targeted additional growth in this area, could be successful.
- **The presence of significant bioscience research base creates a large market for research support services and offers the opportunity for the region to specialize in advanced biomolecular research services.** The Johns Hopkins University and the University of Maryland, Baltimore combined generate over $700 million in bioscience research. A considerable share of this bioscience research funding goes for purchasing supplies, equipment and services to support these research activities. This offers a considerable market, which from discussions with procurement officials already leads many vendors and equipment manufacturers to have staff routinely available to provide technical assistance to research labs. In addition, the universities themselves have been able to create shared service centers for key research lab needs from gene sequencing to cell culture to electron microscopy, which can be made available more broadly to provide services to bioscience industry and to other bioscience research institutions located outside of the region.
- **At the same time, these university-research efforts generate new advances in biomedical techniques, from advanced approaches to high throughput biological**

screening to innovations in imaging and analysis of tissue specimens, which can be used to create partnerships with existing research instrumentation and services companies.

- **More broadly speaking, the Baltimore region may also be able to move into more specialized areas of predictive medicine and disease management services leveraging its strong regional specialization in hospitals and medical labs together with its basic biomedical research capacity.** Many of those interviewed noted that what made the Baltimore biomedical research environment special, particularly at JHU, was that it not only was a leading biomedical research institution but that there were strong connections with its outstanding clinical practices, which are leaders in advancing innovations in medical treatments. This combination of having leading research capabilities, particularly with a strong genomics approach, together with the premier clinical research and care practices found at the region's teaching hospitals and a growing base of commercial research and testing companies, can help position the Baltimore region into being a leader in predictive medicine and other specialized diagnostic services and disease management.
- **A key advantage for growing will be the need to profile the region's proximity to both big pharma and to NIH.** Baltimore needs to promote its strategic location, having two leading academic health centers and its proximity to other biomedical research centers being nearby to the Philadelphia/New Jersey region with its high concentration of pharmaceutical companies and Washington, D.C. with its presence of NIH to a broad range of commercial research and testing companies.

Key Challenges for the Baltimore Region

Moving forward on a focused effort to exploit the region's potential in commercial research services and closely related diagnostic services needs to address the following challenges:

- **Establishing and sustaining linkages between universities and companies**. There are many potential collaborations to develop and commercialize new specialized research and testing technologies being advanced in the labs at JHU and UMB. These range from new techniques in high throughput biology to predictive medicine services to unique animal models for pre-clinical testing. But there is no focused effort, particularly, at JHU to address this need on an ongoing basis. Industry interviews identified many situations where potential collaborations fell through the cracks.
- **Putting in place a pro-active outreach effort to key vendors providing services to major academic health centers to locate product development, testing and production facilities in the region.** Today, there is no focus on commercial bioscience research and testing as a target of opportunity for the region. Many of the key relationships with these firms is found in the procurement activities of the major academic health centers, but there is no mining of this information or development of a relationship building program to reach out to key vendors and grow their activities in the Baltimore region.
- **Lack of affordable research laboratory space in a multi-tenant flex space facility**. For Baltimore to become a leading location for commercial research and testing companies, it must address the ability of the region to offer affordable specialized wet lab facilities in a multi-tenant flex building approach that can offer office space and light manufacturing space together with its wet lab space. Due to the specialized nature of this type of space, it not a real estate product that the commercial sector is likely to generate without public sector and

non-profit sector partnerships in place. In particular, there is an element of having a limited amount of ready to go, speculative space so that companies can have the advantage of being able to move immediately rather than encounter delays, particularly that many activities located in the Baltimore region may start small and grow over time.

Opportunity Statement: Promote active relationships with leading national bioscience firms

Overview and Market Potential

There continues to be a broadening of the approaches that large corporations, including leading biomedical companies, are taking towards research and development. BusinessWeek notes: "…a new R&D model is emerging, dubbed open innovation. Companies of all sizes are rounding up more partners, big and small, than ever before and they're casting wide research nets, snapping up work at diverse corporate, government and academic labs."[6]

In drug discovery, these efforts are taking an accelerated course. A recent article in MIT's Technology Article, explores the changing nature of commercial drug industry R&D and finds that a "transition has been under way at many pharmaceutical companies for several years, but firms are now moving rapidly to search out mergers, forge collaborations with academic groups, strike deals with biotechnology companies, and establish outposts near hotbeds of university research."[7]

What is driving this new approach in drug discovery is the fact that as R&D spending is climbing, fewer and fewer wholly new drugs are making their way through the pipeline. The decline in new drug approvals, according to MIT's Technology Review article, reflects that many low-hanging opportunities for drug development have been plucked, but it also points out that it takes a number of years for new technologies to be incorporated into the drug discovery process.

Already many major pharmaceutical companies have established "lablets" or key outposts for advancing new drug R&D, including:

- Novartis in Cambrige, MA including a focus on oncology and infectious diseases
- Pfizer in Cambridge, MA focusing on ultrafast screening of genome-derived drug targets
- Abbot Labs in Parsippany, NJ focusing on autoimmune drugs
- GlaxoSmithKline in Research Triangle Park for metabolic and viral diseases, as well as in the Philadelphia region for microbial, musculoskeletal and proliferative diseases

The Baltimore Advantage

The growing base of industry supported bioscience research in Baltimore—rising from minimal levels in the 1980's to now over $100 million—suggests that the Baltimore region is maturing in its relationships with biomedical companies. Moreover, the licensing of technology from JHU, UMB and UMBC continues to advance, and in the most recent year reported (2000) a total of 134 licenses were executed and a total of 183 licenses are generating income.

[6] "Reinventing Corporate R&D," BusinessWeek, September 22, 2003, pg. 74.
[7] Stephen S. Hall, "Revitalizing Drug Discovery," MIT Technology Review, October 2003, pg 39.

A key advantage for the Baltimore region going forward will be its ability to not only offer a premier research base that attracts top talented biomedical researchers, but its ability to connect with an outstanding clinical base for advancing clinical research and gaining access to thought leaders in how to approach new medical treatments.

Key Challenges for Baltimore Region

Despite the apparent advantages found in the Baltimore region for locating lablets, it is notable that none have been developed.

One clear need identified for JHU School of Medicine is that of a more one-stop, pro-active industry liaison function. From discussions with leading faculty at JHU, from time to time there have been opportunities identified, but they have failed to materialize because there is a perception that JHU in particular is not interested and would not move quickly to seize the opportunity. On a similar note, discussions at a recent corporate advisory board formed at JHU, indicated that major corporate leaders do not see a Baltimore location as viable for promoting serious R&D relationships. And, even more discouraging, interviews with local companies identified specific instances where JHU simply failed to follow-up on establishing relationships. Cutting across all of these points of "evidence" is the lack of someone empowered and responsible for making these connections—that are less about commercializing new research discoveries, and more about creating an environment where biomedical industry feels it can be part of a high-value, robust research environment.

UMB, meanwhile, has a number of growing research relationships with pharmaceutical companies that potentially could be generated into more of a physical presence, particularly with Novartis and ALZA. But, similar to the case at JHU, there needs to be a value proposition put forward that makes sense.

The development of the proposed research parks at JHU and UMB may address the issue of locating a corporate research outpost and in that way help raise the profile of the region to major biomedical companies. With the development of research parks closely associated and proximate to both the campuses of JHU School of Medicine and UMB, the Baltimore region will have logical locations for satellite research offices of pharmaceutical and biotechnology companies.

But a strong outreach effort needs to be put in place to complement these new physical locations. The Baltimore region needs a serious effort to explore how to put these lablets into place. Baltimore needs to establish and sustain a broad outreach to change the way national pharmaceutical and biotechnology companies view the region. One suggestion raised is the need for a well-recognized biomedical industry leader to be put in charge of forging these broader corporate relationships. A key starting point is taking a close examination with leading faculty who serve on advisory boards of national pharmaceutical and biotechnology companies to discuss opportunities for locating satellite facilities and key issues to address in having Baltimore be at the top of the list of preferred sites.

Opportunity Statement: Foster a new generation of leading therapeutic and medical device companies in the Baltimore region.

Overview

Given the fast pace of technological advances and the broad market opportunities, it is not surprising that new venture development is a hallmark of the biosciences. Corptech, the leading company database tracking business developments across technology fields, reports that bioscience industry areas, including biotechnology, pharmaceuticals and medical products—have a higher rate of new firm formation than all technology fields.

This is particularly true for biotechnology, in which nearly one in 10 companies listed in Corptech have been founded since 2000. By comparison, across all of the technology fields only one in 20 firms listed were started since 2000. Overall, new bioscience firms started since 2000 represent nearly 10 percent of all new technology business start-ups nationally as tracked by Corptech.

For major research universities, the biosciences is a key area of new firm formation. Based on an analysis of data reported by technology transfer offices of major research universities, teaching hospitals and independent, non-profit research organizations, it is estimated that on average a new bioscience firm is established for every $50 to 75 million of bioscience research.

A key driver for new and emerging biotechnology companies focused on specific disease areas is the strong relationships with pharmaceutical companies that is now a well-developed approach for R&D in the biosciences. These new and emerging bioscience ventures typically have a proprietary technology and specific know-how focused on applying advances in molecular biology, biotechnology, chemistry and bioinformatics for new drug discovery and improved drug delivery. With this technology platform, the smaller specialized biotechnology company can become a key partner tapping into the broader marketing, drug development and resources of larger pharmaceutical and biotechnology companies.

Often overlooked is the great potential for new start-ups in the medical device sector. The overall market for medical devices and diagnostics stands at $165 billion, with estimated growth of five to eight percent annually. There are many niche market opportunities found in the medical devices, with many high tech products offering high-profits and strong growth prospects, including diagnostics, cardiovascular, minimally invasive surgery and outpatient and home health care monitoring systems. This depth of niche opportunities is reflected in that 80 percent of the 10,000 existing medical device companies have less than 50 employees, and a significant percentage are developmental companies according to recent surveys by the Health Industry Manufacturers Association. New medical device ventures also do not face the high level of regulatory scrutiny confronted by bioscience companies pursuing new drug development, but issues of inclusion under insurance reimbursement are a major concern for new, innovative products.

The Baltimore Region Advantages

The quality and depth of the region's biosciences base is outstanding and offers a strong base for creating new bioscience companies. As one venture capitalist suggested, if a JHU faculty member is interested in speaking with them, they will make the time to sit down.

Research universities in the Baltimore region do have a better than recognized track record of start-up companies commercializing research discoveries at their universities as well as close relationships and associations of new start-ups with faculty at Baltimore-based research institutions. The general perception that Baltimore research institutions cannot generate new start-ups or that faculty are not involved in new start-up activities is too extreme. There are start-ups created by research universities based in Baltimore—11 in 2000 are reported from JHU, UMB and UMBC— but the success of these ventures has not been strong and many do not remain in the region. Similarly, faculty at JHU and UMB are involved with start-up firms, but these firms are largely based outside of the Baltimore region in nearby regions of Suburban Maryland or Philadelphia. A recent study of the genealogy of bioscience and medical instrument companies in Maryland by Marsha Schachtel and Scott Heacock at the Johns Hopkins Institute for Policy Studies, commissioned by DBED and TEDCO, identified the ties of Maryland-based companies to research institutions and found that 30 Maryland-based companies were identified with JHU ties, primarily faculty or staff, and 13 companies have UMB ties.

Key Challenges to Address

There is still significant improvement needed in start-up activity from the universities. The rate of new start-up formation relative to the research bases found at JHU, UMB and UMBC are at the median level or below.

The ability of region to capture these start-ups is not strong. Out of 17 new start-ups generated by JHU in 1999 and 2000 only six remained in Baltimore.

Lack of ability to translate targets into drug discovery and development. As noted earlier, there is a concern that the research discoveries in Baltimore are too early stage or basic in nature to be commercially viable. The Baltimore region does not have a strong drug discovery and development capability to match its basic research capacity.

Interviews identified an untapped potential for the Baltimore region in the area of medical instrumentation and devices. Baltimore boasts strong research competencies in biomedical devices, ranging from radiology/imaging to biomaterials to research instrumentation to biological sensors to systems engineering.

But perhaps the most difficult issue facing Baltimore in advancing new venture development is having experienced management teams. Venture capitalists see the Baltimore region as not having in place the quality management teams to advance new bioscience ventures. This is viewed as a chicken and egg problem. Interestingly, though, the suburban Maryland area, just 30 miles down the road, seems not to have this management problem.

Opportunity Statement: Generating talent pools of bioscience workers across skill levels

Overview and Market Potentials

As Baltimore seeks to advance its position in the biosciences, it is important to demonstrate the availability of a trained workforce, especially in laboratory science positions. At the same time, for East Baltimore, it is important to ensure that the jobs generated at the Biotech Research Park can benefit local residents.

The biosciences support a broad mix of occupations and skill levels. Leading occupations include laboratory technicians, manufacturing technicians, quality control and regulatory affairs workers. For hospitals, the leading field is health care practitioners, though they only comprise about one-half of the total jobs in hospitals. Among the health care practitioners, doctors are not the dominant occupation, comprising under three percent of all hospital workers, rather it is registered nurses and nurses aides, who combined represent nearly one-third of hospital workers.

Among the key challenges in bioscience workforce development are:

- Nursing is a field that is in shortage nationally.
- Not as well publicized are the looming shortages for medical technicians and technologists, who work in clinical labs. These medical lab workforce is aging and the level of new graduates is falling off significantly.
- Hard for colleges and universities to keep up with the changing demands for bioscience researchers where increasingly a multi-disciplinary workforce is needed able to integrate computer science, engineering disciplines, nanotechnology and other physical sciences to advance discoveries, develop products and deliver services.

The Baltimore Advantage

One advantage for Baltimore is the broad range of occupations it supports in the biosciences, particularly in clinical care. With over 66,000 bioscience workers employed in Baltimore in the clinical care arena, a plethora of opportunities from lab technicians to medical assistants to surgical technicians to nurses are in demand.

Baltimore is a leading region in the generation of biomedical and medical sciences graduates, with nearly 5,000 graduates in 2001. This is among the leaders, being greater than seven of the 10 benchmarks, and surpassed only by Boston, Philadelphia and Chicago, which have larger base of post-secondary schools. The region has a broad range of higher education opportunities for students at different levels interested in pursuing biosciences careers, with specific focuses on lab technicians and biomanufacturing along with more traditional academic focuses.

Another key advantage for Baltimore is its mix of programs in education and training for bioscience career changers. Unlike other regions, Baltimore has a focus on training adults for careers in the biosciences with the BioTechnical Institute of Maryland and the STEP program.

Key Challenges

Despite the significant size of the bioscience research activities found in Baltimore, employment in bioscience research occupations is much lower relative to the overall bioscience occupational base than in most of the benchmark regions. While bioscience research occupations comprise just under four percent of all employment in bioscience occupations, in Boston it stands at 9.6 percent, San Francisco 9.7 percent, Philadelphia seven percent and Research Triangle 15.2 percent.

So two particular issues for Baltimore will be how to:

- Leverage the hospital and research base to develop skill competencies that can transfer to more commercial bioscience activities.
- Retain graduates to work in the region.

CONCEPTUAL PLAN FOR DEVELOPING THE EAST BALTIMORE LIFE SCIENCES AND TECHNOLOGY PARK

The targeted market opportunities provide a business development framework for growing the Baltimore region's bioscience base by leveraging the strengths of its research anchors as well as the presence of its bioscience industry base. This development framework can be summarized as:

Four key growth opportunities should be pursued with a near term focus on growing a robust commercial research business cluster complemented by an ongoing, sustained effort in promoting active relationships with leading national bioscience firms to gain a stronger presence in the Baltimore region, fostering a new generation of leading therapeutic and medical device companies in the Baltimore region and generating the talent pools to support broader biosciences development.

These targeted market opportunities translate into a conceptual plan for the development of the East Baltimore Life Sciences and Technology Park. Specifically, the East Baltimore Life Sciences and Technology Park can become within the context of a broader regional development:

- A hub for the region's commercial research and diagnostic services cluster.
- An entry point for biosciences industry into the JHU environment with a strong focus on advancing broader R&D relationships with bioscience industry.
- Enhancing the ability to generate new bioscience ventures leveraging the major research programs found at JHU.
- Providing educational and training facilities with a strong outreach to minority community and existing workers seeking careers in the biosciences and upgraded skills.

Another key role that the East Baltimore Life Sciences and Technology Park can serve is to advance public health interventions and community-based public health enterprises by addressing in partnership with the community ways to improve public health in the East Baltimore area. This additional activity can clearly demonstrate the Park's recognition of the need to improve the quality of life in East Baltimore, not only in generating jobs and skills development for residents, but in broader community impacts.

The discussion below sets out the specifics of this conceptual plan, examining:

- Specific opportunities to anchor the four target growth opportunities and the additional public health partnerships within the East Baltimore Life Sciences and Technology Park;
- Key mechanisms needed to ensure the success in pursuing these specific opportunities; and
- Anticipated staging of the development over time.

Specific Opportunities to Anchor the East Baltimore Life Sciences and Technology Park

Largely from the interviews with key administrators and faculty at JHU and with industry executives, a range of specific opportunities for the East Baltimore Life Sciences and Technology Park have been identified that are aligned with the overall targeted growth opportunities for Baltimore.

Hub for Commercial Research Activities

There are major opportunities to house within the East Baltimore Life Sciences and Technology Park a range of high-end core laboratories that can serve not only the JHU research community, but be a base of operations for serving other research institutions and biotechnology and pharmaceutical companies.

One specific opportunity is to locate the JHU Genetic Resources Core Facility within the East Baltimore Life Sciences and Technology Park. Over the past fifteen years, the JHU School of Medicine has established a leading set of genetic core laboratory facilities as part of the Genetic Resources Core Facility to provide:

- DNA analysis involving sequencing reactions, synthesis of genetic materials, and data analysis of micro-array. Recently this unit went to on-line ordering;
- Cell culture facility that grows cells outside of the body to isolate DNA, which currently has an 80,000 to 90,000 cell line with extensive database; and
- A new high throughput genotyping facility to replicate whole genome scans or do fine mapping, as well as perform genotyping on customized arrays based on the technology platform developed by Illumina.

A recent decision has been made to open these services more broadly to researchers at other universities, NIH and pharmaceutical and biotechnology companies.

The Genetic Resources Core Facility has had to scatter its operations across Baltimore because of the lack of space in East Baltimore. There is an opportunity to consolidate within the East Baltimore Life Sciences and Technology Park all of the core lab facilities. Currently these operations employ approximately 20 employees in approximately 5,000 to 10,000 sq. ft. of space. However, substantial growth can be expected in the future, as the Genetic Resources Core Facility opens its services to other researchers and pursues specific opportunities. For instance, a recent contract undertaken by the Genetic Resources Core Facility for performing customized DNA testing of blood samples for a federal agency now employs five full time workers, suggesting that even more growth can occur when adequate space is available rather than the scattered locations. In addition, the development of the genotyping facility can also begin to move the Genetic Resources Core Facility into a more active role in predictive medicine applying these genotyping technologies for more diagnostic uses.

Similar to the Genetic Resources Core Facility is the opportunity to consolidate within the East Baltimore Life Sciences and Technology Park the growing tissue specimen banks associated with JHU, which has scattered operations and needs a more centralized facility to ensure quality control, monitoring and ease of transporting. These tissue specimens have been developed around long-term disease specific research activities, such as research into colon cancer in which families have been followed overtime as part of cohort studies conducting for many years. Already companies have been seeking partnerships to work collaboratively with these tissue specimen banks to identify potential drug targets. Also associated with these tissue specimen activities could be a central phlebotomy facility to support clinical trials activities at JHU, many of which are conducted with industry support.

Not only are there opportunities to house specific laboratory activities found at JHU, which have growing commercial relationships, but to bring in private vendors who can serve JHU and use

East Baltimore as a base of broader operations in the region and perhaps to support national activities. For instance, a major national transgenics research model company is considering locating in the Baltimore region to provide services to JHU researchers engaged in pre-clinical studies and potentially could serve as a basis for broader regional operations. Similarly, JHU is considering how to collaborate with major information technology partners to offer a new information technology platform to meet the growing informatics needs of JHU researchers. The East Baltimore Life Sciences and Technology Park could be a location for housing the data servers, data management, and other supportive services for these informatics efforts of commercial partners to JHU.

Having the presence of these core laboratory facilities—able to serve not only JHU research community but a broader range of researchers in other institutions and companies—may serve as a magnet for other vendors to JHU or commercial research companies offering more niche or innovative research and testing services to be co-located and be part of a growing commercial research services hub.

Key to the success in attracting these core facility operations is having affordable specialized wet lab space combined in a more flex office/light manufacturing configuration. One reason these services are not found in East Baltimore today is not only the lack of space, but the fact that standard JHU research facilities carry a very high leasing rate. Unlike research activity supported by NIH research grants, which allows institutions to capture indirects for supporting space needs, these core research facilities are highly sensitive to cost factors. Discussions with key administrators suggest that leasing costs of $15 to $20 per sq. ft. were what was an affordable range for these operations.

Similarly, discussions with commercial research companies already present in the Baltimore region identified lack of affordable wet-lab space with ability to support light manufacturing and office space, was a constraint in their business operations and future growth.

Promoting active relationships with leading national bioscience firms to gain a stronger presence in the Baltimore region

There is an opportunity for the East Baltimore Life Sciences and Technology Park to be the location for future "lablets" or satellite research offices of more nationally based bioscience firms.

An initial first step is for the East Baltimore Life Sciences and Technology Park to have available at any given time the ability to provide "landing party" space for these nationally-based bioscience firms to gain an initial foothold in the Baltimore region and begin its collaborations with JHU. It is expected that as these firms make longer term commitments to satellite research offices in the Baltimore region, then there will be the opportunity to lease them land for their own stand-alone facilities either directly or through a commercial developer, or alternatively they can become anchor tenants in a future multi-tenant facility. In our interviews, at least one such national firm indicated an interest in taking approximately 5,000 sq. ft. of space to undertake product development testing for advanced diagnostic equipment.

It is important to recognize that it is not just space proximate to JHU being marketed, but a deeper connection with a vibrant biomedical community. A serious and tangible program offering is needed that can make real the promise of the value of being located close to JHU's East Baltimore campus. These can include ready access to clinical researchers for clinical trials, pre-

clinical testing, relationships in collaborative research, access to talented post-docs and graduate students, etc. What is key is having an ability to deliver on these connections.

Completing this program focus is the need to have an ongoing effort to leverage the broader ties of JHU faculty, departments and other entities with the biomedical community to begin an outreach effort to potential companies interested in exploring a landing party approach. The most likely targets are those companies that already have a relationship and ties to JHU. Key targets of opportunity identified from interviews include:

- **Leveraging JHU faculty relationships and alumni with large pharma, biotech research organizations and emerging biotech companies.** Interviews identified several JHU faculty serving on Boards of Directors and Scientific Advisors for major bioscience companies (Merck, Biogen, Affymetrix) as well as emerging biotech companies. Note: No active program to build broader partnerships between JHU and these bioscience companies.
- **Leveraging alumni of JHU, who are serving in powerful positions across bioscience companies in U.S.** Recent example is formation of Advisory Council to new Institute of Basic Biomedical Sciences, which includes senior executives at J&J, Aventis, Smith Kline, etc.
- **Building upon clinical research relationships with industry, includes new Specialized Programs of Research Excellence from National Cancer Institute, which gives companies ability to tap clinical trial reviews.**

Fostering the next generation of therapeutic and medical device companies

A longer term initiative is to position East Baltimore as a prime location for new bioscience start-ups, particularly associated with JHU.

Similar to the situation with landing party space for nationally-based bioscience companies, a number of interviews indicated that existing start-ups associated with JHU faculty might be interested in locating their operations in East Baltimore if the location was competitive in pricing. This is more akin to having available some potential multi-tenant space at any given time than it is having a well defined incubator program. In many ways this is similar to the Pittsburgh experience where the availability of highly affordable space at UParc, the old research facilities of Gulf Oil, has led many emerging bioscience companies to open their operations in that location.

However, this is not to say that a well-conceived incubator program for spin-off technology commercialization opportunities associated with JHU would not be of significant value for East Baltimore. In particular, an incubator facility combined with specialized proof-of-concept resources focused on specific areas of innovation seem ripe for East Baltimore. These areas of focus include:

- **Advancing drug discovery and development building off biological targets.** JHU has recognized that it faces a real limitation in advancing its research discoveries of biological targets for new therapeutic interventions by not having a stronger drug discovery program. A key new initiative being established is a "chemcore" facility to ramp up the ability to conduct high throughput screening against potential libraries of chemical agents. Even with this facility, JHU is missing an associated medicinal chemistry to further refine and design possible chemical agents involving toxicity studies, drug delivery, formulation, and other

analytical methods. Proof-of-concept resources are needed to conduct these drug development activities before the commercial viability of a new start-up can be ascertained. Possible opportunities might be to partner with the University of Maryland School of Pharmacy or alternatively to engage the services of contract research companies.

- **Research instrumentation and medical devices.** JHU has a number of opportunities to advance new research instrumentation and medical device ventures. These activities may not be the blockbuster companies that a new therapeutic commercialization would support, but it can create solid, mid-sized companies in the region. Among specific areas of potential is the major new faculty hires at JHU in proteomics, with a strong bent on developing new technologies, instrumentation, etc., the growing applications in cardiology involving new approaches for measuring of blood pressure, locating catheters in the body, etc., and the ongoing work in biomedical imaging technologies. This focus also ties into the biomedical engineering expertise found at Morgan State, as well as the significant applications for biomedical devices found at the Applied Physics Lab. What would be significant for advancing these opportunities is the presence of a medical device proto-typing center that can be a meeting place for linking clinicians and biomedical engineers and move from the bench level to initial product design for new innovations.

Another important activity is to promote entrepreneurial awareness and development. The recent efforts of the JHU Biotech Network—reaching out to graduate students and postdocs—offers a promising platform for undertaking a more comprehensive effort to offer seminars, speakers, short courses, and business plan competitions, which together can raise the awareness and understanding of what it takes to commercialize technologies as well as form and grow bioscience companies.

Generating Talent Pools

The East Baltimore Life Sciences and Technology Park can become a locus of activity for a broad range of bioscience education and training initiatives from young adults seeking to enter the biosciences to existing bioscience workers seeking to upgrade their skills to K–12 students seeking to gain a specialized science and technology education.

A cornerstone of this education and training activity would be the location of the BioTechnical Institute of Maryland (BTI) in the park. BTI has deep roots with JHU, being led by Dr. Sue Penno, a faculty member at JHU and the director of the cell culture resource facility at the Genetic Resource Core Facility. BTI has a strong track record in being able to train recent high school graduates with minimal work experience for entry level bioscience lab positions. Ongoing proposals have been developed to expand this program into the high schools. There is also an interest in augmenting and integrating with the activities at Dunbar High School and possibly creating other specialized life science schools.

While an expanded BTI program can be the centerpiece for a regional bioscience education and training center at the East Baltimore Life Sciences and Technology Park, it is not the only activity. Other opportunities for bioscience education and training would include:

- Strong linkage with the University of Maryland Biotechnology Institute and its ongoing efforts in K–12 bioscience outreach and advanced degree programs;

- Availability of shared K–12 instructional facilities that could be used by K–12 schools from across the region for hands-on classes in biological techniques as well as offer specific training for science teachers in K–12 and after-school programs.

Currently BTI has 10,000 sq. ft. of space. This can be the anchor for a larger free-standing bioscience educational and training center of perhaps 20,000 to 30,000 sq. ft.

Addressing Public Health Partnerships and Community-Based Enterprises

Given the public health expertise found in Baltimore it is important that East Baltimore be a national leader in neighborhood-based public health partnerships. As noted in the core competency analysis, a major clustering of bioscience research activity in Baltimore is found in public health interventions, with JHU being a leader focus of activity, but other institutions from Morgan State to UMB having considerable activities.

There is an opportunity for the East Baltimore Life Sciences and Technology Park to be the home of the growing Public Health Program of Morgan State, with its close ties to JHU's Bloomberg School of Public Health and pursuing innovative community-based public health initiatives. This program is the first doctorate-granting public health program at a Historically Black College or University. It brings a unique focus combining excellence in public health research with a very practice-based, community-oriented program targeted to address needs of urban minority communities. As Dr. Yvonne Bronner noted in the first commencement of graduates from the Public Health Program: "our graduates are a new generation of public health professionals. A generation that understands that you cannot study a community without serving it, and that you cannot help a community without working with and empowering its members." This philosophy of community public health partnerships is a powerful one and one well-suited for East Baltimore.

There is also a close partnership between Morgan State and JHU in their public health research efforts, embodied in a joint center for health disparities as well as broader access to JHU research faculty as advisors to students. So having Morgan State's Program in Public Health in East Baltimore can build on important ties to JHU as well as to the community.

At the same time, there is an opportunity to explore, through the efforts of a focused public health program in East Baltimore, how new community-based services can be developed as community enterprises for ensuring prevention, home-based care and other key public health applications can be established. Several Baltimore area funders, particularly foundations such as the Casey Foundation and the Open Society Institute, have launched a Baltimore Fund, administered by The Reinvestment Fund, to invest in high-growth companies located in the region, promoting job-generating enterprises as part of a comprehensive workforce development approach. Advancing new health care enterprises is a promising opportunity to meet the Baltimore Fund's criteria of high growth businesses creating job opportunities for low-income residents. A focused program on health care activities could complement the training efforts identified earlier as well as create important community-based public health services.

Key Mechanisms and Resources for Ensuring Success

From the identification of specific opportunities, a number of critically important mechanisms and resources are needed to ensure the success of the East Baltimore Life Sciences and Technology Park. Three particular mechanisms stand out:

- Addressing the ability to create affordable wet-lab space on an ongoing basis;
- Establishing an industry liaison function that functions both strategically and day-to-day to advance collaborations with industry.
- Forming a technology commercialization entity tailored to the needs of the Baltimore region to advance the formation of new start-up ventures, while also tackling the broad entrepreneurial culture of the region.

At the heart of having a viable research park in East Baltimore is developing a mechanism for ensuring the production of specialized wet-lab, flex office space. This need cuts across nearly all of the targeted growth opportunities for the East Baltimore Life Sciences and Technology Park, from being able to consolidate core lab facilities to developing a bioscience education and training center to being able to attract new and emerging companies and satellite research operations of nationally-based bioscience companies.

It is not an easy nut to crack, but successful research parks in even more isolated bioscience locations, such as Worcester, Massachusetts and Richmond, Virginia have been successful. Key is having a development entity leading the research park development that can address the gaps found in how far commercial developers will go towards developing these types of space. An interesting innovation put in place at the UMB Research Park is having resources available from the state's Sunny Day fund targeted to finance the cost of tenant improvements, so that the risk of developing this specialized space is shared with the commercial developer.

Given the importance to the overall Baltimore region of developing its anchor facilities, it may be worth considering how a broad based regional entity can support the development of such a research park. This is not an unusual approach. In Pittsburgh, the Strategic Fund was developed to support a broad range of strategic community and economic development activities. In the Philadelphia region, the University Science Center has supported research park developments across the region, including the research park in Delaware, and in Worcester its regional development entity is now helping to launch another research park in nearby Grafton.

There is a need for a one-stop, pro-active industry liaison and outreach function. The importance of making real the promise of what a Baltimore-regional location can mean for a bioscience company is critical to advancing the research parks and the overall region's prospects in bioscience development. For East Baltimore, this need for pro-active industry liaison and outreach seems critical. Industry has voiced ongoing problems in collaborating with JHU, from organizing meetings to putting in place basic research agreements.

An effective industry liaison function within an academic setting serves as the one stop place to address industry needs with ongoing follow-up as relationships advance and activities are planned. As its name connotes, an industry liaison needs to be highly customer focused, while bringing the facilitation and management capabilities to match the needs of the company with partners at the university. This means that the industry liaison function needs to think strategically about how to bridge the needs of industry with the orientation and focus of the institution as well as troubleshoot day-to-day issues.

Those institutions where an industry liaison function works most effectively are where the leadership takes an active interest and where there are incentives from the academic side to partner with industry.

From discussions with JHU administrators and faculty, a number of ideas arose for strategic approaches that an industry liaison function can help develop and promote. For instance:

- **Provide broader access to talent as bioscience companies move into new disease and technology areas**. Access to talent is critical to the success of bioscience development. JHU is a breeding ground for the best and brightest researchers in the biosciences. One opportunity is to have companies sponsor post-docs as part of their satellite office activities, who can then move into staffing and growing the company's operations in Baltimore. This has the advantage of allowing the faculty to focus on their research activities, while using post-docs as the link to a longer term sustainable relationship with the company.
- **Develop "translational" research partnerships that brings together basic and clinical research activities with a corporate partner.** It was noted in interviews that what makes JHU a special place is the combination of having world-class research and clinical care side-by-side. An industry liaison function can help package these efforts around a potential collaboration with industry. Particular opportunities may be found around the many NIH funded centers that JHU has been able to attract.

Advance a technology commercialization entity to support new venture development. Major research universities—outside of Stanford and MIT—are learning that fostering and supporting new venture formation needs its own focus separate from technology transfer activities. The key activities being advanced include:

- Market opportunity assessments of new technologies and vetting of new business plans for new ventures;
- Supporting reduction to practice and proof-of-concept of the technology to validate its commercial potential;
- Building the capacity for entrepreneurship across faculty, post-docs and graduate students; and
- Attracting management talent and venture financing.

Best practices suggest that these efforts can be undertaken either directly as part of the university or from an outside entity. For instance, the Oklahoma Technology Commercialization Center is advancing technology commercialization and new technology ventures from outside of the universities. It provides a comprehensive and often integrated set of services that ranges from market opportunity assessments of university technology, vetting of business plans for new and emerging technology ventures from the perspective of venture investor, proof-of-concept financing typically linked to those technology ventures that have been vetted, formation of angel investor networks to which vetted technology ventures are presented, linking new and emerging technology ventures with seasoned entrepreneurs and broader network of professional service providers and operating incubators near key research drivers.

St. Louis has recently launched its own technology commercialization entity addressing its needs to focus on the commercialization of technology from its research drivers, with a strong focus on identification of promising technology platforms, followed by market assessment, then proof-of-concept funding and linked with a pre-seed fund to move towards launching a new business venture. This effort in St. Louis is finely tuned to augment the active and successful incubator efforts underway in the region, and is augmented by technology commercialization activities

underway at Washington University, the region's major university research driver. Moreover, Washington University established a separate entrepreneurial development institute, as a program of its Olin School of Business, which provides education and outreach targeted to students and to broader business community.

In house efforts in technology commercialization are not uncommon. For instance, Baylor Medical Technology serves as a dedicated technology commercialization entity focused on advancing research discoveries made at the Baylor Medical System. Even MIT is moving in these directions. It recently launched a $20 million Deshpande Center for proof of concept funding to advance high potential technologies into new business ventures. It includes a $50,000 Ignition Grant for initial proof of concept and a follow-up $250,000 Innovation Program Grant to refine prototypes and finalize market strategies. And, perhaps, one of the most successful university efforts that served as an important outreach arm to broader venture capital and entrepreneurial community, was the San Diego CONNECT activities, established in 1985 as a mentoring, networking and advocacy organization that functions like an "incubator without walls" but imbedded in the university's extension programs. CONNECT later absorbed a separately founded Technology Financial Forum, an early experiment in introducing local entrepreneurs to venture capitalists based in the Bay Area.

A more hybrid model is being advanced in Pittsburgh, where the University of Pittsburgh and Carnegie Mellon University have come together with strong industry and community support to advance the Pittsburgh Life Sciences Greenhouse. The Greenhouse is a separate entity but is responsible to a governing body that includes the universities, foundation funders and industry. It engages in a broad range of activities including commercialization efforts that particularly address the lack of management talent in the region and the need to grow new bioscience ventures.

Maryland has efforts in technology commercialization through the Maryland Technology Development Corporation. But these funds are limited and focused statewide. Moreover, given the strong research base found in Baltimore, the specific regional gaps that need to be addressed and the specific regional opportunities, as well as the region's critical need to foster a more entrepreneurial culture and reach a critical mass of new venture activity, it is suggested that a more focused effort be established for the region, possibly as a partnership of TEDCO, EBDI, the City of Baltimore and universities.

The need for technology commercialization in Baltimore is a community-wide need, yet it must work as a value-added, change agent within the context of the major research drivers in the region and the developing research parks. Based on the findings, the Baltimore region's needs go beyond that of St. Louis, but share its need to leverage the region's research base, and include many of the new and emerging ventures services performed by the Oklahoma Technology Commercialization Center and the broader entrepreneurial development efforts found in CONNECT. It is suggested that a Baltimore technology commercialization partnership be formed as an independent entity with the capabilities to:

- Conduct market opportunity assessments;
- Undertake proof-of-concept funding;
- Vet business plans of new and emerging ventures;

- Assist new and emerging ventures with developing management capacity; and
- Promote entrepreneurial development for graduate students, post-docs and faculty.

Staging the Development of the East Baltimore Life Sciences and Technology Park

The development of the East Baltimore Life Sciences and Technology Park is a long-term project. Similarly, the integration of the proposed development activities also should be viewed over distinct time periods.

It is proposed that the East Baltimore Life Sciences and Technology Park be staged in three periods:

- Stage 1 – Anchoring the Park
- Stage 2 – Developing the Park
- Stage 3 – Maturing the Park

Stage 1 – Anchoring the Park

In this first stage, it is critical to show development activity that reflects the value proposition of the Park as set out in its vision statement. It is important that the Park not be set apart from the community as an unfriendly and unknown place where people go to work. Rather it must be a place that also offers services to the community for education and training as well as public health.

Five specific activities are proposed to anchor the park:

- Establishing a hub facility for bioscience commercial research activities. This would include the development of a multi-tenant wet-lab enhanced facility to house the laboratories of the JHU Genetic Resource Core Facility, as well as possibly a centralized pathology laboratory, and an informatics core with server farms and grid access. A specialized wing or adjacent facility might also be developed for transgenics animal models.
- Design and launch the technology commercialization and entrepreneurial development initiatives, including incubator and prototyping space for targeted development in medical device and drug development as part of a BioCollaboratory. This can be incorporated into the commercial research hub facility or if sufficient funding is available for facility and operating support as its own facility.
- Establish the industry liaison function – addressing region's value proposition to industry – and ensure availability of a small amount of space (15,000 to 25,000 sq. ft.) in the commercial hub and/or biocollaboratory facility for potential satellite research offices, post-incubator companies and commercial research companies.
- Educational and training facility that would be anchored by housing the BioTechnical Institute of Maryland, Inc. (BTI) and would also be the home for expanded K-12 bioscience offerings expanding on Dunbar High School, reaching out to lower grades and offering shared lab space for students at other schools. Many of BTI's classes for its current programs with young adults moving into bioscience careers and continuing skill upgrading for existing bioscience workers would be held in the evening so laboratory and classrooms could be shared between the ongoing BTI activities and the charter school. It is suggested that

separate entrances, office and open meeting space be constructed, so as to maintain the identities of the separate programs. It is expected that many of the laboratory technician positions needed by the hub commercial research facility will be filled by those going through the BTI training program, and that workers at the hub facility would be taking skill upgrading programs at the education and training facility through BTI.

- A new facility for the Morgan State Public Health Program be developed. This facility might also offer some swing space for other Morgan State researchers to have close labs to JHU, as well as dedicated space for outreach education and training geared for the community.

This initial anchoring stage could take up to two years.

Stage 2 – Developing the Park

The second stage in the development of the park will be focused on realizing the fruits of the pro-active outreach marketing effort and the technology commercialization program put in place as part of the first stage of activities.

The types of developments anticipated are primarily multi-tenant facilities, with key anchor tenants helping to advance specific multi-tenant facilities.

A full scale BioCollaboratory incubator and prototyping facility should be developed if not already in place with appropriate state, local, federal, private foundation and other support.

It is expected that this stage of activity in developing the park will take another two to three years.

Stage 3 – Maturing the Park

As the park emerges from its second stage, a steady program of space development will be required to ensure that there is always available at least 25,000 to 35,000 sq. ft. of absorbable space. Without this continual development stream, the momentum of development can be stalled. This focus on sustained development must be factored into the development mechanisms for the park.

It is also likely that build to suit facilities for individual tenants will occur as the park matures, if not earlier.

SUMMARY

The East Baltimore Life Sciences and Technology Park is an important anchor not only for the redevelopment of the East Baltimore area, but for the overall regional biosciences development of the Baltimore Region. The park can help lead growth in the targeted opportunities identified for the Baltimore region. The analysis identifies specific opportunities for carrying out the initial start-up of the research park, as well as key development mechanisms that need to be put in place to ensure ongoing development in the future. Ultimately, the success of the research park as well as the region's efforts to broaden its bioscience cluster with a strong commercial bioscience business base will depend on the leadership from universities, government, industry, and foundations in the region.

Table 15: Opportunities Identified for East Baltimore

Targets for Growth	East Baltimore Opportunities	Key Incentives and Program Activities
Grow a robust commercial-oriented bioscience research and diagnostic bioscience cluster	• JHU genomic core labs, including gene sequencing, cell culture, and new genotyping • Animal facilities operated by commercial operator • Bio-informatics core facilities as a partnership between JHU and leading information technology companies	• Affordable space, possibly with incentives for build out and initial attraction.
Promoting active R&D relationships with existing bioscience firms	• Attracting satellite R&D	• One stop industry liaison activities • Innovative approaches for shared use of post-docs • Advancing broader programs that link basic research and clinical research

Foster a new generation of leading therapeutic and medical device companies in the Baltimore region through a comprehensive bioscience technology commercialization effort	• Prototyping facilities
	  ○ Advancing drug discovery and development
	  ○ Biomedical device, instrument and diagnostic development
	• Attracting satellite R&D
	• Co-location of Emerging Technology Center incubator
		• Funding support for development of proto-typing and incubator space development
		• One stop industry liaison activities.
		• Support of a technology commercialization initiative as a partnership between TEDCO, EBDI, City of Baltimore and universities.
		• Entrepreneurial development programs—like Limbach Enterpreneurial Center, build off Biotech Network

Supporting the growth and attraction of bioscience businesses through the region's ability to generate talent pool of bioscience workers at all levels	• Expanded home for BTI • Training for entry level bioscience lab technicians • Skill upgrading for bioscience lab workers • Augmenting and integrating with Dunbar High School and pursuing other specialized life science schools • Strong outreach and technical assistance programs to K–12 for Baltimore region in conjunction with UMBI	• Need for state, federal, local, and foundation funding support
Advancing public health interventions and business opportunities	• Location of Morgan State public health program • Support establishment of community-based businesses for health services	• State funding for new Morgan State facility • Partner with Open Society

Appendix A:
Benchmarking Case Study Write-Ups

Appendix Contents

New Haven – Science Park at Yale

VISION, HISTORY, BUILD-OUT TARGET, AND CURRENT STATUS

Science Park at Yale[1] is a 20-year-old project to adaptively reuse an 80-acre urban industrial brownfield, a World War I-era manufacturing complex for the Winchester Rifle company. Winchester, whose presence in New Haven dated to the 1860s, was acquired in 1980 by Olin Corp., and the giant chemical company nearly immediately absorbed ammunition manufacture into its existing operations in Illinois, leaving behind only the U.S. Repeating Arms Corp., a spin-off licensed to use the Winchester name for rifles and shotguns (there are other licensees for other weapons, located elsewhere). What was once a workforce of 38,000 at its peak and still mustered close to 20,000 even in the 1960s, rapidly dwindled to just a few hundred skilled employees. This represented an economic catastrophe for New Haven as a mid-sized city dependent on manufacturing, and led directly to the Science Park project.

Inspired by the site's proximity to Yale's Science Hill[2] (from which it is separated by the Forestry School's greenhouse complex), city planners conceived the idea of converting the site into a large-scale technology incubator. However, the target technology sectors were only vaguely defined and could at best be said to represent a "multisector" approach. In this context, Science Park Development Corp. (SPDC) was incorporated as a 501(c)(3) in 1981 with board participation from the City, the State, Olin Corp. (which retained ownership of much highly contaminated land in the park), and the working-class Dixiehall neighborhood. However, at that time and even until fairly recently the project was known simply as Science Park and had no authority to use the name Yale or New Haven in its title. The development corporation was aggressively staffed (28, at its peak) and was intended to perform in-house all property management, redevelopment, and business-incubation functions. Unfortunately, it was never adequately capitalized for this very ambitious mission.

Buildings in Science Park, even the few that were actually used for incubation, remained unmodernized and therefore incapable of attracting viable, stable tenants who could pay near-market rates. No significant funds were available for remediation of the remaining sites, and the park lurched from crisis to crisis with only a small fraction of the acreage ever transferred to the control of the development corporation. Science Park did attract a broad range of tenants—80 at its peak, and 300 in cumulative total—but there was very high turnover and only one original tenant remains. The tenant mix included not only technology firms but community and church groups, city agencies, service firms hoping to gain new clients, and miscellaneous "mom and pops." At that time, SPDC was the billing intermediary for all amenities offered by Yale—including health insurance. Because the tenants were mostly undercapitalized, they fell behind on both rent and fees, leaving Science Park deeply in debt to its own sponsors throughout the 1980s.

[1] No active website. Battelle interviewed Science Park Executive Director Sheila Anastas and Lyme Properties associate Laura Woznitski, both on April 1, 2003.

[2] A cluster of physical and life-science laboratory buildings located in the opposite end of town from the New Haven Medical Center and its own research labs.

SPDC was offered a series of bailouts in exchange for board reorganizations—first in 1991 and then again in 1994—but these were one-time fixes that did not resolve underlying structural difficulties. SPDC never received funding for either environmental remediation or business incubation, and slipped repeatedly back into debt. The cycle of failure bred resentment of the state government for making loans instead of underwriting functions that could not be self-supporting. Moreover, governance became awkward, as the board of 20 started having trouble achieving quorum. By the late-1990s, roofs were leaking, garages had caved in, and elevators were failing. Several of Science Park's most prestigious bioscience tenants publicly announced their displeasure and intention to move out. The founder of Alexion, a highly promising Yale spinout, was quoted as saying, "The quality of development is insufficient to keep us here. None of the parties have really shown any interest…they have all displayed the lowest quality of ownership." A vice president of Vion Pharmaceuticals added, "There is no acceptable space available."[3]

At the same time this crisis was developing, however, Yale was completely reordering its approach to community engagement, in response to a perceived deterioration in neighborhood conditions and a wave of violent crime against students. In 1995, the university created its first Office of Community and State Affairs. Three years later, the university recruited Bruce Alexander, a Yale alumnus and retired Rouse Company executive from Baltimore, to be a new university vice president in charge of the office. Yale developed a strategy of four interrelated parts:[4]

- **Economic development** – with a new and specific stress on levering the university's $300 million R&D expenditure budget as an engine for the generation of spin-offs that could be developed in the city.
- **Neighborhood revitalization** – involving both a cash incentive program for faculty and staff to buy homes in the city,[5] and a specific effort to engage with and improve local public schools.
- **Downtown development** – leading to creation of the Town Green Special Services District,[6] and eventual recruitment of Baltimore developer Williams Jackson Ewing[7] to rehabilitate the Chapel Square Mall, and construction of downtown market-rate apartments.
- **Promotion –** aimed at affecting both the "image and reality" of New Haven, and backed by a $1 million "Market New Haven" campaign raised from Yale, city business interests, and the Community Foundation for Greater New Haven.

As part of the first strategy, the university Office of Cooperative Research (OCR) was tripled in size. A succession of savvy pharmaceutical executives was recruited to lead OCR, and it was given the explicit mission to produce spin-offs and keep them local.[8] This initiative matched well with the governor's commitment to build a "bioscience cluster" in Connecticut, with New Haven as its heart. The state's efforts relied heavily on Connecticut Innovations Inc. (CII),[9] a nonprofit seed fund first created through legislative appropriation back in the 1980s and which had been

[3] For both quotes, see http://www.yaleherald.com/archive/xxv/3.27.98/news/firms.html.
[4] For a good description, see *Yale University Financial Report: 2000-2001.* Available at http://www.yale.edu/finance/fr/finrep00-01.pdf.
[5] For the program in its current structure, see http://www.yale.edu/hronline/benefits/24fa.html.
[6] See http://www.cityofnewhaven.com/economic/Town%20Green/.
[7] See http://www.wjeinc.com/Projects_Under_Development/development_projects.htm (as of April 2003).
[8] See http://www.librapharm.com/bin/news/upload_dir/TP03profile(4)1.pdf.
[9] See http://www.ctinnovations.com/site/home.html

quite successful in its IT investments. With seed funding from CII, OCR ramped up Yale's generation of spin-outs, achieving by the year 2000 a total of 1,000 employees in some 40 Yale-associated bioscience firms, with billions of dollars in private and public capital invested.

After the City of New Haven took two properties in Science Park for tax arrears and threatened to foreclose on one more, events came to a climax. In 1997, as Genaissance was spinning out of Yale and dissatisfaction with Science Park mounted, a final bailout was arranged for Science Park. In a deal brokered by the Governor's representative to the board (the CEO of CII), the board was pared to 11 and Richard Grossi, the retired CEO of United Illuminating, was brought in as the new, high-profile chairman. The new board then dismissed virtually the entire staff, retaining a new executive director on an annual renewable contract, assisted by just one holdover. All non-essential services were terminated, and most others outsourced to local vendors, including a property manager who deferred payment. The new chairman's mandate to the new board and executive director was: either find new money or go out of business. Under the strategy that emerged the state committed $14 million in final loans through two separate agencies. For the first time, the state bailout was targeted not at retirement of an operating deficit (Yale agreed to defer what was owed it), but instead for the demolition of obsolete structures, modernization of two others, and general positioning of Science Park for privatization. This financial recapitalization of Science Park was announced with fanfare by the Governor in conjunction with a housing renewal program for the surrounding neighborhoods, but in fact the initiatives were separately managed.

Stabilized in this way, SPDC was able by 2000 to sign a package deal with Lyme Properties LLC, a deep-pocket real estate venture based in New Hampshire but known for its infill development of 2.8 million square feet of bioscience space in Cambridge, Mass. The outline of the deal was as follows:

- A 65-year land lease on Building 25, with a commitment to pay off $600,000 in back taxes and invest $34 million in a complete rehabilitation and expansion from 192,000 square feet (s.f.) to 266,000 s.f.[10] so that it could serve as the park centerpiece.
- Agreement to lease the balance of park property from SPDC once the EPA and state agencies approve remediation plans, so that the land can be transferred by Olin to SPDC in return for a tax deduction. SPDC has reserved some of its loan funds to participate in remediation, and Lyme will also invest. However, it took 18 months to negotiate indemnification terms.
- Possibility of eventual (arms-length) purchase of the two properties still under the control of SPDC, although under the bailout agreement with the state, this cannot happen until after 2004.
- A 10- to 15-year master plan for development of 2 million square feet, including space for retail, community recreation, and development of light-manufacturing job opportunities for neighborhood residents. Possible ultimate investment of $500 million.

Subsequently, Yale agreed to allow Lyme to rename the development as "Science Park at Yale" for no additional consideration. In the words of the current executive director, this plan leaves

[10] Lyme endured an 18-month environmental cleanup negotiation on this property and the parking lot next door, and faced ongoing difficulties with undocumented underground utilities. Full re-opening of Building 25 is still six months off, targeted for the end of 2003.

Science Park's situation "not as good as it looks, but better than ever." There is now 100 percent occupancy of the two buildings that SPDC still owns (4 and 5), and a $1 million fund balance is anticipated, reversing an earlier deficit of similar size. However, there are claims on this cash. The $14 million in state loans are structured as interest-only, with balloon payments due in 2008. Until that time, however, SPDC must pay 50 percent of its excess cash flow to the state. In addition, SPDC's agreement with Yale commits another 40 percent of cash flow to the university. Therefore, there is really only 10 percent of cash flow available for further remediation needs. The SPDC board now urgently wants to restructure again so that it can use the land lease revenues from Building 25 to amortize the debt in a more conventional manner and work with Olin to prepare additional properties for transfer. Science Park's current complement of 1,200 employees over 30-odd tenant companies is distributed as follows:

Table A1: Science Park's Current Complement of Employees over Companies

Building	Owner	Size	Tenants	Comments
WRAC	WRAC/Olin	225,000 s.f	Winchester Repeating Arms Corp. (WRAC)	New building opened 1994 for precision manufacture.
SNET (2 buildings)	City took these for back taxes in the 1990s	N/A	Southern New England Telephone (SNET)	
Building 4	SPDC	20,000 s.f.	Kodak Scientific Imaging Vion Pharmaceuticals (Yale-related public co.)	Rehabbed with latest state loan package
Building 5	SPDC	102,000 s.f.	Genaissance Pharmaceuticals (Yale spin-out public co., majority tenant with 60,000 s.f.) Ikonisys (cell-based diagnosis) PhytoCeutica (Yale spin-out private company) Yale offices	Rehabbed with latest state loan package
Building 25	SPDC (land) Lyme (building)	266,000 s.f.	Still in re-rental Alexion kept 32,000 s.f. pilot labs after following through on earlier threat to move HQ to suburban Cheshire One circuit board manufacturer	Rehabbed by Lyme. Targeted for re-opening late 2003.
35 miscellaneous derelict or underutilized lots	Olin	~900,000 s.f.		Subject to environmental cleanup

Source: Interviews with principals and various news releases

The multiyear buildout plan for Science Park divides as follows:[11]

Table A2: Multiyear Buildout Plan for Science Park

Phase	Tract	Building project	Space added	Parking added	Comment
1	B1	Redo surface parking; improve security		30 surface spaces	In process; substantial environmental problems
	B2	Renovate and extend Buildings 6 and 7 for office/biomedical use	155,000 s.f.	60 surface spaces	
	C	Reuse existing Olin building for light manufacturing	49,000 s.f.		
	E	Demolish obsolete structures		296 surface spaces	
	K	Renovate Building 25	211,000 s.f.	74 surface spaces	In process
	Green	Landscaping, café, security			In process
	Streets	Extensive rerouting, reconnecting, traffic calming, extension of canal Greenway to the park		80 space street parking	
2	A	Renovate suitable buildings for office/biomedical	628,000 s.f.		
	A	Construct new space	10,000 s.f.	150 surface spaces	
	C	Construct new light industrial building	50,000 s.f.		
	D	Demolish remaining structures		249 spaces	
	E	Construct Phase I of new 7-level structured parking garage where surface lot had been built in Phase 1, plus retail	10,000 s.f.	926 less 296 lost	
	J	Construct new surface parking		185 spaces	
	Streets	Continued extensive rerouting			

[11] Lyme Properties LLC. *Science Park at Yale.* Master plan summary, available in hard copy only. Provided to Battelle courtesy of Lyme Properties LLC.

3	B1	Construct new office/biomedical building on land where surface parking had been improved in Phase 1, plus retail/commercial	100,000 s.f.	Loss of >>30 spaces (total unclear)	
	C	Construct new light-manufacturing buildings in place of old Olin buildings	120,000 s.f.		
	D	Construct new office/biomedical building plus retail/commercial if feasible	60,000 s.f.		
	E	Construct Phase II of structured parking		966 spaces	
	Streets	Continued extensive work			
4	Infill	Fill in beyond core development area but within boundary, then possibly outside boundary	To total of 2 million s.f.		

POSITIONING AND REGIONAL CONTEXT

Lyme Properties is positioning Science Park at Yale as the supply answer to the continuing demand for space generated by Yale's invigorated spin-out program. The company believes that Yale's history of four to six spin-outs a year in recent times is now well enough established for venture capitalists to be very comfortable working with it indefinitely. This experience allows Lyme to project space-absorption rates at least into the mid-term. Since the remaining lots at Science Park are not in wide demand by developers because of the challenge and cost of environmental remediation, Lyme believes it is best positioned in the region to incrementally fill this need over time, pursuant to the master plan it paid for and laid out. Although some firms have left the region completely (GeneLogic moved to Gaithersburg in 1996 before the Science Park deal came together), the only significant regional competition is in suburban Branford, where a developer is sequentially unshelling 30,000 s.f. shell flex buildings on fairly large lots. Examples of companies which, taken that route, include:

- Cellular Genomics (a Yale spin-out).
- CuraGen (a public company started by Yale personnel), which went to Branford from another New Haven location.
- Neurogen (a Yale-related public company), which started in Branford.

Within the City of New Haven itself, there is one important competitor, which because it was substantially less complex, proceeded from concept to opening before the rehabbed Building 25 could get to the market. This is 300 George St.,[12] a six-story, 518,000 s.f. former telephone company building situated downtown (and therefore much closer than Science Park to the Yale-New Haven Medical Center). The property was bought several years ago for $27 million by local de-

[12] See http://www.winstanleyenterprises.com/www/300george/index.html.

veloper Winstanley Enterprises, which invested an approximately equal amount in its renovation as a wet-lab-equipped multitenant structure. Space is being offered at $18 per square foot (p.s.f.) triple-net, compared with about $50-60 at similar structures in Cambridge, Mass. The building has attracted tenants such as:

- Molecular Staging (Yale spin-out, private company)
- Achillion Pharmaceuticals (anti-infective drug discovery—CEO is an ex-NCI researcher who had originally targeted the company for Princeton)
- Rib-X Pharmaceuticals (anti-infective drug discovery—development-stage Yale spin-out)
- A small branch laboratory of Pfizer, the New York City-headquartered pharmaceutical company whose R&D operations are based less than an hour away in Groton and New London.

DEVELOPMENT APPROACH AND MARKET DIFFERENTIATION

Lyme Properties' principals believe that Science Park offers much better connection than Branford to the Yale community, and "not the kind of funky space where creative scientists are most motivated." Also, Science Park leverages Yale's $500 million program of re-investment in the academic labs of Science Hill, and also offers more flexibility to grow as additional properties are rehabbed. Lyme also knows that 300 George St. is now nearing full occupancy, and believes that the sooner this happens the better for Science Park. Although there had been discussion in the mid-1990s of a separate research-park development near the Medical Center, this does not appear to fit the City's current development master plan. Therefore, 300 George St. is essentially landlocked, and once it fills, Science Park will be the only expansion space available in town. Lyme's experience in Cambridge teaches it that while some bioscience companies fail and others "lumber along," a handful will take off and end up taking the majority of the wet-lab space in a region. David Clem, a principal of Lyme, has been quoted in newspaper articles as projecting 400,000 square feet in annual absorption in the New Haven region (prior to the downturn of 2000), with a goal of capturing 25 percent of that for Science Park.[13]

Lyme moved aggressively even before the Building 25 upgrade was complete to take tenants off the month-to-month leases they had from SPDC onto conventional long-term real-estate leases. This had the effect of squeezing out many of the smaller community-based organizations that were part of the park's history, but opened space for laboratory construction and other renewal.

Long-time plans for a University of Connecticut Research Park at the main Storrs campus have never taken hold, in part because the university's medical center is 35 miles west, on the far side of Hartford.

KEY TURNING POINT IN PARK HISTORY

There can be no question that the privatization deal of 2000 is the key turning point. Lyme brings deep pockets to a capital-intensive and high-risk redevelopment project. Moreover, thanks to its experience in Cambridge, Lyme understands the advantages of positioning the development as

[13] See http://www.yale.edu/ocr/ocr_new/abstracts/NYT.2000.12.31.html.

university-related, even though the nonprofit sector will no longer have strong control over the development process.

Lessons from the Development Process

Many of the lessons from the early stages of Science Park are lost to repeated turnover in board and staff, but the current management team believes strongly that the park as originally conceived was doomed to fail because the substantial and multidimensional development challenges were not matched by an equally strong source of capital and commitment. A developing focus on bio-science spin-outs sharpened the critical need for restructuring, and now points the way to future buildout.

Linkages with Sponsoring Institutions

As noted, the original concept for Science Park included SPDC acting as billing intermediary for a variety of Yale-provided amenities, including access to the library system, conference facilities, laboratories on campus, the healthcare program, and faculty consulting. With the downsizing SPDC, tenants are expected to negotiate directly with Yale for any services they require, although library access is still provided free of charge to all Science Park tenants (regardless of which entity is their landlord) through an office now administered by Lyme Properties. Lyme expects this kind of linkage to be critical to its development strategy and wants these benefits to become "more robust" over time.

Role of Emerging Businesses/Incubation

Ironically, a park that once saw itself *in toto* as an "incubator" now has no business incubator at all and only market-rate tenancy, although Lyme Properties has not ruled out hosting a nonprofit business incubator if one can be identified with a steady and reliable funding stream. Nonetheless, it is clearly Yale spin-outs that form the core of Lyme Properties' strategy for buildout of Science Park. Yale's revitalized OCR has a vigorous spin-out program, leaning on a well defined model for equity sharing with venture investors.[14] It claims credit for five public companies, eight private ones, and 13 in development.

Yale's spinout program in turn benefits substantially from seed-fund support provided by CII, as demonstrated in the following table by the overlap (in **bold**) between the portfolios of CII[15] and the Yale.[16]

[14] See http://www.yale.edu/ocr/images/docs/equity_policy.pdf.
[15] See http://www.ctinnovations.com/site/portfolio/portfolio_companies.asp. This list includes only bioscience companies in CII's portfolio. The overlap in information technology or advanced materials would be less dramatic.
[16] See http://www.yale.edu/ocr/indust_ventures.html. This list includes only bioscience companies, and only the first three categories in Yale's list: publicly traded, other developed by Yale, and under development. It omits "other companies originating from Yale Research," a broader list including companies from around the region and the nation.

Table A3: Overlap between the Portfolios of CII and Yale

Bioscience companies in CII's seed-fund portfolio	Bioscience companies in Yale's start-up portfolio	Location
Achillion	**Achillion**	**300 George St.**
	Agilix	New Haven – other
	Alexion (ALXN)	HQ in Cheshire, Pilot Lab in Science Park 25
	Archemix	Cambridge, Mass.
	Axotech	Unknown
Cardium Technology		Danbury, Conn.
Cellular Genomics	**Cellular Genomics**	**Science Park, then Branford**
	Chemasense	Unknown
CiDRA		Wallingford (near Hartford)
CuraGen (CRGN)	**CuraGen (CRGN)**	**New Haven, then Branford**
	Epigenix	Unknown
	GasNet	New Haven – unknown
Genaissance (GNSC)	**Genaissance (GNSC)**	**Science Park 5**
Halox		Bridgeport, Conn.
Hepaticus		Farmington, Conn.
Ikonisys		Science Park 5
	L2 Diagnostics	New Haven – unknown
	Molecular Staging Inc. (acquired polyGenomics)	300 George St.
Neurogen		Branford, Conn.
	Phoenix Drug Discovery	Unknown
PhytoCeutica	**PhytoCeutica**	**Science Park 5**
	Protometrix	Branford
	Radiotracer	New Haven – unknown
Rib-X Pharmaceuticals	**Rib-X Pharmaceuticals**	**300 George St.**
Sopherion Therapeutics		Branford, Conn.
	TurboGenomics	New Haven – other
	Ultrabiotics	Unknown
	VaxInnate	New Haven – unknown
	Vion Pharmaceutical (VION)	Science Park 4
Vivax Medical		Torrington

Many of these firms, including Genaissance in Science Park and also Cellular Genomics now of Branford, have benefited from CII's Bioscience Facilities Fund.[17] This fund, capitalized with $30 million from the state and $10 million from reinvested proceeds of CII's gains from seed

[17] See http://www.ctinnovations.com/site/initiatives/bioscience_fund.asp.

investments in IT companies prior to 2000, supports facilities fit-out loans. Lyme Properties anticipates that Science Park tenants will continue to use the program, but noted that some venture capitalists regard its procedures as too bureaucratic. In such cases, Lyme is prepared to extend its own capital for facilities financing, acting more quickly albeit at more expensive terms.

COMMUNITY ISSUES

Science Park abuts Dixwell and Newhallville—two Victorian-era New Haven neighborhoods whose predominantly working class residents and housing stock were hard hit two decades ago by the loss of so many manufacturing jobs at Winchester. Housing stabilization and renewal was part of the original vision for Science Park, and while the Governor announced $80 million in federal and state funding for construction and renovation of 450 affordable housing units as part of his release of the Science Park recapitalization loans, these funds are controlled by the City and several small (and troubled) Community Development Corporations (CDCs), not SPDC. However, Lyme Properties expects that as the park develops, there will be opportunities to leverage the Yale Homebuyer program, which provides $25,000 in grants over ten years to Yale employees (faculty or staff) who purchase homes in designated areas of the City, with $7,000 payable at closing.

Provision of employment opportunity for neighborhood residents remains an important consideration. The surrounding CDCs have had sporadic discussion with Gateway Community College about revitalizing its programs to train laboratory technicians, but even if this happens, there will remain residents who do not want such training or cannot qualify. From the outset of the Science Park project, the 11-acre Tract C has been set aside for light manufacturing that could offer semi-skilled jobs, but this tract has never been developed. For many years the only park tenants in this category have been USRAC itself and Cyclone Microsystems, a circuit-board assembler in Building 25. SPDC's failure over decades to deliver on this plan has been notable, and has drawn sharp criticism even from Yale faculty. Even though the park is located within a federal "empowerment community" (EC) and contributed information to the successful application, there has never been reason to call on EC funding for training because the opportunities are so limited. However, the park is also part of a state enterprise zone,[18] and additional tax deferrals are available from the City. With these incentives, Lyme Properties believes it will be able to build out Tract C as originally envisioned.

SUMMARY OF SUCCESS FACTORS

In its first several incarnations, Science Park failed because it was positioned as "something for everyone"—an incubator, a brownfield redevelopment, and an engine for community renewal—without any corresponding source of capital. Its rebirth as a well capitalized bioscience park capitalizes on Yale's new commitment to spin-off formation and local economic development as part of its multipronged strategy for community engagement. Alignment of the project with a sophisticated and deep-pocket speculative developer presents the most hopeful scenario the park has seen in its 25-year history, although substantial challenges remain. Most significantly, the developer

[18] See http://www.chinapdf.com/PDF-samples/product-brochure/Enterprise.pdf.

remains committed to keeping this a university-related park with all that implies, but also tapping other tenant pipelines such as manufacturing.

Philadelphia – The Science Center

VISION, HISTORY, BUILD-OUT TARGET, AND CURRENT STATUS

The Science Center is a 1.5 million s.f. urban research park set on a narrow, 17-acre strip running several blocks along both sides of Market St., in West Philadelphia. The Science Center is adjacent to the campuses of the University of Pennsylvania and Drexel University, two of the six original incorporators[19] but now a small minority of the geographically diverse base of 34 institutional "shareholders."[20] The concept was first envisioned by the West Philadelphia Corporation, a community-development entity created at Penn's initiative following the unsettling murder of a graduate student in 1958.[21] As early as the 1920s, Penn had decided not to yield to the impulse for suburbanization and relocate to then-available land in suburban Valley Forge.[22] However, post-World War II university presidents became increasingly concerned about "white flight" and business disinvestment then roiling wide swaths of West Philadelphia. They focused their anxiety on the Market Street corridor, a low-income but historically African American neighborhood whose underutilized industrial look seems to have concerned them.

The concept for a Science Center that could attract large industrial research laboratories to the neighborhood (existing facilities of GE and Du Pont were nearby) appealed not only to university leaders but also to the City's Redevelopment Authority, which made it the focal point of the City's proposals to the federal Urban Renewal program for West Philadelphia. The University City Science Center was incorporated in 1963 as a vehicle for land acquisition, with the majority of shares in Penn's hands. Possibly inspired by the example of Research Triangle Park and the Research Triangle Institute, the Center was also given a subsidiary, the University City Science Institute. The story of the Science Center's development since then represents a complex interplay among the university's ambitions for a global research franchise; the city's urge for urban renewal and bias toward institutional development as its source; the resistance of several surrounding African-American neighborhoods to the displacement of some 700 low-income residents; and student turmoil of the 1960s.

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[19] The best history of the Science Center is written by a student intern. See Mackenzie S. Carlson, " 'Come to Where the Knowledge is': A History of the University City Science Center." September 3, 1999. Available only line at: http://www.archives.upenn.edu/histy/features/upwphil/ucsc.html and related web pages.

[20] The current shareholders of the nonprofit corporation are: American College; Bryn Mawr College; Burlington County (NJ) College; Children's Hospital of Philadelphia; Delaware State University; Drexel University; East Stroudsburg (PA) University; Haverford college; Lafayette College; Lehigh University; Lincoln University; MCP Hahnemann University (now operated by Drexel); Mercy Health System; National University of Singapore; Penjerdel Council; Pennsylvania College of Optometry; Pennsylvania Hospital (now part of Penn health system); Philadelphia College of Osteopathic Medicine; Philadelphia University (former Textiles College); Presbyterian Foundation; Rowan University; Rutgers, the State University of New Jersey; Swarthmore College; Temple University; Temple University School of Podiatric Medicine; Thomas Jefferson University; University of Delaware; University of Pennsylvania; University of the Arts; University of the Sciences in Philadelphia (former Pharmacy College); Villanova University; West Philadelphia Partnership; Widener University.

[21] See "The West Philadelphia Story." *The Pennsylvania Gazette*, November 1977. Available online at http://www.upenn.edu/gazette/1197/philly6.html.

[22] See same story, http://www.upenn.edu/gazette/1197/philly5.html.

In 1965 the Science Center acquired its first (existing) building, and its subsidiary Institute began accepting federal research contracts. Under significant pressure from the neighborhoods, including an occupation of the Mayor's office, the city was unable to initiate condemnation proceedings on the balance of the site until 1967, and then only after it agreed to return seven acres for replacement housing. The following year, the project came under attack from student activists, who objected that the Science Center Institute was being used to shelter classified federal bioweapons research off the university's books, but still adjacent to campus. Even as the second building was being built and the third site acquired,[23] the Science Center came under direct attack from the Students for Democratic Society, which occupied the university president's office. In response, the Penn trustees (as still the majority shareholder of the Science Center) strengthened their commitment to community participation and creation of affordable housing through the then-new Section 8 program.

Before the dust had settled, several opportunities for development (an FDA lab, a Hilton hotel) had evaporated, but in 1971 development resumed with construction of a high rise backed by a lease from the federal General Services Administration. Political scandal followed, and also a liquidity crisis, resolved only by urgent fund-raising in 1972 by then Science Center president Randall Whaley, who saw the Science Center as a quasi-academic community with the additional mission of economic development. Also, the Science Center experimented with direct entrepreneurship, privatizing Penn's data-processing functions into a spin-off company known as Uni-Coll, which was subsequently bought and sold several times and has become part of the Center's business-creation lore. As construction resumed, it was increasingly in partnership with private developers[24] who were attracted by the possibility of institutional rentals. Indeed, current tenancy has stabilized at about 45 percent leases to Penn, Children's Hospital or other institutions, and 55 percent private-sector entities, either for-profit, non-profit, large, or small. No current tenant directory of analysis is available from the Science Center.

Following is a history of development in the Science Center:

[23] Both for the Monell Chemical Senses Center, an institute whose endowment was raised by Penn but which has remained a standalone corporation.

[24] Battelle interviewed Science Center President and CEO Jill Felix on April 18, 2003, whose knowledge of Center history picks up at about this point.

Table A4: History of Development in the Science Center

Address	Function	Square Feet	Year Opened	Main Tenants	Comment
3401 Market	Multitenant Office	99,000	1963	Various	Adaptive-reuse; current renovation into cheap labs; Opportunity Zone
3508 Market	Multitenant Office/Lab	50,000	1969	Monell Chemical Senses Institute	Owned by Science Center
3500 Market	Single Tenant Office/Lab	50,000	1971	Monell Chemical Senses Institute	Owned by Monell, which is independent of Penn
3535 Market	Multitenant Office/Retail	40,000	1973		Owned by third party; Managed by Science Center
3624 Market	Condo Office/Lab	165,000	1974		First condo office development in Phila.
3700 Market	Multitenant Office/Lab	50,000	1975	Kulgian Engineering	Also Penn offices
3501 Market	Single Tenant Office	132,500	1978	Institute for Scientific Information	Note ISI is a for-profit business now owned by Thomson.
3440 Market	Multitenant Office	119,000	1981	Penn offices	
3624 Market Annex	Condo Office/Lab	44,500	1985		
3550 Market	Multitenant Office/Retail	74,000	1986	Many institutional offices	
3600 Market	Condo Office/Retail	193,622	1989		
3750 Market	Single Tenant Office	135,000	1994	National Board of Medical Examin-ers	Owned by tenant
3665 Market	Garage	133,200	1994	Garage Operator	Owned by Science Center
3615 Market	Single Tenant Office/Lab	21,000	1996	ADAC Labs, a subsidiary of Philips	Flex building developed by Science Center
3701 Market	Incubator	145,000	2001		Partnership of Science Center and Townsend Co.[25] of Towson, Md.
3777 Market	Unknown		Proposed		
3711 Market	Unknown	84,000	Proposed		
3601 Market	Unknown	250,000	Proposed		
3400 Market	Unknown	150,000	Proposed		
3800 Market	Unknown	465,000	Proposed		

Source: Combination of Science Center web pages, historical documents and other.

[25] See http://www.townsendcapital.com/real_estate/real_estate_investment_maryland.html.

Plans for a conference center fully integrated into the Science Center first missed the Bicentennial window in 1976 and then were scuttled in the 1980s by a combination of opposition from community-based merchants, and developer/lender skittishness over Penn's plans to add its own executive-conference facility to the Wharton School. Eventually a small conference center with heavy participation from West Philadelphia caterers was built by an AME Church-affiliated group on land across the street from the Science Center. Physical development stalled after 1996, with 1.5 million s.f. in capacity remaining. A new president and CEO—the first one with commercial real-estate experience rather than academic background—was recruited the following year. The new CEO, who had worked for two decades with Rouse & Co. to develop the Great Valley Corporate Center in suburban Malvern, arrived in 1997 and made the following changes:

- Reduced staff from 90 to 60, turned over all but four of the professionals, and revitalized an aging board of directors;
- Bought out the equity interests of the developer who had assisted with the earlier buildings on the south side of Market St.;
- Phased out what had by then become money-losing direct research operations of the Center through its subsidiary corporation, and a technology transfer consortium;
- Created the Center's first formalized business incubator, and eventually took it in house (see below).
- Removed the name "University City" from the Science Center's logo to emphasize its regional base of shareholders and operations in other regions (see below).

The CEO reports that the Science Center is at 98 percent occupancy and ready to develop additional sites, probably preserving the historic orientation to multitenant flex space that is wet-lab capable. She also has plans to rehabilitate several older buildings to produce wet-lab space that is very inexpensive.

POSITIONING AND REGIONAL CONTEXT

The technology center of the Philadelphia region is unquestionably the Route 202 corridor that meanders through many communities in the city's western and northern suburbs. Just off the corridor are several major pharmaceutical facilities such as Wyeth (Collegeville), GlaxoSmithKline (Gulph Mills), and Merck (West Point). All along the 202 corridor, in suburbs like Malvern, Exton, Wayne and Radnor can be found a series of office parks that cater to technology uses, including wet-labs. The oldest and largest is the 2 million s.f. Great Valley Corporate Center in Malvern, which was developed starting in the 1970s by Rouse & Co. (now Liberty Properties).[26]

Through virtually the entire time that Route 202 was developing as a technology corridor, the Science Center was the region's only university-related research park. Since then, the Science Center has helped develop the only other such parks in the region:

- **University Technology Park**[27] **(UTP)** in Chester, a planned three-building park on 20 acres situated between Crozer-Chester Medical Center and Widener University, in this extremely

[26] See http://www.libertyproperty.com/company.background.html.
[27] See http://www.universitytechpark.com/aboutus.html.

distressed small city. The Science Center partnered with UTP on a 30,000 s.f. office building but sold out its interest after concluding the market was not developing as it had hoped. UTP has subsequently developed a second, 40,000 square foot building, in a tax-advantaged state Keystone Opportunity Zone. So far no wet-lab space has been developed.

- **Delaware Technology Park**[28] in Newark, Delaware, a five-building, 250,000 s.f. complex on a 40-acre site at the eastern edge of the main campus of the University of Delaware. The Science Center is an equity partner along the university, which contributed the land. Other partners are the state-supported Delaware Biotechnology Institute and the building/construction manager. Tenants include the state Biotechnology Institute, branch operations of Du Pont, the state's largest technology-business incubator, and two of the six North American contract-research operations of the Fraunhoffer Institutes, in advanced materials (a Du Pont and University of Delaware specialty) and biotechnology.[29]
- **Rowan University** in Glassboro, New Jersey, where the Center is consulting on development of a state-supported "South Jersey Technology Center."[30]

This outreach mission underlies the subtle change in the Center's tag line from the original "Come to where the knowledge is!" to the present "Developer of knowledge communities," a branding that was proposed by a current board member who is also CEO of the Franklin Mint collectables company.

Development Approach and Market Differentiation

The fact that the Science Center has large institutional tenants tends to make financiers look favorably on its overall development plans, since space vacated by failed technology ventures can often be re-rented on a temporary, surge-space basis to the institutional partners. The Science Center therefore has ample capacity to raise and manage construction and long-term debt, both for its University City location and for the Delaware Technology Park. Taking on equity partners, while it has been helpful in the past on the south side of Market Street and for the incubator building on the north side, probably works against the goal of regional wealth creation because a partner would usually rather have an institutional tenant than a non-credit-worthy technology company that is contributing to regional wealth creation. Two recent examples of incubator graduates are instructive:

- One company (unidentified) took 3,700 square feet in another Science Center building, for $16.50 p.s.f. net plus $20 in tenant-improvement financing over 20 years. The total was not significantly lower than in the 202 corridor, but the location enabled them to take advantage of animal-care facilities at the University of the Sciences (the former Philadelphia College of Pharmacy and Sciences, one of the Center's initial incorporators, which is located a mile away in Southwest Philadelphia).

[28] See http://www.deltechpark.org/about.htm.
[29] See http://www.fraunhofer.de/english/profile/international/index.html.
[30] See http://www2.rowan.edu/news/display_article.cfm?ArticleID=215.

- Biorexis, a startup which raised $10 million in venture capital, chose to graduate to a sublease in the Great Valley Corporate Center. However, when it came time to go "on the lease" itself, the company found that the landlord was less than fully helpful, because Biorexis was not considered a high-quality credit tenant. As a former Rouse partner, the Science Center CEO was able to make some intervention.

In general, the Science Center CEO believes that companies that come to the University City location were not in the Route 202 market in the first place, because other factors like connectivity to the institutions were more important to them at this phase in their development.

KEY TURNING POINTS IN PARK HISTORY

Key turning points in the Science Center history could be characterized as follows:

- The financial stabilization following the liquidity crisis of the early 1970s, leading to a partner-oriented development model heavily dependent on institutional rental;
- Recruitment of key single-tenant anchors such as Monell in the 1960s, ISI in the 1970s, and the National Board of Medical Examiners in the 1980s;
- Resolution of most outstanding community issues with housing construction by independent developers in the 1970s and a conference facility by a church-affiliated entity in the 1980s; and
- Revitalization of the speculative development model in the 1990s, pointing the way to eventual completion of the full buildout.

LESSONS FROM THE DEVELOPMENT PROCESS

The CEO notes that there is an inherent tension between contributing to the regional economy through startup formation and preserving credit-worthiness by serving the needs of the major institutions. The proper balance is a matter for board and stakeholder consensus, in Philadelphia and elsewhere, and execution of the development mission depends on identifying nonprofit funding flows.

LINKAGES WITH SPONSORING INSTITUTIONS

There is no formal roster of affiliation benefits, but the Science Center will strive to act as a "portal" to resources at any of its member institutions, as it did in the case of the animal-care facility needed by its incubator graduate. The CEO observes that Penn in particular "is a complicated institution, and no one phone call ever suffices." In effect, the Science Center takes on the uncompensated role of an industrial liaison between its tenants and its member institutions.

ROLE OF EMERGING BUSINESS/INCUBATOR

The Science Center claims credit for "incubating" more than 200 businesses, but most of these were simply commercial tenants that "passed through" on their way to suburban expansion space. The best known example is the antibody pioneer Centocor, founded at the Science Center in 1979 because it was close to the Wistar Institute and offered a generally supportive environment. Co-founder Hubert Shoemaker has been quoted as saying that the Science Center was a great place to start, but that large-scale manufacturing of the kind that Centocor eventually needed to do did not fit well with the Science Center setting.[31] In 1982 the firm moved to Malvern where it ultimately expanded into five buildings on 22 acres. It went public in 1984 and was acquired several years ago by Johnson & Johnson. During this period, Science Center managers took additional risks on companies they thought would grow larger, but had no formal business incubator with a single consolidated location or any source of funding to support below-market rentals.

That changed in the late 1990s, when the Center CEO was able to raise state grant funding for a "Port of Technology"[32]—two separately operated 25,000 s.f. incubator floors in a newly constructed speculative multitenant building at 3701 Market St., which was designated a Keystone Opportunity Zone.[33] One floor was designated for IT companies, and another for wet-lab bioscience startups. The "entrepreneur in residence" was an Internet millionaire, and the plan was for the nonprofit incubator to take equity in its tenants. As soon as the Port of Technology opened, however, the Internet market peaked and crashed. Last year, the Science Center dissolved the separate incubator corporation, taking the incubation function back in-house. At that time, the Science Center also took on many commercialization-assistance functions that were once performed by the Southeastern Pennsylvania Ben Franklin Center.[34] Although the Science Center is itself a shareholder in the BFP Center, the latter moved out of the Science Center at the time the new CEO arrived, putting both organizations in the position of competing for a regional mandate.

As this was unfolding, Penn was revitalizing its technology transfer function, moving from a royalty orientation to an aggressive posture that has resulted in formation of 50 startup companies in which the university holds equity (annual pace of about 15 a year). However, unlike Yale's approach, Penn has not specifically committed to keep these startups local. Some of the diffusive effects of this policy, combined with competition among regional development agencies, and the spread-out nature of the suburban 202 corridor, can be seen in Table 5, which compares the portfolios of Science Center incubator companies,[35] graduates,[36] Penn spin-outs,[37] portfolio companies of Ben Franklin,[38] and of the recently created Life Sciences Greenhouse.[39] The overlaps are in **bold.**

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[31] See "A Successful Centocor Outgrows its Research Park," The Scientist 5[18], September 16, 1991. Available on-line at http://www.the-scientist.com/yr1991/sept/kefalides_p1_910916.html.
[32] See http://www.portoftech.com. The words referred to a state plan for a network of incubators to serve as a portal for international inward investment. The Science Center port is the only one that ever opened.
[33] See http://koz.inventpa.com/what.html.
[34] See http://www.sep.benfranklin.org/who/overview.html.
[35] See http://www.sciencecenter.org/community_companies_port.asp.
[36] See http://www.sciencecenter.org/community_companies_alumni.asp.
[37] See current list at http://www.finance.upenn.edu/ctt/opportunities/portfolio.shtml.
[38] See http://www.sep.benfranklin.org/capital/portfolio1.pdf and http://www.sep.benfranklin.org/capital/portfolio.html.
[39] See http://www.bioadvance.com/home/articles/Bioadvance_PR_4.24.03.pdf.

Table A5: Comparison of Science Center Companies, Graduates, Penn Spin-outs, Ben Franklin Portfolio Companies and Life Sciences Greenhouse

Current Science Center Bioscience Incubator Tenants	Science Center Bio-science Incubator Graduates	Penn Office of Tech Transfer Equity Spin-offs in Bioscience	Ben Franklin Bio-science Seed Fund Investees and Port-folio Companies	BioAdvance, Life Sciences Green-house Inves-tee/Portfolio Companies	Location/comment
ABCCellular Therapeutics					Incubator
Aderans Research Institute					Incubator
			Adolor		Exton, Pa.
		Advaxis			Unknown
	Applied Clinical Intelligence				Philadelphia – Other
Astrolabe Analytica					Incubator
			Beacon Bioscience		Doylestown, Pa.
			Biocoat		Fort Washington, Pa.
	BioRexis				King of Prussia, Pa.
	Biosupplies.com				Washington, D.C.
			Biosyn		Huntingdon Valley, Pa.
		Caliper Technologies			Mountain View, Calif.
CardioNet					Incubator
		CareScience			Science Center – Other
			Centocor		"Graduate" of Science Center; now J&J subsidiary
			Cephalon		West Chester, Pa.
	Concurrent Pharma-ceuticals				Fort Washington, Pa.

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Controlled Chemi-cals					Incubator
			Devine Foods		Media, Pa.
			Dynamis Therapeu-tics		Philadelphia – Other
				Eagle Vision Phar-maceutical	Exton, Pa.
Eurogentec					Incubator
			Exocell		Science Center – Other
		Endacea			Research Triangle Park, N.C.
Infonale					Incubator
		Genta			Berkeley Heights, N.J.
				Gelifex	Philadelphia – Other
			Gentis		Science Center – Other
		Inkine Pharmaceuti-cal			Blue Bell, Pa.
Integral Molecular		Integral Molecular		Integral Molecular	Incubator
		Layton Bioscience			Atherton, Calif.
Kibow Biotech					Incubator
				MacroArray Technologies	Villanova, Pa.

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Mitergy					Incubator
		Morewood Molecular			Pittsburgh, subsidiary of for-profit accelera-tor LaunchCyte
	Morphotek		Morphotek		Exton, Pa.
		Neose			Horsham, Pa.
		NeuroPace			Mountain View, Calif.
			Orthovita		Malvern, Pa.
			Phoenix Biomedical		Valley Forge, Pa.
			Physician Verification Services		Bala Cynwyd, Pa.
PlantGenix		PlantGenix			Incubator
ProSanos					Incubator
		ProtoMed			Unknown
		Provid Pharmaceuti-cals			Piscataway, N.J.
				RetinaPharma Tech-nolgoies	Jenkintown, Pa.
			Spectrasonics Imaging		Wayne, Pa.
				Spliceomix	Malvern, Pa.
		Targeted Genetics			Seattle, Wa.
			TrueTek		Chadds Ford, Pa.
			Ultratouch		Malvern, Pa.

Table A5: Comparison of Science Center Companies, Graduates, Penn Spin-outs, Ben Franklin Portfolio Companies and Life Sciences Greenhouse

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			Uramix		Lansdowne, Pa.
		Valley Forge Pharmaceuticals			Irvine, Calif.
		Viral Genomics			Science Center – Other
			ViroPharma		Exton, Pa.
		Xcyte Therapies			Seattle, Wa.

COMMUNITY ISSUES

As a consequence of early community opposition, the Science Center has long been tied to neighborhood initiatives:

- **West Philadelphia Partnership.**[40] Under its current bylaws, the Science Center is entitled to a seat on the board of the Partnership. In past years, the same person who filled this seat also served as a board member of the affiliated **West Philadelphia Partnership Community Development Corporation**, a City-recognized nonprofit housing developer serving West Philadelphia. This is not the same developer, however, which created the low-income housing on the land that was ceded from the Science Center project in the 1970s.
- **University City District.**[41] The Science Center likewise is entitled to representation on the board of this unique, voluntary special services district, which provides street-cleaning, security, loop-bus routes, and other services to a broad swath of West Philadelphia that was neglected by city services. The district was constituted as a nonprofit when it was discovered the prevalence of tax-exempt property in university city precluded creation of a conventional district with taxing powers.

Partly as a consequence of yet another graduate-student murder, in the mid-1990s, Penn itself has adopted aggressive tactics for community improvement, starting with its support of the UCD but also including:

- Creation of Center for Community Partnerships[42] as a focal point for "service-learning" initiatives that connect community and campus. CCP has received grant support from HUD to operate a Center for Community Outreach Partnership.
- Concentration of all economic development strategies within the Office of the Executive Vice President, which runs the university's business operations including its "buy West Philadelphia" program.
- Provision of cash homeownership incentives for faculty and staff that focus on the immediate University City neighborhoods, similar to programs with which Penn President Rodin became familiar when she was provost at Yale.[43]
- Adoption of "The Urban Agenda – Penn in Philadelphia" as one of the university's six academic priorities.[44]
- Academic and fiscal collaboration with the Philadelphia School District on a K–8 school to enhance the appeal of the surrounding neighborhoods to faculty and staff.[45]

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[40] See http://www.westphilly.org. WPP is the trade name for the same "West Philadelphia Corporation" referenced above which gave rise to the Science Center concept.
[41] See http://www.ucityphila.com/about/index.cfm.
[42] See http://www.upenn.edu/ccp/.
[43] See http://www.upenn.edu/president/westphilly/housing.html.
[44] See http://www.upenn.edu/president/priorities.html/.
[45] See http://www.upenn.edu/almanac/v45/n01/PreK-8.html.

One of the most interesting aspects of this collaboration pertains to the public high school that is situated across the street from Science Center headquarters. Originally intended as a "lab school" to complement the Science Center, this "University City High School" met fierce neighborhood resistance as a perceived elitist intrusion in the 1970s, and was therefore constituted instead as a comprehensive neighborhood high school. Through the Center for Community Partnerships, Penn has attempted to upgrade the academic experience at UCHS by connecting pupils to student and faculty mentors at Penn, but even more significantly, the concept of a "science school" at the Science Center has returned to the fore. Under current plans, the School District's very distinguished Carver High School of Engineering and Science—currently in North Philadelphia—will relocate in 2005 to a newly constructed 950-student facility on a 2-acre lot controlled the Science Center. Penn has committed to engage its faculty with the school, to promote linkages with the Science Center and its members, and to help revise the school's mission statement to encompass these partnerships.

SUMMARY OF SUCCESS FACTORS

The Science Center has overcome a significant heritage of early missteps by focusing on steady physical development that leans heavily on institutional rental, and only entering the business-incubation business when it could find grant funding explicitly targeted at that function. Its long term plans have also benefited significantly from Penn's stepwise acceleration of its engagement with surrounding communities.

Pittsburgh – UPARC, Panther Hollow, Pittsburgh Technology Center, South Side Works, and Hazelwood LTV Site

VISION, HISTORY, BUILD-OUT TARGET ,AND CURRENT STATUS

UPARC

UPARC is a mature technology park associated with the University of Pittsburgh (Pitt). Situated in suburban Hamarville 14 miles upriver on the Monongahela, U-PARC is a 55-building technology-industrial park. Originally the research center of Gulf Oil, the facility became redundant when Chevron acquired Gulf in 1984, and so Chevron donated it to Pitt in 1986. Large parts of the campus—particularly Gulf's 32 pilot-plant facilities in chemical and mechanical engineering—were originally operated by Pittsburgh Applied Research Corporation, a university spin-off. UPARC was itself acquired in 1998 by privately-held Gemini Holdings.[46] A good deal of space remains under university control, used mostly by the Pitt engineering school for a variety of sponsored projects. Several buildings with wet-lab space are also rented to multiple commercial tenants. While UPARC is operated by the Pitt real estate office and not formally as an incubator, the low rent for wet-lab space ($16-18 p.s.f.) has made the campus a de facto incubator. Several of the region's important bioscience firms such as Cellomics made their start at UPARC.

Panther Hollow

Panther Hollow is a valley that runs northward from the Monongahela riverfront past Schenley Park and then essentially divides the campuses of Carnegie Mellon University (CMU) and Pitt. The CMU hillside of Panther Hollow is the site for a state-supported, 125,000 s.f. commercial building (on top of a 270-space parking garage) that is the first phase of a planned 500,000 s.f. "Panther Hollow Research Park. " The first phase building is targeted at large companies that are CMU's research partners in information technology, chip design, and robotics. The planners would like to rent space in small segments (5,000 to 10,000 square feet) to companies such as Okidata, Intel, Sony, Boeing and General Dynamics. The project is steered Panther Hollow Development Corp., a consortium of CMU and the Carnegie Museums, which own most of the land. However, the first building will be developed and operated by the Pittsburgh Regional Industrial Development Corporation (RIDC),[47] which has done similar development deals with CMU's Software Engineering Institute and its University Technology Development Center. If the park is successful it will ultimately spread across both hillsides and even into the Hollow itself. Panther Hollow will not turn away CMU spin-offs, but the development is not planned as an incubator, and it will not have any wet-lab space. [48] CMU received state support of $6 million toward the projected $32 million cost.[49]

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[46] See http://www.parctech.com/history.htm.
[47] See http://www.ridc.org/about/index.html.
[48] Battelle interviewed Dr. Don Smith, head of CMU's Center for Economic Development, joint appointed at Pitt, and currently the acting CEO of the Pittsburgh Life Sciences Greenhouse, on April 28, 2003.
[49] See http://www.cmu.edu/cmnews/011019/011019_panther.html.

Pittsburgh Technology Center

Following Panther Hollow back down toward the riverfront leads and remaining on the downtown side of the "Hot Metal Bridge," one finds a 48-acre brownfield redevelopment site somewhat optimistically called the Pittsburgh Technology Center (PTC). This is one of three sites made available by the decline of steel manufacturing in downtown Pittsburgh. PTC was the Pittsburgh Works (hot-strip mill) for the Jones & Laughlin Steel Co., which closed it in 1979 and sold it to Park Corp., which intended to develop it. Since it was severely contaminated and impossible to develop without public subsidy, much of the site was sold again to the Pittsburgh Urban Redevelopment Authority (URA), which had led the post-World War II reinvention of downtown Pittsburgh as a skyscraper business district.[50] As the conduit for $18 million in state and federal remediation funds,[51] URA gradually returned the site to productive use. Over the years, URA has sold or leased lots to whichever private or public developers had the capital, not necessarily insisting on true research park uses. As in the case of Panther Hollow, the RIDC has served as the developer of certain sites. Both universities own research buildings on the site, and both have options on additional lots. However, the balance of uses tips heavily to mid-tech manufacturing. Although the PTC is nominally in the "South Oakland" neighborhood, in fact it is a linear waterfront development isolated from the Oakland neighborhood by highways.

PTC has several lots and a few hundred thousand square feet yet to develop. Following is a roster of current developments.

Table A6: Roster of Current Developments

Address	Function	Square Feet	Year Opened	Main Tenants	Comments
300 Technology Drive	Multitenant office space	91,000 s.f.		Pitt Center for Biotechnology and Bioengoineering	Owned by Pitt
700 Technology Drive	Institutional lab space	90,000 s.f.		CMU lab space (formerly CMRI).	Owned by CMU
1000 Technology Drive	Single-tenant manufacturing	175,000 s.f.		Union Switch and Signal, a CMU research partner	Developed by RIDC
2400 Second Ave.	Single-tenant manufacturing			Metaltech, manufacturer of coiled steel	Site still owned by Park Corp
?? Second Ave.	Single-tenant manufacturing	80,000 s.f.	1997	Aristech, polypropylene manufacturer, owned now by Sunoco.	Developed by City's economic/industrial development corporation

[50] See http://www.ura.org/maj9.htm and http://www.ce.cmu.edu/Brownfields/NSF/sites/ptc/info.htm.
[51] For environmental reasons all sites are built on slab, with no basements.

Address	Function	Square Feet	Year Opened	Main Tenants	Comments
2000 Technology Drive	Multi-tenant office	70,000 s.f.		Oakland Consortium (Innovation Works, Technology Council)	Developed by RIDC
Parking Garage	Structured parking				Developed by URA under TIF
	Single-tenant	30,000 s.f.	1998?	Hyperion/Adelphia telecommunications switching center	
Bridgeside Point	Multitenant lab/office	165,000 s.f.	2001	Cellomics; Life Sciences Greenhouse and associated incubator/venture firm	Developed by John Ferchill of Cleveland
Untitled	Multitenant lab/office	45,000 s.f.	Proposed	Speculative	To be developed by Colliers Point

South Side Works

Directly across the Monongahela from PTC[52] is the former J&L South Side Works finishing mill, which was acquired by LTV and used in steel manufacture a few years longer than the hot-strip furnace. The URA purchased the 130-acre brownfield site from LTV for $9.3 million in 1993, anticipating a riverboat gambling initiative that never materialized and then considering it as a replacement site for Three Rivers Stadium. By the mid-1990s, in view of what it considered the success of the PTC, the URA had articulated a South Side Works plan[53] calling for:

- 1 million square feet of R&D space;
- 500,000 s.f. of light industrial/flex space
- 450,000 s.f. of retail (both neighborhood and regional);
- 100,000 s.f. of professional office or services space
- 200-300 residential units; and
- 26 acres of open space, including a town square, parks, etc.

However, much of this technology-oriented planning was abandoned in the practical negotiations that led to selection of the Soffer Organization[54] as master-developer for a 34-acre core of the site, and some subsequent land trades. To the extent there is technology use at South Side Works, it is dominated by institutional uses by the quasi-autonomous University of Pittsburgh Medical Center

[52] Connected by the J&L Mill's old "hot metal bridge," which has been redeveloped for auto use, and an old railroad bridge, which is slated for conversion to pedestrian and bicycle use. See http://www.pghbridges.com/pittsburghE/0588-4475/hotmetal.htm.
[53] See http://www.ce.cmu.edu/Brownfields/NSF/sites/ltv/info.htm.
[54] See http://www.sofferorganization.com.

(UPMC). The current plan is for 28 separate buildings, representing $250 million in private investment and generating $8 million in incremental tax revenues for the city. Following is a roster of components currently built, whether developed by Soffer on the core site or by others, on nearby lots that were part of the same original parcel:[55]

Table A7: Roster of Components Currently Built

Address	Function	Square Feet	Year Opened	Main Tenants	Comments
	Warehouse	83,000 s.f.		UPMC	
	Clinical	260,000 s.f.		UPMC Sports Medicine	
	Single-tenant office	125,000 s.f.		IBEW	Traded for land IBEW owned at new PNC Park site
Carson St.	Single-tenant institutional lab	45,000		UPMC McGowan Institute	Also has labs at PTC Bridgepoint
Waterfront trail	Park				
Quantum I, 29th St.	Single-tenant office	160,000		UPMC	
Carson St.	Senior housing	69 units			
Sarah St.	Townhomes	30 units			
3311 Carson St.	Single-tenant	47,000 s.f.	2002	FBI	Oxford Development
Carson St. & 28th St.	Retail	41,000 s.f.			
Garage 1	Structured parking	679 spaces			
25th & 26th Sts.	Residential	270 units	2003		
2600 Carson	Residential	84 loft units	2003		
Garage 2	Structured parking	367 spaces	2003		
27th St.	Cinema	50,000 s.f.	2003		
Quantum II, 29th St.	Multitenant office/flex	186,000 s.f.	2003		
	Manufacturing		Proposed		
2700 Carson	Retail		Proposed		
Restaurants 1, 2, and 3			Proposed		

[55] See http://www.ura.org/SSW2.PDF.

Address	Function	Square Feet	Year Opened	Main Tenants	Comments
Garages 3 and 4			Proposed		
3100 Sidney St.	Mulitenant office		Proposed		
Hotel			Proposed		

TissueInformatics in nearby privately owned space has spinoff BioSpace Development Inc. two southside projects.

Hazelwood LTV Site

A fifth and possibly final component of Pittsburgh's network of research-park-like entities could be developed over the next decade at the 138-acre former LTV coke mill situated in the economically distressed Hazelwood neighborhood. Hazelwood is on the city side of the Monongahela, but about a mile upriver of the Hot Metal Bridge. Closed for good only in 1997, the coke works were tied up for several years in LTV's bankruptcy proceedings. In the interim, the city initiated a community planning exercise,[56] which with the involvement of neighbors from Hazelwood and Oakland called for development of a "new economy office park" at the end of the property closest to the PTC. The city's plan describes this technology park as "either analogous to or an extension of" the PTC. However, it must be noted that the overall Hazelwood project is extremely complex, and even in the most optimistic case, the technology park would comprise only a very small component of the site's total acreage. The balance of the site was slated for commercial, recreational, and—assuming adequate remediation can be accomplished—residential development.

The most unusual feature about the Hazelwood Project has been the heavy involvement of Pittsburgh's community of private foundations. Not wanting the property to fall into the hands of the URA, which they perceived as mainly opportunistic in its approach to redeveloping this site, four leading foundations took matters into their own hands. The Benedum, Heinz, Richard King Mellon, and McCune foundations put up the capital to form Almono LP, whose general partner is the RIDC. Despite threats by the city to take the site by eminent domain or outbid the partnership and turn it over to Forest City Enterprises, Almono succeeded in October 2002 in buying the property for just under $10 million. While Almono's limited partners are cognizant of the site's technology potential, their main goal has been to act as a patient landbank so that appropriate and strategic uses can be identified. They have a strong commitment to ensuring that the development plan respects the interests of Hazelwood, whose street grid they very much want reconnected with the river and with job opportunities in the park.

The RIDC immediately launched its own master-planning process,[57] which has so far endorsed the technology-park concept, and recently issued a Request for Quotations[58] to identify private-sector developers interested in a master contract. Selection of a master developer could occur by the end of the year. The project is complicated because it intersects with the ambitions of Hazelwood for community improvement, with the state Turnpike Commission's plans to route a high-

[56] Available at: http://www.city.pittsburgh.pa.us/cp/html/comprehensive_planning.html.
[57] See http://www.hazelwoodhomepage.com/ltv_concept_plan.html or Tom Barnes, "Concept Plan is Released for Hazelwood Development," *Pittsburgh Post Gazette,* Jan. 22, 2003.
[58] See RIDC Release, "ALMONO Seeks RFQs for LTV Hazelwood Site," April 25, 2003.

way extension through the site (which could subtract half the acreage available for development), and with the status of the CSX rail lines (which if the railroad could be convinced to trade them for other alternative routes could add back more than 100 acres). It is therefore completely impossible to project buildout. Finally, it is still unknown whether CMU and Pitt would desire a stronger role in steering this project than they have had in the case of the URA's PTC or South Side Works projects.

Positioning and Regional Context

Aside from a few scattered buildings owned and occupied by medical device companies, there is no part of the Pittsburgh suburbs that is known as a bioscience corridor. It is not so much that Pittsburgh's quasi-research parks have failed to position themselves with respect to suburban private development as that they have failed to develop critical mass at all. PTC is emerging as the strongest bioscience base, as recognized by the decision of the state-supported Life Sciences Greenhouse building to locate in the Bridgepoint building occupied by Cellomics (which had downsized since the project planned). The Hazelwood site, if developed as a bioscience-oriented extension of the PTC, could solidify the city's market positioning, but it is far too early to be certain.

The Life Science Greenhouse CEO believes that a key to connecting Pitt and CMU to any further real-estate development at the riverfront is the integration of transit options into Panther Hollow. The local street (Bates Ave.) connecting the institutions to the PTC can now take half an hour or more to drive, and rapid transportation of some kind could pull university connectivity to PTC, the South Side Works, and the Hazelwood site. Neighbors are in favor of transit uses, rather than an expressway routing, but the outcome probably also hinges on CSX's decision on its rail link—currently the only stretch between Washington and Chicago with a tunnel too low to allow double-tracking.

Development Approach and Market Differentiation

UPARC

As a mature, university-owned technology park with many long-established tenants, UPARC does not appear to be in the development business at present, although rehabilitation and redevelopment of aging structures cannot be excluded as a future initiative.

Panther Hollow

CMU will likely continue to rely on RIDC for development of commercial space in the Panther Hollow, as the university does not wish to be the direct owner of a research park. Bioscience space does not appear to be high on CMU's priority list.

Pittsburgh Technology Center

While PTC relied extensively on public-sector subsidy for brownfield remediation, it has also had creative involvement of the private sector. For example, debt on part of the $22 million Bridgepoint structure housing Cellomics and the Greenhouse is held by the Strategic Investment Fund,

an initiative of the Allegheny Conference on Community Economic Development. [59] The Strategic Investment Fund is structured so that it can receive either charitable contributions (from industry partners or private foundations) or "program-related investments" from private foundations.

PTC is nearly fully built out, with only two sites remaining, both apparently under university option.

South Side Works

Although Soffer has indicated willingness to take additional bioscience tenants into its Quantum II multitenant building, it quoted a $65 p.s.f. rental rate that would be uncompetitive in the Pittsburgh market, according to the Greenhouse CEO.

Key Turning Points in Park History

The most dramatic turning points in development of Pittsburgh's research-park network have both involved the area's leading foundations:

- Formation of the Almono partnership and its purchase of the Hazelwood sites, under unrelenting pressure from the city and its redevelopment apparatus.
- Involvement in foundations in creating the Strategic Investment Fund, which played a role in PTC as well as other, more conventional industrial and downtown developments, but is now nearly fully committed and may need to be recapitalized.

Lessons from the Development Process

The Greenhouse CEO says that the principal lesson of research park development in Pittsburgh is to think of the industrial-recruitment process as a pipeline. Just as in information technology or robotics, it is not realistic to expect that large bioscience firms will establish large, thousand-person labs the first time they enter a region. Rather, it is important to expose small operations of such firms to the joint research strengths of the institutions, and then create and real-estate options where they can grow or expand. Also it is important to provide housing options for the knowledge workforce, and not just rehabilitation of old housing, but new and modern facilities. In his view, the URA's experience with several riverfront redevelopments on which it has placed residential housing (e.g., 9 Mile Run and Washington's Landing) has demonstrated that the city has unlimited capacity to absorb modern, market-rate residential space at the high end.

Linkages with Sponsoring Institutions

As a university-owned project, UPARC has the strongest campus linkage, although it is clear that Pitt does not regard it formally as an economic-development enterprise or incubator. Although it will not be university-owned, Panther Hollow will arguably have a stronger connection to CMU

[59] See http://www.accdpel.org.

since it is being developed on the explicit theory that it can bring into the region companies that are already research partners of the university.

While both universities have a presence at PTC, they do not manage it or see any reason to establish special linkages with what are predominantly non-R&D tenants. This may change as the Life Greenhouse fills up.

Finally, the R&D promise of South Side has all but evaporated, represented only by the presence of the small McGowan Institute building and the efforts of a real-estate development subsidiary created by biotech firm TissueInformatics, which is on the South Side but outside the district's formal development boundaries.

Whether Hazelwood will have strong university connections is not yet known, although this was the strongly expressed preference of the community throughout both recent planning exercises, the city's and Almono's.

Role of Emerging Businesses/Incubation

While CMU has had a strong record at spinning out IT businesses, there have also been some embarrassing relocations out of region. Pitt until recently has had very little exposure to equity holdings in its licensing portfolio. Until creation of the Life Science Greenhouse incubator, neither university had a traditional business incubator, either wet-lab or office.

Community Issues

UPARC

There appear to be no significant community issues in play at UPARC.

Panther Hollow

Although Panther Hollow Research Park has not itself been controversial, its location at the heart of the Oakland neighborhoods does highlight community issues that the institutions have not yet fully addressed. With several sub-districts, Oakland is a sprawling area that bills itself as the largest commercial corridor west of Philadelphia other than downtown Pittsburgh. Like the neighborhood around Penn in Philadelphia, it has suffered some deterioration stemming from conversion of older housing stock into absentee-owned rooming houses, while higher-income faculty (at least those interested in a racially diverse urban neighborhood) tend to cluster a bit farther away from the institutional district. As a consequence, the Forbes-Fifth retail corridor caters to students and others of low income and has a faded look.

These are not new issues in Oakland. In the years following closure of Forbes field, activists created a variety of mechanisms for neighbors to interact with the institutions over issues of common concern, such as housing and the condition of the commercial district. There is now a university/community council, a community development corporation focusing on Oakland, a Oakland Business Improvement District,[60] and even a city-sponsored Oakland Improvement Strategy.[61]

[60] See http://www.oaklandbid.org/.
[61] Available at http://www.city.pittsburgh.pa.us/cp/html/comprehensive_planning.html.

Also like Penn, Pitt hosts a HUD-sponsored Community Outreach Partnership Center,[62] which has written its own community plan.[63] Both these plans call for initiatives to promote home ownership in the core of Oakland, especially by faculty, but the institutions in Pittsburgh have been less successful than those in Philadelphia or New Haven at making this happen.

Pittsburgh Technology Center

Because PTC is physically isolated on a former industrial site, no one lives or works nearby, and there are no significant community issues except those faced by Hazelwood (see below).

South Side Works

The South Side neighborhood, long an ethnic enclave with some bohemian qualities, was in the process of becoming fashionable even before the South Side Works development unfolded. Because private landowners had already begun to create lofts and other housing serving the knowledge workforce, there was minimal community opposition to the further gentrifying effects of high end retail. However, the opening of the hot metal bridge has funneled additional traffic into South Side from PTC, where there are absolutely no retail services. This has added to congestion on Carson Street, a major community concern but one without social dimensions.

Hazelwood LTV Site

The most difficult community issues will be presented by the Hazelwood project, because Hazelwood is a deeply distressed and racially segregated area. Parts of the coke-works have been designated a Keystone Opportunity Zone, and it is clear that the surrounding community expects to be connected to job opportunities in the technology park, as well as to benefit from some housing rehabilitation. The ultimate balance between market rate and affordable rehabs or ownership opportunities is not yet known.

SUMMARY OF SUCCESS FACTORS

It can fairly be said that no true university-related research park has developed in Pittsburgh, although elements of a research park network do exist. In part this may be due to the conservatism of Pitt combined with the engineering-oriented scope of CMU's ventures. In part one can also see a pattern of envisioned R&D uses to city-controlled property giving way to pragmatic development by whoever has capital available.

[62] See http://www.pitt.edu/~copc/about.html.
[63] "Oakland Connections: Competing & Complementing community Interests." December 2001. Available at: http://www.pitt.edu/~copc/oaklandconnections.pdf.

Raleigh – NC State Centennial Campus

VISION, HISTORY, BUILD-OUT TARGET, AND CURRENT STATUS

The Centennial Campus of North Carolina State University (NC State)[64] is a greenfield development about two miles from the center of Raleigh and immediately adjacent to the older, main campus of the university. Centennial was assembled in phases and now totals 1,334 acres. The oldest section of the campus was built on the grounds of a former state mental-health campus (comprising a hospital and therapeutic farm) and is centered on Lake Raleigh, a former reservoir. Centennial was envisioned from the outset as a dual-use "campus of the future," integrating both academic buildings and a research park serving the industry "partners" of the NC State research enterprise. Two of NC State's colleges (textiles and engineering) have essentially fully relocated to Centennial, and several others have chosen to rent space there. The campus also includes recreational, retail, and residential components, and a public middle school is already open. The Centennial master-plan reflects a "new urbanist," town-center orientation.

The concept for a research park/campus nicely complements NC State's traditionally vigorous interactions with industry. State has no medical school, but as the land-grant college of the UNC system has a tradition of serving local leaders in agricultural production and both discrete and process manufacturing. In fact, industry accounts for the origin of 11 percent of the university's research expenditures, making NC State a true outlier in the data set collected by the National Science Foundation.[65] Also, its Office of Technology Transfer (OTT) is strong: it boasts excellent royalty performance and in recent years since its last reorganization has averaged more than five start-ups created per year. In all, OTT counts 43 spin-offs based in part on NC State-developed inventions: 39 still active, 4 defunct.[66] Two of these are publicly traded companies, and 12 make their home base at Centennial Campus.

In practical terms, Centennial dates to 1988, when under an initiative launched by Gov. Hunt several years earlier, the first half of the land was finally conveyed to the UNC system. The second half was added by Gov. Martin in the early 1990s. In addition, the NCSU Foundation bought 200 additional acres from the Diocese of Raleigh. Last year, 214 adjacent acres already owned by the UNC system on behalf of the NC State College of Veterinary Medicine were renamed "Centennial Biomedical" and integrated into the Centennial project. Since state-owned land cannot be transferred easily to private owners, all private-sector development in Centennial is by long-term land lease, which has been authorized by law.

Table 8 indicates the current status and full buildout-plans for Centennial. A reasonable estimate is that the campus is at 15 percent of its eventual full size.

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[64] Good documentation is available at: http://centennial.ncsu.edu. Battelle also interviewed Centennial Coordinator Bob Geolas on March 24, 2003.
[65] See *Science and Engineering Indicators.* Table B-39.
[66] See http://www.ncsu.edu/ott/presentations/presentations.html.

Table A8: Current Status and Buildout Plans for Centennial

Measure	2002	At full buildout
Buildings	17	150
Corporate/government employees	2,300	12,500
Faculty, staff and postdocs	1,400	12,500
Housing units	400	7,000
Middle school students	600	600
Support services personnel		2,400

Source: data provided by Centennial Campus coordinator

Another way to look at status is to consider the list of top 10 employers in the Centennial campus. Evidently the history to date of the campus is oriented to software and information technology, although there is a growing presence of the life sciences, starting with an agency of the USDA:

Table A9: Top Ten Employers in the Centennial Campus

Employees	Company
350	ABB Inc. (70,000 s.f. standalone and 42,000 s.f. space in multitenant building)
200	Red Hat Inc. (120,000 s.f. standalone originally built for Lucent)
156	USDA—Animal Plant Health Inspection Service (offices)
120	Telesyn
80	TogetherSoft
70	CCMS
55	Ericcson
50	USDA—Animal Plant Health Inspection Service (laboratories)
42	Advanced Energy
36	Plexus Technology Group
36	Spirent Communication

Source: data provided by Centennial Campus coordinator

To understand the Centennial model and stage of development, it is important to be familiar with the complex range of building types that are contemplated in the park's master development and financial plans:

- **Appropriations funded** – Infrastructure elements and also academic buildings designed for the relocation or expansion of NC State Colleges as well as other, smaller uses.
- **Research** – Multipurpose buildings (four to date) developed by the university itself, mostly through revenue-bonding authority granted by law, and designed to house both university and some rent-paying non-profit or government tenants.
- **Partners** – Developed by the university in the same way as Research Buildings, but for occupancy by rent-paying university and private-sector "partner" organizations. Partners I is wet-lab, while Partners II is office space only. Partners I hosts the laboratory component of the on-campus incubator sponsored by the North Carolina Technological Development Authority.

- **Corporate** – Single-tenant buildings, developed either by the university (as was the case for ABB) or by third-party private developers (the Lucent/Red Hat building) on 99-year land leases.
- **Venture** – A cluster of five multitenant buildings (the first ones were office only, but follow-ons will be wet-lab-equipped) developed by private investors (Craig Davis[67] for the initial office properties, then Phase 3 Properties for the wet-lab space) on 99-year land leases. Venture II hosts the software component of the NCTDA incubator.
- **Housing** – Market-rate condos by private developers (Comstock, initially) which are being sold for $150,000 to $300,000.
- **Hotel/Conference/Retail** – This is the subject of a major political controversy described below.
- **Middle School** – A public middle school of the City of Raleigh.

The challenge posed by development of the hotel/conference center is a major political issue in North Carolina at present. The university's preference was to have this facility provided by a private developer, possibly facilitated by taxable revenue bonds, but no third party would touch the project without a subsidy to either the developer or the hotel operator (such as room nights guaranteed by the university). North Carolina has a strong tradition (backed by a state law called the Umstead Act) that prohibits public agencies from competing with the private sector, and this gave the hotel association leverage to object strenuously to any subsidy as an unfair advantage to the selected developer. (Nonetheless, individual members of the association have indicated they would be delighted to develop the hotel under such terms.) The best guess of the Centennial coordinator is that the entire issue will be shelved until the economy improves, at which time the association will not be so concerned about the issue or less subsidy will be required or both.

POSITIONING AND REGIONAL CONTEXT

The essence of the Centennial master plan is to position the park as a "technopolis"—a live/work community defined by its joint capacities in both the academic/research and private/commercial sectors. All private-sector tenants (and subtenants of third-party developers) *must* have a signed partnership relationship with NC State University. The partnership requirement is broadly construed (it may involve a full research relationship or simply a commitment to hire graduating students). However, the insistence on joining the two sectors in some way makes Centennial's positioning unique in North Carolina, because even the Research Triangle Park does not have this expectation, and also has no residential component. According to the Centennial coordinator, "Other parks say, 'What space do you need?' We say, 'What do you do? What are you interested in? Are you working with the university?'" He adds that so far as park management is concerned, "a huge focus is what happens after locating at Centennial."

Also unlike RTP, Centennial does not offer huge blocks of space where companies can spread out and keep to themselves, precisely because the campus is designed to promote connectivity among all sectors and participants. Centennial management sees RTP as "an older model, a great success…and we wouldn't be here if they weren't." However, some of Centennial's large-company

[67] See http://www.pearyhs.org/text/cdavis.htm.

partners are actually small, satellite offices of firms with regional or U.S. headquarters at RTP. Centennial management considers that the market has validated the uniqueness of its positioning strategy by awarding space at Centennial higher-than-market rents with lower-than-average vacancies. The region is currently reporting vacancies of 13-18 percent in comparable space, while Centennial's experience is between one and seven percent (the five-year plan projects a 5 percent rate going forward).

Development Approach and Market Differentiation

Management sees the principal steps in the development process as follows:

- **Identify the areas of interest** – these are IT, advanced materials, and bioscience to start with.
- **Scope out respective park 'neighborhoods'** – that is, for each targeted sector, design a physical cluster of the campus to serve it.
- **Consider what 'anchors' are required** – for each neighborhood, there will be university facilities that need to "come over" as anchors to attract private-sector partners.

Key Turning Point in Park History

Looked at this way, Centennial sees its "big win" not as the large ABB facility (indeed, they found that few people in the region had ever heard of ABB, a European technology conglomerate whose American electricity transmission and distribution affiliate is based at Centennial). Rather, it was the university's success at winning appropriations to bring over to Centennial the university's Engineering Graduate Research Center and the other, smaller academic anchors (genome research and bioinformatics labs, for example) in the park neighborhoods. The Engineering Research Center focuses on computer networking and multimedia. This turned out to be absolutely the correct anchor for the height of the IT boom. IT companies in North Carolina wanted space, and Centennial was able to offer them Class A space "in the Triangle" and one block from a highly relevant major research facility with seemingly endless numbers of students available for part-time employment during their studies or recruitment upon graduation.

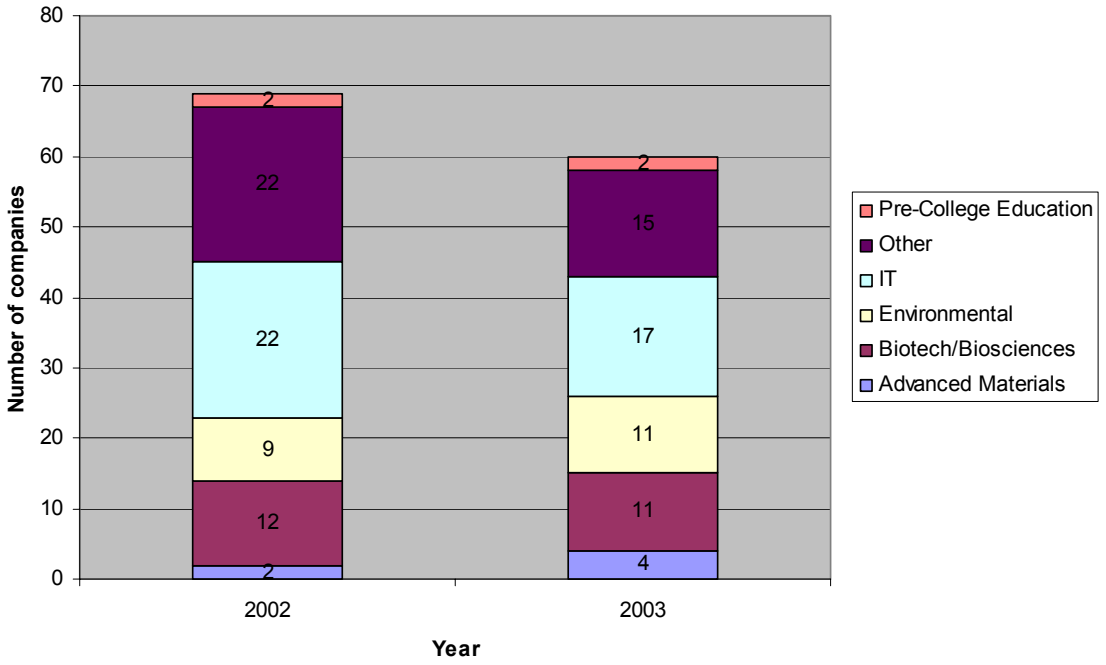
Lessons from the Development Process

In retrospect, Centennial management believes that it was absolutely necessary to start with the university-developed appropriation-funded academic buildings and bond-funded Research buildings, so that appropriate academic anchors could be brought over to Centennial from the main campus. However, the Research buildings were multipurpose—part wet-lab and part office—and were thus very inefficient from a cost standpoint. The next key step was to successfully produce the bond-funded Partners buildings, which were completely differentiated—any given building was either all-office or all-laboratory. Finally, the developer-financed Venture buildings were essential validation, demonstrating to the real-estate, banking and financial communities that it was possible to build "on spec" successfully at Centennial. This has enabled the developer of the Venture complex to turn his attention to the even more challenging problem of speculative devel-

opment of wet-lab space, which is going to be essential for Centennial to fulfill its bioscience ambitions absent a medical school. Moreover, if one developer can do speculative work, then so can others. Having a diversity of partner developers is very important to the long-term financial plans of the park, so that no further bonding capacity need be used to build out the park.

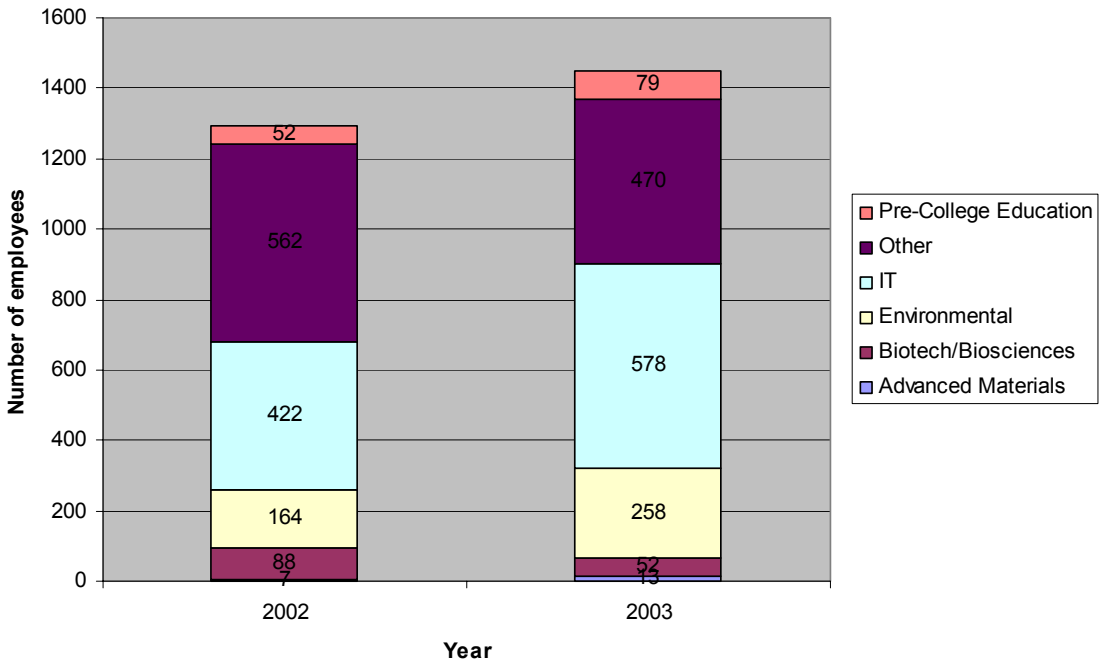
It also proved very important that while Centennial was aggressively developing IT tenancy, it was also working on advanced materials. Therefore it was not stuck with only bankrupt dot-coms when the IT boom crested. In addition to the three technology neighborhoods already created (IT, advanced materials and biosciences) Centennial already hosts partners in pre-college education and environmental technology, and intends to create new neighborhoods for them in due course. Meanwhile, despite the diversification, the economic slowdown of the last several years is apparent in the overall numbers of partner/tenants.

Figure A1: Total Number of Companies in Centennial by Sector (Source: NCSU data)



Nonetheless, the number of *employees* of Centennial partners continues to grow.

Figure A2: Total Number of Employees at Centennial Companies by Sector (Source: NCSU data)



LINKAGES WITH SPONSORING INSTITUTIONS

As a park that is fully university-owned and operated, Centennial has one of the most robust packages of affiliation benefits to offer its tenant/partners. Among the principal elements of the package available to partner employees are:

- Gym membership
- Intercampus bus privileges
- Opportunity to buy athletic season tickets
- Discounts on arts events
- Intramural sports participation on par with NC State faculty and staff
- Full access to bookstore, library, faculty club, and computer network
- Ability to rent teleconference and conference facilities
- Course enrollment benefits.

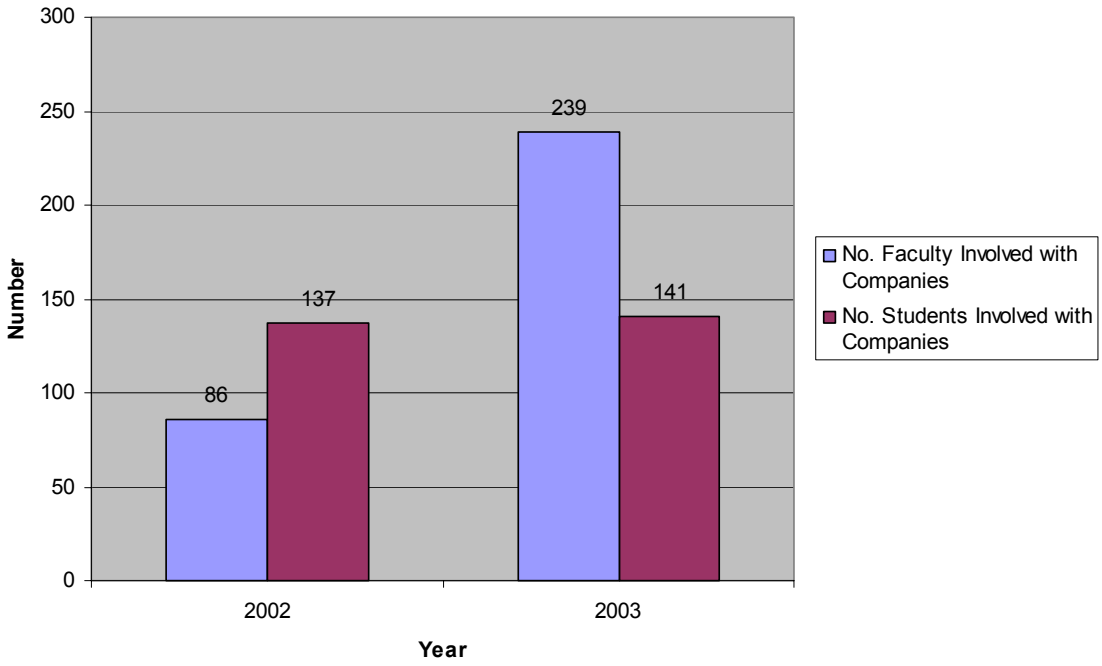
In addition, there are specific *workforce* linkages that are promoted:

- Adjunct appointments for senior technical staff
- Service on curriculum-development committees relevant to the partner's sector
- Advising/mentoring graduate students, and service on thesis committees

- Hiring graduate students as interns or employees
- Hiring undergraduates as interns, co-op students, or part-time employees
- Sponsorship of senior-design projects in the engineering school.

Measurement of the efficacy of the partnership linkages is incomplete, but Centennial believes that $35 million in sponsored research can be attributed to partners who are tenants at the Centennial campus. In addition, the following data are available on the number of interactions with faculty and students.

Figure A3: Measures of Interactivity with Centennial Companies (Source: NCSU data)



ROLE OF EMERGING BUSINESSES/INCUBATION

Small and emerging business generally—not just NC State spin-offs—play a very important role in Centennial's conception of its future. Just as it does not want only IT companies, it does not want only large firms. For the sake of diversification, the Centennial coordinator "would rather have 1,000 small firms than 100 large ones." The NC State OTT does look to Centennial first, as a preferred option for locating its spin-out companies, but Centennial cannot always accommodate because suitable space is not always available in the short time frame involved in these actions. However, even if the spin-out goes elsewhere in North Carolina, Centennial counts that as a partnership "win." Centennial sees that as key difference between its approach and that of a privately owned technology/industrial park, which wants to hold on to every tenant it can.

To serve small and emerging firms, Centennial has had a long-standing relationship with the incubators sponsored by the North Carolina Technological Development Authority (NCTDA), a

former state agency that was spun-off as an appropriation-funded nonprofit in the 1990s.[68] NCTDA rents 8,300 s.f. of wet-lab space in the university's Partners I building, and 8,000 s.f. of office space suitable for software/IT uses in the privately developed Venture II building. NC State currently has no direct role in operating the incubators, but it may develop one: NCTDA is under political attack for various reasons and may not survive. If NC State cannot find another third party to operate the incubators, it may be forced to do so itself, because the university will not give up on business incubation.[69] Some 60 percent of NC state spin-outs are in IT or semiconductors, though the proportion in bioscience—especially agricultural—is growing.

To develop its contingent of emerging businesses, Centennial has leveraged another program that was begun by NCTDA, the Centennial (now Academy) Venture Fund.[70] Conceived by the then-president of NCTDA and the NC State Vice Chancellor for Research, this is a $10 million pre-seed venture fund that targets NC State spin-offs with early-stage investments of between $15,000 and $750,000. Its sole investors were 14 separate NC State endowment foundations, although NCTDA guaranteed the first-year management fee for the general partner until the deal could be closed, in exchange for a carried interest. This is a rate-of-return-oriented fund, but all investments must be NC State related in the same broad sense that Centennial tenants must be NC State partners. Of the first 13 deals (the fund closed its investment phase at 15):

- 10 had licensed intellectual property from NC State OTT;
- 12 had NC State principals;
- All 13 had sponsored-research agreements with NC State; and
- 7 chose to locate at the Centennial campus.

In this context it is also worth noting that emphasis has shifted at Centennial from what it categorizes as "start-ups" to those firms that are simply "small businesses" but may not be brand-new.

[68] See http://www.nctda.org/nctda/bi/rt_incubators.html.
[69] As reported in June 2003, the NCTDA had voted to dissolve itself, with assets to be distributed to some unnamed successor, possibly the state government for reassignment to a newly created entity.
[70] See http://www.academyfunds.com/.

Figure A4: Distribution of Centennial Companies by Type (Source: NCSU data)

COMMUNITY ISSUES

Community issues have had minimal impact on the development of the Centennial campus. The site has had multiuse zoning from its earliest days, and as a greenfield is not closely connected to Raleigh City's urban-redevelopment ambitions. The 400-odd market-rate condos developed by Craig Davis properties are not intended as faculty housing, but rather are aimed at the professional/executive workforce associated with Centennial partners or in the region as a whole. There is no pressure from the City or County for providing subsidized affordable housing because such is available in nearby neighborhoods. In the view of the campus coordinator, the local governments are more than satisfied that a formerly tax exempt property is now in large part returned to the tax roles.

SUMMARY OF SUCCESS FACTORS

Centennial sees its successes to date as tied to its programmatic orientation, and not just to its development model. However, it acknowledges there was also good luck involved in getting so much land so close to the main campus, and succeeding at developing and validating demand before the downturn in IT, while also advancing in other technologies. The coordinator credits the decision to move key college facilities to the campus as key. He looks forward to continued challenges in development of the hotel/conference center component and in maintaining the sense of community and partnership even as the campus grows to its full buildout potential.

Research Triangle Park

Vision, History, Build-Out Target and Current Status

The Research Triangle Park (RTP) struggled at first but in recent years has emerged as a widely recognized success story. Sited on 7,000 acres of former forestland between the three university towns that comprise the region,[71] the RTP now hosts 140 tenant organizations occupying 18 million square feet, embodying $2 billion in capital investment, and employing some 38,500 North Carolinians—nearly all in organizations classified as R&D-based.[72,73] The RTP has also leveraged substantial additional technology-oriented development and employment just outside its gates. Most significantly, it has completely transformed the image of North Carolina in the minds of business decision-makers around the world. Until the RTP was proposed, North Carolina had relied for its economic development strategy on a non-union manufacturing environment, and usually stayed close to its roots in the tobacco-processing, textile and apparel, furniture-manufacture, and automotive-parts sectors.

As early as 1952, though, local business leaders and academics began to conceive the three Triangle universities as an asset that could be exploited specifically to recruit the industrial research laboratories of major corporations.[74] Civic leaders believed this approach held significant promise not only for competing with the large, industrialized states of the Northeast and Midwest, but also for creating the kind of jobs that would enable graduates of the three universities to find employment without leaving the state, a cultural change which they fully appreciated as radical and transformative. An organizing committee was formed in 1956, as much to agree on the "branding" strategy as anything else, and a private developer began assembling undeveloped acreage for his own account. In 1958, with support from then-Gov. Hodges and the then-Chairman of Wachovia Bank, the organizing committee was converted into the nonprofit Research Triangle Foundation. This new structure was used to raise contributions sufficient to buy out the interests of the private developer and to acquire the necessary additional acreage directly, albeit encumbered by various loans and mortgages for many years to come.

Since its acquisition of the core acreage, Research Triangle Foundation has acted as a land bank—it develops the RTP essentially by liquidating its land holdings in favor of developers and owner occupiers. However, the Foundation has also made strategic contributions of its land holdings. For example, it donated the 160 acres, on which was constructed with state support, the park's first building, which housed the Research Triangle Institute (RTI).[75] Included from the outset in the organizers' vision, the RTI is often but incorrectly thought of as a collaborative of the

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[71] Raleigh, home to NC State; Durham, home to Duke; and Chapel Hill, home to UNC.
[72] RTP defines an R&D-based organization as one where at least 25 percent of the workforce holds an advanced degree in science or engineering, or performs equivalent work.
[73] See http://www.rtp.org/rtpfacts/factsheet.html. Battelle also interviewed Research Triangle Foundation President Jim Roberson, on March 24, 2003.
[74] The park's capsule history can be found at http://www.rtp.org/about/history1.html. A more elaborate "official" history is: Albert N. Link. *A Generosity of Spirit: The Early History of Research Triangle Park.* Research Triangle Park, NC: Research Triangle Foundation, 1995.
[75] See http://www.rti.org.

three Triangle universities. In fact, it always was and remains a standalone contract-research institute that actually *isolated* its university partners from the industrial research sponsorship that they then disdained. Although RTI competes with the universities for federal funding, it also exposed the region to sources of corporate sponsorship not then accustomed to working with universities, and made possible various subcontracting relationships that better integrated the expertises of the region into coherent specialties.

Although RTI was a success from its earliest days, the Foundation itself struggled. The park did attract industrial labs such as that of Chemstrand, but the Foundation also came close to foreclosure of its bank loans on several occasions. Not until 1965-66 was the first unequivocal success scored. By that time, Gov. Hodges had become President Johnson's Secretary of Commerce and was in a position to influence the outcome of a search for the site of a newly created National Institute for Environmental Health Sciences (NIEHS). With strong support from the three universities and donation of 500 additional acres by the Foundation for a "federal research campus," the deal was clinched. The NIEHS has since grown to 1,000 employees, and the presence of developable land set aside for federal agencies leveraged the recruitment in 1971 of several labs of the Environmental Protection Agency, which has recently opened a new facility and now has twice as many employees in RTP as does NIEHS. There is room for one more federal laboratory.

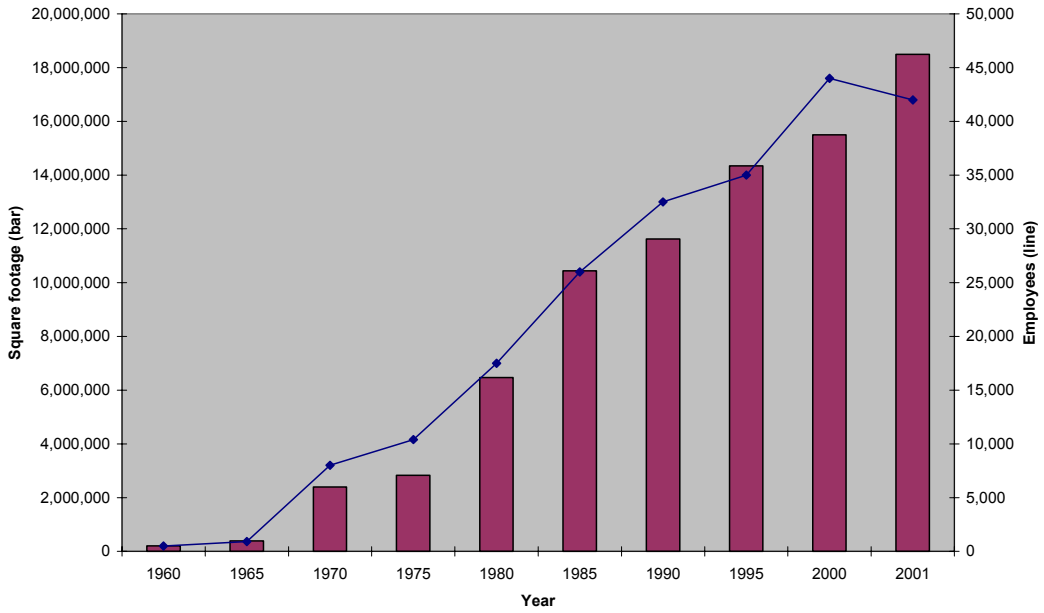
Also in 1965, business and state leaders succeeded in attracting a major R&D facility from IBM. Together, NIEHS and IBM not only accounted for major employment, but they reinforced the work of RTI in establishing the Research Triangle "brand" in the eyes of corporate decision-makers. In effect, these recruitments had positioned the Triangle and the RTP as a respectable and even desirable locational choice for decision-makers in the corporate sector—especially, as it turned out, for major pharmaceutical companies. The first to arrive was Burroughs Wellcome, which decided on RTP in 1970, based on existing relationships the company had with the schools of medicine at UNC and Duke. This was the first international company in RTP, and since its researchers would be awarded two Nobel prizes, it gave additional visibility to the park. The second international arrival was Glaxo, which found by that time it could recruit talent to the Triangle as easily as anywhere else.

Also in the 1970s, the Foundation made its third and final land donation: this time to the Triangle University Center for Advanced Studies (TUCASI), envisioned as a sub-campus on which the university partners themselves could station remote operations. It was on the TUCASI plot that the State of North Carolina paid for the construction of homes for two key intermediary organizations: the North Carolina Biotechnology Center[76] and what was then called the Microelectronics Center of North Carolina (now simply MCNC).[77]

[76] See http://www.ncbiotech.org.
[77] See http://www.mcnc.org/.

These quantum jumps in square footage in 1965 and the early 1980s can easily be seen in RTP data.

Figure A5: Cumulative Growth at RTP in Square Feet (bar) and Employee (line) (Source: Battelle analysis of RTP data)



Moreover, the intervention of the state in the early 1980s seems to have been decisive in solidifying the relative weighting of R&D uses in the park.

Figure A6: Number of R&D and Non-R&D Companies in RTP (Source: RTP Web Page)

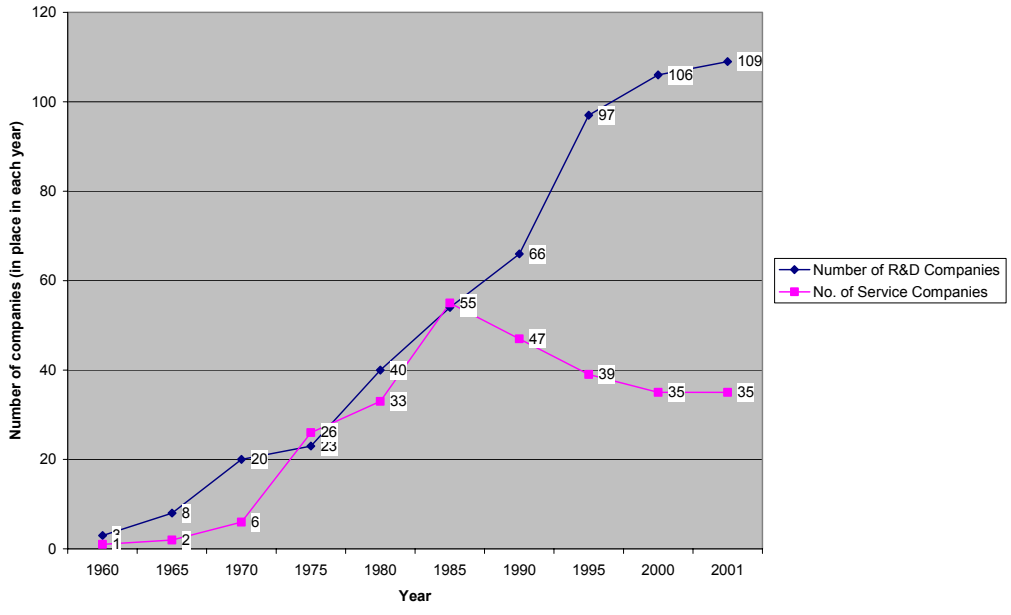


Table A10: Current Top Employers in the Park

Employees	Company
14,000	IBM
5,000	GlaxoSmithKline
4,000	Nortel Networks
2,500	Cisco Systems
2,100	Research Triangle Institute
2,000	EPA
1,000	National Institute of Environmental Health Science
750	Sony Ericsson Mobile
525	Underwriters Laboratories
500	Diosynth Biotechnology
500	Bayer CropScience

Source: Battelle analysis of RTP on-line tenant directory.

Because occupancy data are skewed by these very large organizations, although 40 percent of the park's tenant organizations have 10 or fewer employees, fully 50 percent of all employees in the park work for multinational enterprises. There are 1,100 acres remaining to develop, in the southern section of the park.

Positioning and Regional Context

Although there is no formal requirement that tenants do business with any of the three Triangle universities, RTP positions itself as a university-related research park, not a business or office park. In fact, the universities have always been the magnet for the largest and most important recruitments, especially in pharmaceuticals and environmental technology. RTP views itself as the first in the nation to have practiced this university-related model, since it developed at a time when the Stanford Research Park was essentially a real-estate investment for the Stanford endowment without any connection to the university's research programs.

RTP faces competition within the state from Centennial Campus but sees itself as in an entirely unrelated sector, since it has much more land to develop. And although there is much private-sector development taking place just outside its gates, RTP can compete on price by using land that it already owns through the charitable fund-raising campaigns of the 1950s and 1960s. The Foundation president notes, "We make land available at reasonable prices, but don't allow them to use very much of it."

RTP also has some niche competition in Durham, where some multitenant wet-lab space has been brought on line by private developers, but the park is now well served by its own incubators (see below). The Piedmont-Triad Research Park in Winston-Salem is an urban-footprint park that RTP does not regard as competitive at all.

RTP breaks down by industry sector as indicated in the following two charts, first by organization and then—since employment is skewed by IBM, Nortel and Cisco—by employment:

Figure A7: RTP Tenant Organizations by Sector
(Source Battelle analysis of RTP tenant directory)

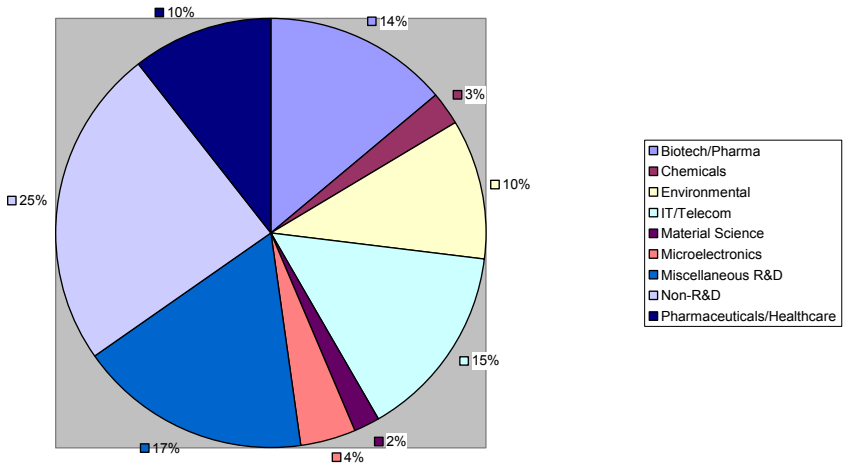
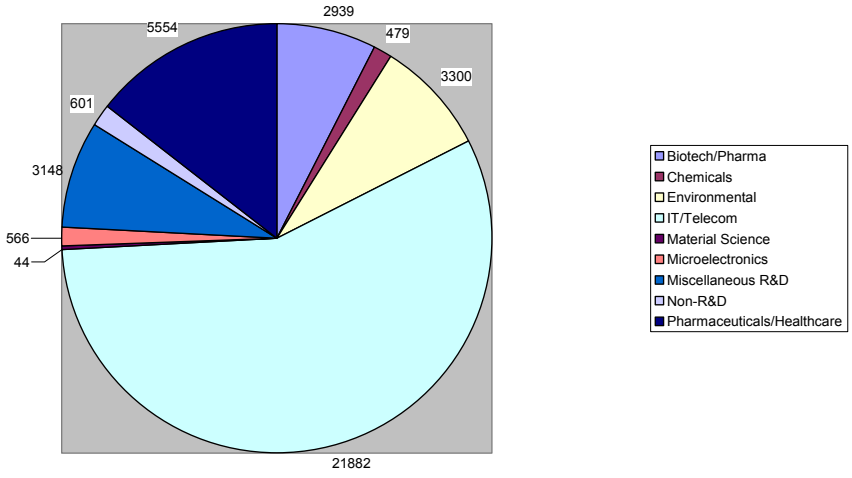


Figure A8: RTP Employees by Sector
(Source: Battelle analysis of RTP tenant directory)



Development Approach and Market Differentiation

The Research Triangle Foundation operates essentially as a land liquidator, conveying title to land, subject to restrictive covenants on use (such as a building footprint of less than 15 percent of lot size, and approval of all plans by the Foundation's Board of Design). Nearly all the structures in the park are owner-occupied, and the few third-party builders are required to start construction soon after closing, even if they are not yet certain who will occupy or purchase the structure. About 100 acres have been transferred not to third parties, but to Triangle Service Center Inc., a captive, for-profit developer owned by the Foundation, which houses many of the park's retail and service-sector tenants in its multitenant "Park Service Center."

Key turning Points in Park History

The Foundation management cites several key turning points from the park's history:

- The NIEHS and IBM recruitments of the 1960s
- The first two multinational pharmaceutical recruitments of the 1970s
- State activism in the 1980s (NCBC, MCNC and other entities in the 1980s
- Recent resolution of the problems with Wake County over sewer infrastructure, which had been a major barrier to development of the southern section of the park. According to the Foundation president, the County originally demanded that tenants be in place before extending the sewer lines, but the Foundation argued that it made more sense to extend the lines first, so that tenants could be obtained with minimal delays. This problem was resolved only in the last several years, leading to rapid development of the southern section.

Lessons from the Development Process

Foundation management believes that a non-political board structure has had a lot to do with the park's success. One third of the board is appointed by park tenant organizations, and two thirds are representatives of the original founding sponsors, both academic and business. The only ex officio seat for a politician is the Governor's appointment. The board meets twice a year and loves being affiliated with the universities, and being part of the attempt to fight "brain drain" statewide. Although the park has affected North Carolina's reputation overall, its effects have not reached into every corner of the state, and this is something that still concerns the board. The foundation is structured as a 501(c)(4), meaning that contributions are not tax-deductible, and so it does not fund-raise any longer. It supports itself through land liquidation and operation of its captive subsidiary. The Foundation receives no state government funds directly, although the state has built buildings for various organizations and has supported the operations of the intermediaries referenced above.

Linkages with Sponsoring Institutions

The Foundation management makes every attempt to promote connectivity with the universities, but there are no formal affiliation agreements. Much of this work is accomplished either through

hiring university graduates, or by the intermediary organizations that the state established in the 1980s, which fund academic/industrial collaboration.

ROLE OF EMERGING BUSINESS/INCUBATION

While most of the RTP tenant organizations are small, they are not necessarily spin-offs. Absorbed in the recruitment of large domestic and multinational R&D laboratories, the Foundation did not focus on entrepreneurial business development until relatively late in RTP's development. In the 1980s, the state began supporting the Council for Enterprise Development,[78] a tenant of the Park Service Center that involves financial and service-sector mentors in developing the capacity of local entrepreneurs to raise venture capital in national markets. In addition, the resident NCBC and MCNC intermediary organizations adopted small-business promotion as parts of their missions (MCNC even created a new-ventures unit). Finally, in the 1990s, the state spun off its Technological Development Authority as NCTDA, a private non-profit operator of incubators and seed-stage investment funds. Together, these actions began to generate entrepreneurial activity. Anecdotally, the Foundation believes more than 1200 spin-offs can be attributed to either park tenants or the universities themselves, but most have gone elsewhere.

Those spinoffs that do come to RTP may be captured by one of four public or private incubators:

- First Flight Venture Center, [79] a 28,500 s.f. incubator owned and operated by NCTDA, and which is reported to have the best occupancy rate in the NCTDA portfolio;
- A 20,000 s.f. incubator operated by NCTDA in space leased from Phase 3 Properties, a San Diego-based developer,[80] on Miami Boulevard just outside the formal Park boundaries;
- RTP BioVenture Center,[81] a for-profit accelerator owned by BD Technologies, a subsidiary of Becton-Dickinson, aimed at the medical-products company's strategic partners; and
- Emerging Technologies Center, a 40,000 square foot multitenant building being renovated by Alexandria REIT and positioned as an incubator because one of its tenants will be the A. M. Pappas venture capital fund (although tenants need not be investees).

Bioscience firms represent three-quarters of the spin-off portfolios held by both UNC and Duke. NCTDA also operates an incubator in Durham, also leased from Phase 3 Properties, and one at Centennial, leased from another developer. However, companies graduating from these incubators do not typically come to RTP. The Foundation president believes that firms with this kind of space need may do better "in a loft in Durham." He is referring to two downtown Durham buildings that have been rehabbed by Chapel Hill-based developer Scientific Properties[82] into multitenant bioscience laboratory space. One interesting counter-example was Sphinx Pharmaceuticals, a Duke spin-off that was acquired by Eli Lilly of Indianapolis. Since the founders would not have considered anywhere except RTP, Lilly built its new division a 150,000 s.f. headquarters laboratory.

[78] See http://www.cednc.org/.
[79] See http://www.nctda.org/nctda/bi/rt_incubators.html.
[80] See http://www.phase3properties.com/development.html.
[81] See http://www.bd.com/technologies/busdev/BioVenture.asp.
[82] See http://www.scientificproperties.com/.

Community Issues

There is no housing in the park, since its 8-mile by 2-mile shape would be ill-suited to a "walk to work" orientation, and many of the contemplated uses involve environmental issues that are considered not compatible with residential living. The park believes that this lack of housing has contributed to the failure of the surrounding counties to develop road and water/sewer infrastructure in a timely manner, since "only homeowners vote" but still believes that no housing was a wise decision. Some housing is beginning to be developed "outside the gates."

Summary of Success Factors

RTP is the premier national example of a long-term, patient development strategy based on tightly controlled, cheap real estate and concerted promotional efforts to attract R&D anchors. It took a site from forestland to major employment center in under 50 years and completely reinvented the image of the state. Its tight design covenants have resulted in an attractive campus that is more spacious than competitors like Centennial but not so spread out that land is used uneconomically. The park has historically had broad support from its university partners, although formal connections are actually minimal.

Worcester – Massachusetts Biotechnology Research Park and Boston – BU BioSquare and Boston – MIT University Research Park

VISION, HISTORY, BUILD-OUT TARGET AND CURRENT STATUS

Worcester

The Massachusetts Biotechnology Research Park is a mature, million-square-foot research park on 105 acres that has carved an identity for Central Massachusetts as a low-cost alternative in the biosciences to Cambridge and the inner Boston suburbs. The park traces its history[83] to the 1970s, a period of alarmingly rapid industrial disinvestment for Worcester, which is the state's second largest city and is situated about 40 miles west of Boston. Somewhat isolated geographically in the days before completion of the I-495 outer beltway and the MBTA commuter rail lines, Worcester recognized that its only hope for long-term revival lay with its institutions of higher education,[84] particularly the University of Massachusetts Medical School[85] and the Worcester Foundation for Biomedical Research, on 80 acres in nearby Shrewsberry.[86] In 1982, Michael Dukakis ran for the governorship on a "bring back the cities" platform. This commitment coincided with a drive of several years standing by local civic activists to convert the grounds of the former Worcester State Hospital, which was situated just across the street from the medical school, into a biomedical research park.

The transfer of the property had been delayed by bureaucratic inertia and local opposition based on loss of open space and the perceived risks of specializing in what was then a very new set of DNA-based technologies (in Cambridge, local residents had mounted the same kind of opposition to Harvard's plans). Shortly after his election, Dukakis engineered the rapid transfer of the first 75 acres for $450,000 (an estimated one-third the market value) to the Worcester Business Development Corporation (WBDC), a nonprofit development company that handled city economic-development business and was closely affiliated with the Worcester Chamber of Commerce. Payments on the sale were deferred until first occupancy. Gov. Dukakis followed in 1985 by designating the area around the University of Massachusetts Medical School a "center of excellence" for life sciences and biotechnology. He also provided $1 million in cumulative grant support to the Massachusetts Biotechnology Research Initiative, a closely associated commercialization venture (see below), and assisted in obtaining $3 million from U.S. EDA for

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[83] A good history highlighting the role of the state government is: Eric T. Nakajima and Robert W. Smith. *State Economic Development Policy in Massachusetts (1983-1991): A Case Study of Worcester's Biotechnology Industry.* Berkeley, Calif: UC Berkeley Department of City and Regional Planning, July 2001. Available online with a brief summary at: http://http://www.curp.neu.edu/sitearchive/splotlight.asp?id=1558.

[84] See http://www.cowc.org/members.html.

[85] Founded 1962 not in Springfield, where the state's largest tertiary-care hospitals outside Boston have long been located, but instead for fundamentally political reasons in Worcester, which was already home to the state university's dental, nursing and allied health schools. See http://www.umassmed.edu/about/.

[86] Established in 1944 as an independent entity, the foundation was merged organizationally into the medical school in 1997. See http://www.umassmed.edu/pap/pubs/annual_report/2001/wfbrar.pdf.

ture (see below), and assisted in obtaining $3 million from U.S. EDA for environmental impact reviews and infrastructure improvements.

After a false start trying to sell land to end-users, and a turnkey arrangement with Hines Industrial Properties, WBDC began speculative development of its first building "not knowing what was going to happen,"[87] but backed by the financial resources of the Worcester Chamber and its leading member companies. Three major multitenant buildings were built in rapid succession, followed by recruitment of BASF, which had been looking for laboratory space in the Boston suburbs and was directed to Worcester by the state government in the late 1980s. Thirty-two more acres were acquired, and three additional multitenant units constructed have been sold to Alexandria Real Estate Investment Trust, a publicly traded REIT which specializes in laboratory space. While there has been considerable tenant turnover since the start, the mix remains robust: some university space, some startups, and some branch operations of larger entities. The following table summarizes current status:

Table A11: Current Status of Worcester

Building	Function	Square feet	Year completed	Major tenants	Comment
One Biotech	Multitenant office/lab	80,000	1987	UMass office of Commercial Ventures and Intellectual Property	Developed on spec by WBDC; now owned by UMass
Magnetic Imaging Center	Lab and clinical	10,000	1988	Clinical operator for diagnostic imaging; WPI for research imaging	Developed by WBDC; current status N/A.
Two Biotech (373 Plantation St.)	Multitenant office/lab	90,000	1989	UMass Program in Molecular Medicine and other centers	Developed by WBDC; now owned by UMass
Beechwood Center	Hotel/ conference center	80,000	1989		Owned by Sedler Corporation.
Three Biotech (One Innovation Drive)	Multitenant office/lab	114,000	1991	Advanced Cell Technology, a research partner of UMass, ViaCell; and branch of AstraZeneca	Developed by WBDC; now owned by Alexandria REIT
BASF	Single-tenant office/lab	350,000 + 250,000	1993	Anchor tenant BASF laboratory and scale-up bioprocessing facility (now Abbott Laboratories)	Owned by BASF (Abbott)

[87] Marc Goldberg, as quoted in: Kim Ciottone, "Buying into Biomed." *Worcester Business Journal.* February 26, 2002. Available on-line at http://www.massbiomed.org/news_mbi/?action=view&id=54.

Building	Function	Square feet	Year completed	Major tenants	Comment
Four Biotech (377 Plantation)	Multitenant office/lab	93,000	1994	Athena Diagnostics; research space rented by UMass	Developed by WBDC; now owned by Alexandria
Six Biotech (381 Plantation)	Multitenant office/lab	112,000	Recent	Red Cross; others	Developed by WBDC; now owned by Alexandria

Sources: Previous interviews, previous WBDC website at http://www.biorealestate.com/, current UMass information at http://www.umassmed.edu/gsn/graduate_study/extend.cfm. and Alexandria REIT 10-K

WBDC has re-invested its cashed-out equity in Centech Park, a 120-acre R&D park 10 minutes away in Grafton, adjacent to the Tufts University School of Veterinary Medicine campus. Centech is a multi-sector park, with strength in information technology. It is currently at three buildings and is targeted for buildout to 10 sites and 675,000 square feet. This effort has in turn leveraged development initiative by Centech's next-door neighbor. Through its subsidiary Tufts Biotechnology Corporation, Tufts now plans to develop 106 acres on the western edge of its campus in two phases, encompassing 702,000 square feet of space in a cluster of three-story buildings.[88] This project is still in planning phase.

Boston – BioSquare (BU)

Established in 1993, BioSquare[89] is a high-density research park being developed by Boston University at its Boston Medical Center campus along the Albany Street corridor in the Crosstown area of the city's South End. Crosstown is an underutilized, formerly industrial district that adjoins the entry ramps to the new Boston Central Artery tunnel. It buffers three neighborhoods—working-class Roxbury and South Boston, and economically struggling Dorchester—from the Fenway-area cultural institutions to the north, including the multi-institutional Longwood Medical and Academic Area.[90] BioSquare is one of three major development projects under way in Crosstown, including also the heavily subsidized CrossTown Center mixed-use commercial complex and a privately financed renovation of a group of aging warehouses and factories along Harrison Street.[91] On what was once a vast surface parking lot, BU has constructed two buildings totaling 400,000 square feet. The total buildout potential is 2.5 million square feet over 14 acres. Following is summary of the development plan:

[88] See http://www.tufts.edu/vet/sciencepark.
[89] See http://www.biosquare.org.
[90] See http://www.longwoodsecurity.com/about_area.html.
[91] See Richard Kindleberger, "Developers Tout what they Call the Next Hot Spot: Albany Street," *Boston Globe,* April 14, 2000. Available on-line at http://www.boston.com.

Table A12: Summary of BU Development Plan

Building	Function	Square feet	Year completed	Major tenants	Comment
Center for Advanced Biomedical Research	Institutional	200,000	1993	Core laboratories and new animal-care facilities to replace aging ones	
Evans Bio-medical research Center (650 Albany St.)	Multitenant commercial condo	192,000	1998	Medical-center affiliated research foundation; three biotech compa-nies (largest is CombinatoRx) and one business incubator with startups	Condo structure allows mix of tax-exempt and taxable uses
Garage	Structured parking	1,000 spaces	2000		
Building D	Undetermined	151,000	Proposed		
Building E	Undetermined	172,500	Proposed		
Building F	Hotel/Conference Center	240 rooms	Proposed		Note, however, that subsidized hotels are being built elsewhere in Crosstown
Building G	Undetermined	172,500	Proposed		
Garage	Structured parking	1,200 spaces	Proposed		
Park					Adjacent to Central Artery Connector
Building K	Undetermined	600,000	Proposed		

Source: BioSquare website

Cambridge—University Research Park at MIT

University Research Park is a nearly fully built-out 27-acre special development district in the industrial Cambridgeport neighborhood that stretches northward from the Charles River water-front, just behind the Massachusetts Avenue frontage of the main MIT campus. MIT began ac-quiring lots in Cambridgeport as it deteriorated in the 1960s, and by the time the huge Simplex Wire and Cable complex closed in the early 1970s, MIT owned 40 percent of the acreage. MIT already had a long history of investing in the Cambridge real-estate market for its endowment accounts, primarily along Massachusetts Avenue and in the Kendall Square area close to the East Campus. However, the university viewed the Simplex site as a combined financial investment and strategic effort to house research partners near the campus.

The City of Cambridge wanted tax development, job development, and creation of affordable, middle-income housing in one of the last neighborhoods not to have gentrified. Planning for

University Research Park started in 1982, and the following year MIT selected Cleveland-based Forest City Enterprises as its master-developer, seeking "a developer with deep pockets and staying power who could work independently with Cambridge to safeguard the town-gown relationship."[92] Forest City, a publicly traded REIT, describes itself as perceiving its best opportunities in core urban markets.[93] The parties signed a 20-year development agreement, providing for 75-year ground leases with reversion to MIT by 2078. The City's Cambridge Port Revitalization Development District plan adopted in final form in 1992[94] sets open-space minimums, design guidelines, and staging requirements on development phases. The City expects creation of 4,000 jobs and incremental tax collections of $10 million annually.

The full buildout target is 2.3 million square feet, including 1.3 million in R&D space, 210 rooms in a hotel/conference center, about 650 units of rental housing (including low- and moderate-income housing as well as market-rate), parking for 2,800 cars, and seven acres of parkland. Two buildings were chosen for adaptive reuse, but the rest will be new construction.[95] University Research Park grew slowly until the late 1990s. The first buildings targeted companies in the software, IT, defense, and computer sectors. As these sectors began to sag in the late 1990s, the biotech sector was just taking off, and Forest City adapted. The park is now 90 percent bioscience oriented, and the majority of space is taken by companies with strong ties to MIT such as Millennium Pharmaceuticals and Genzyme. Following is a review of the park buildout.

Table A13: Review of Park Buildout

Address	Use	Size	Year completed	Major Tenants	Comment
26 Lansdowne	Multitenant lab/office	99,000	1987	Ariad Pharmaceuticals	Adaptive reuse
38 Sidney St.	Multitenant lab/office	121,776	1989	Acambis; Millennium; Genzyme; Partners Healthcare	
64 Sidney St.	Multitenant lab/office	126,065	1990	Akermes; Genzyme	
129 Franklin St.	Residential	142 units	1990		Adaptive re-use Kennedy BIscuits site
46-104 Brookline St.	Residential	143 units	1986-2000		Includes mod income setasides. Built by community-based nonprofit.
20 Sidney St.	Hotel	210 rooms	1998		Supermarket added later
350 Mass. Ave.	Multitenant office/retail	N/A	1998	Millennium	

[92] For an excellent overview of the University Park project, see "University Park at MIT: Precedent Study," available online at: http://web.mit.edu/course/11/11.332/www/pdf/univpark.pdf.
[93] See Bill Archembault, "What's Next for Forest City after MIT's University Park?" *Boston Business Journal*, Feb. 7-13, 2003. Available on-line at http://www.fceboston.com/article_gifs/bbj_02_13_2003.gif.
[94] For zoning accord see http://web.mit.edu/newsoffice/tt/1992/feb26/25836.html.
[95] See http://www.fceinc.com/projects_detail_mixed.asp?id=380.

Address	Use	Size	Year completed	Major Tenants	Comment
55 Franklin St.	Garage	N/A	N/A		
45/75 Sidney St.	Single Tenant lab/office	276,682	1999	Millennium	
30 Pilgrim St.	Garage	N/A	N/A		
University Park Com-mon	Open Space				
65 Lans-downe St.	Institutional lab	122,410	2001	Partners Healthcare	
35 Lans-downe St.	Single ten-ant lab	202,423	2002	Millennium	
91 Sidney St.	Residential	135 units			
88 Sidney St.	Single Tenant lab/office	145,275	2002	Alkermes	
40 Lans-downe St.	Single ten-ant lab/office	214,638	2003	Millennium	
80 Lans-downe St.	Garage	N/A	N/A		
Lansdowne Quadrangle	Open space				
100 Lans-downe St.	Multitenant office/lab	241130	Proposed		
23 Sidney St.			Proposed		

Source: Forest City Enterprises website

The efforts of both the Massachusetts Biotech Park in Worcester and BioSquare in the Crosstown neighborhood must be seen in the context of the emergence in the last decade of Cambridge as the dominant center of the life sciences industry in New England. Of the top 25 bioscience firms in Massachusetts, 14 can now be found in Cambridge—and all but one of those within one mile of MIT and its Whitehead Institute/Center for Genome Research.[96] Altogether, Cambridge hosts 60 companies that are members of the Massachusetts Biotechnology Council. Of those, 51 are within the same one-mile radius:

- 36 in Cambridge's Central Square area up Massachusetts Avenue on the way toward Harvard;
- 13 in Kendall Square, at the intersection of Main and Broadway; and
- 2 in East Cambridge

[96] See http://web.mit.edu/newsoffice/nr/2002/mitbiotech.html.

Bioscience was not always this concentrated in Cambridge, but each time an economic downturn depressed demand by IT-oriented companies (MIT's traditional forte), developers perceived an opportunity to convert office or "tech" space to wet-laboratory space. As a rule of thumb, shell office construction Cambridge costs $125 p.s.f., with office fit-out adding $25 and a bit more for IT uses. Wet-lab-ready shells cost $200 p.s.f. with fit-out expenses of $75, whereas converting an office to a laboratory adds an increment of about $100 p.s.f. (All these figures exclude the $150-$200 p.s.f. in moveable equipment that is the responsibility of the tenant.) As recently as last year, East Cambridge had a 21 percent vacancy rate in offices, but just minimal vacancies for laboratories.[97] This dynamic has driven the takeover of University Research Park by bioscience uses, and stimulated millions of square feet of infill developments or conversions by developers such as:

- Alexandria REIT (whose tenant is Pfizer);
- Boston Properties (Biogen);
- Lyme Properties (Vertex, Amgen, Genzyme, and others);[98] and
- MIT's own real estate office, which bought back the Tech Square development it had started decades ago and then sold to private interests (a major new tenant is Novartis).[99,100, and 101]

Although Cambridge has been creating and absorbing more than 300,000 s.f. a year in bioscience space, the development community is starting to see it as nearly fully built out,[102] and as of 2001 there were the first signs of speculative laboratory development and conversion of single-story flex buildings to laboratory use[103] in the northern suburban (Route 128) communities of Woburn, Lexington, Wilmington and Beverly. Just across the river in Boston, Genzyme has opened a manufacturing plant and Merck has leased space for a 300,000 s.f. R&D lab from Emmanuel College, a liberal-arts college member of the Longwood Medical and Academic Area (known mainly as the home to the major research labs of Harvard Medical School).

All these pressures bring development within reach of BioSquare, although real-estate experts describe Crosstown as still a "frontiering-type location."[104] They also benefit the Worcester/Central Massachusetts area (now home to an Abbott Laboratories research subsidiary) and surely played an important role in the rapid buildout of the last several buildings in the Biotech Park and Tufts's eagerness to develop its own land as a bioscience park. In general, Worcester is becoming less of a standalone region and more of a bedroom community for Boston, enabling

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[97] See Susan Diesenhouse, "Lab Space is Bright Spot in Dim Cambridge Market," New York Times, March 31, 2002. Available on-line at http://www.fceboston.com/article_nyt_040902.htm.
[98] Lyme is also developing a large institutional structure across the river in the Longwood Medical and Academic Area.
[99] See http://web.mit.edu/newsoffice/nr/2001/techsq.html.
[100] See http://web.mit.edu/newsoffice/tt/2002/may08/novartis.html.
[101] See http://www-tech.mit.edu/V122/N41/41techsquare.41n.html.
[102] See Bill Archembault, "Cambridge's Heady Biotech Growth May Soon be Over," *Boston Business Journal*. Feb. 12, 2002. Available online at http://www.bizjournals.com/boston/stories/2002/02/18/story8.html.
[103] See Bill Archembault, "Biotech Goes Suburban," *Boston Business Journal*. Oct. 26, 2001. Available on-line at http://www.bizjournals.com/boston/stories/2001/10/29/story3.html.
[104] See Bill Archembault, "Mayor Touts Crosstown Tour, but is it a Long Shot?" *Boston Business Journal*. December 27, 2002. Available on-line at http://www.bizjournals.com/boston/stories/2002/12/30/story5.html.

developers to position it as a quality-of-life play for bioscience workers who already live in the western suburbs and would rather commute west than east. The Worcester chamber is also making a significant effort to position the region as low-cost manufacturing space for products developed in Cambridge, including not only pharmaceuticals but also biomedical devices.[105]

Development Approach and Market Differentiation

Worcester

As noted above, Worcester's first buildings were developed on speculation to serve a cost-sensitive sector of the biotechnology market. For the first building, WBDC borrowed from a consortium of local banks, and for subsequent projects was able to cross-collateralize by pledging equity on the earlier buildings and in one case using a CDBG guarantee to lever long-term financing from the AFL-CIO Building Investment Trust. Initial tenant fit-out allowances were $35 p.s.f. More recently (Building 5), WBDC was developing shelled, lab-ready space for $70 p.s.f. (not including land) and with fit-out at $80 p.s.f., assuming 60 to 70 percent laboratory use. Rents on triple net basis were $20 p.s.f. with $10 in pass-throughs plus tenant improvements.[106] By contrast, Cambridge competes on convenience, especially for companies with close connections by license or principals to one of the research institutions, and rents are typically twice as high.

Boston – BioSquare

BioSquare has bee developed by BU's in-house real-estate unit, financed by $150 million in loans and (for the non-profit condo owners) tax-exempt bonds.

Key Turning Points in Park History

Worcester

It is not clear that the BASF recruitment was actually the determinant of success at Worcester. The park has had a steady buildout based on entrepreneurial support (see below) and cost advantages.

Boston – BioSquare

BioSquare is still at an early stage of development and has yet to have its first major development victory.

Lessons from the Development Process

One strong lesson emerges from Cambridge, where Forest City notes that explosive demand for wet-lab space has helped it convince its lenders that *fitted-out* biotech space is reusable. At first,

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[105] See Micky Baca, "Mass Gets Biotech Wake-up Call," Worcester Business Journal. Jan. 12, 2003. Available on-line at http://www.massbiomed.org/news_mbi/?action=view&id=64 or Tom Salemi, Worcester Sets its Sights on Luring Medical Device Firms," *Boston Business Journal,* May 15, 1998. Available on-line at http://www.bizjournals.com/boston/stories/1998/05/18/story2.html.

[106] Source: interviews with Tom Andrews conducted by Mitch Horowitz.

the development company's lenders demanded that tenant improvements for laboratory fit-out be amortized over the life of a lease. Now, these lenders will finance $75-$90 p.s.f. of fit-out expenses in precisely same manner as the hard and soft construction costs (i.e., they can be financed through long term mortgages and built into rental rates).[107]

LINKAGES WITH SPONSORING INSTITUTIONS

Worcester

Liaison with UMass, WPI, Tufts and other area institutions was provided during the development of the Biotechnology Research Park by the MBRI initiative, whose board was broadly representative of academic and healthcare institutions. Physical linkages are still quite close with UMass, which is across the street and maintains a mental-health research institute on the grounds of the old state hospital/research park.

Boston – BioSquare

Tenants at BioSquare are offered non-preferential access to university lab and support facilities through a comprehensive core services agreement.[108]

ROLE OF EMERGING BUSINESS/INCUBATORS

Worcester

The Biotechnology Research Park could probably not have thrived in its early years without the parallel effort of the state-supported MBRI to develop entrepreneurial companies, both spin-outs from UMass and others which found the environment attractive. MBRI maintained a below-market incubator inside the park and also put together BioVentures, a $5 million investment fund capitalized by local sources (its successors have moved to Cambridge). This came at the same time as UMass was reinventing its licensing office, by hiring a former venture capitalist to lead it and providing it with a $500,000 patent-development fund.

MBRI subsequently evolved into MBI—Massachusetts Biomedical Initiatives. It now operates two wet-lab incubators in Worcester but outside the park—a small facility at Barber Ave. (3 biotech tenants) and more than 16,500 square feet at the former St. Vincent Hospital at Winthrop St. (9 biotech tenants). Organizationally it also includes

- Central Mass Biomedical Initiatives (CMBI) and a commercialization center serving non-incubator tenants.
- An occupational safety center aimed at assisting tenants with licensees and permits both in the incubator and when they graduate.
- An informatics center aimed at software and tools for drug discovery.

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[107] See "Understanding Corporate Real Estate," *Development.* Fall 2002. Available on-line at http://www.fceboston.com/article_gifs/dev_02fall.gif.
[108] See http://www.biosquare.org/amenities/amenities.html.

Sometimes seeds planted by the incubator and commercialization activities are a long time in sprouting. Recently one of the early MBI incubator companies, t-breeders, merged with Viacord to form Boston-based Via-Cell, which is retaining 12,000 s.f. of lab space in the research park. Some incubator companies have also benefited from seed-stage investments from the quasipublic Massachusetts Technology Development Corp. (also created under the Dukakis administration). However, a current chart of incubator companies[109] vs. MTDC biomedical investments[110] and the portfolio of BioVentures Investors LLC[111] (successor to MBRI's BioVenture, and now based in Cambridge) shows only one overlap—the diagnostics firm Verax. Spin-outs from UMass, BU, Harvard and MIT are not included on this table because comprehensive lists are not publicly available except from Harvard (BU's are also available but many are still at the virtual-company stage).

Table A14: Incubator Companies vs. MTDC Biomedical Investments and the Portfolio of BioVentures Investors LLC

Current MBI Incubator Tenants	MTDC Biomedical Investments	Portfolio of BioVentures (successor to MBRI fund)	Location/comment
		AngioLink	Taunton, Mass.
Antigen Express			MBI incubator
		Ardais	Lexington, Mass.
	Atlantis Components		Cambridge
Avatar Pharmaceutical Services			MBI incubator
Beckman-Coulter			MBI incubator (note subsidiary of large firm, not startup)
	Biofertec		Cambridge
Bioheart			MBI incubator
		BioValve Technologies	Worcester—Biotechnology Research Park
Biomedical Research Models Inc.			MBI incubator
	CardioFocus		Norton, Mass.
		CombinatoRx	BU—Biosquare (but not BU New Ventures spin-off)
	CytoLogix		Cambridge
DXA Resource Group			MBI incubator
		Enanta	Watertown, Mass.
	endoVia Medical		Norwood, Mass.

[109] See http://www.massbiomed.org/tenants/winthrop and http://www.massbiomed.org/tenants/barber.html.
[110] See http://www.mtdc.com/portbiomed.html.
[111] See http://www.bioventuresinvestors.com/portfolio.html.

Current MBI Incubator Tenants	MTDC Biomedical Investments	Portfolio of BioVentures (successor to MBRI fund)	Location/comment
		Genaissance Pharmaceuticals	New Haven – Science Park at Yale
Gene-IT			MBI incubator
GlycoSolutions			MBI incubator
		HospitalCareOnline	Boston
Hypromatrix			MBI incubator
J-Que Biologics			MBI incubator
		MicroMed Technology	Houston, Texas
		nTouch Research	Raleigh, N.C. (not Centennial)
		PhaseForward	Waltham, Mass.
		Pintex Pharmaceuticals	Watertown, Mass.
PolyGenyx			MBI incubator
		Therion Biologics	Cambridge
Verax Biomedical		Verax Biomedical	MBI incubator, moving to Worcester Biotech Research Park
	VisionScope		Ashland, Mass.

Boston – BioSquare

While the goal of BioSquare is to capture the majority of BU spin-out companies, initial development of BioSquare did not include an incubator. Instead, start-ups affiliated with the university's commercialization programs received incubator-like services on a more informal basis. More recently, BioSquare has opened a 12,500 s.f. "BioSquare Discovery and Innovation Center"[112] incubator within the multitenant condo building. The Center supports six office and laboratory suites.

BioSquare is loosely affiliated with BU's Community Technology Fund (CTF), the university's name for a combined licensing office, commercialization function, and direct-investment fund. The direct investment fund was capitalized many years ago by surpluses in BU's general operating fund and is thus operated independently of BU's endowment, as a national-level early-stage investor. However, since it is staffed in part by venture professionals, it performs the additional function of advising the BU endowment on its investments in various venture capital limited partnerships. Together, the direct investment fund of $35 million and the BU endowment's investments give the CTF the apparent size of a $125 million venture investor. Using the same staff for both functions tends to incur reciprocal obligations to look at BU spin-outs, which occasionally receive seed-stage investments from the fund itself. Moreover, the fund's profits finance the work of the CTF New Ventures Unit, which provides internal university proof-of-concept funding whose staff creates spin-out corporations, serves as their interim staff until permanent manag-

[112] See http://www.biosquare.org/bdic/BDIC.html.

ers can be recruited, and arranges for financing by the direct investment fund and syndicate partners.[113]

Boston – Cambridge

Of the 60 bioscience companies in Cambridge, 21 have licensed technology from MIT or were founded by MIT alumni or faculty, including Biogen, Millennium, Ariad, Genzyme, Alkermes and Biopure.[114] Millennium is now the city's largest private-sector employer, with nearly 2,000 workers, and Biogen is the next largest with 1,400.[115]

Harvard reports that of its 15 equity holdings in FY 2002, five were situated in Cambridge (Ariad, Enanta, Modular Genetics, Variagenics, and concurrent Pharmaceuticals).[116]

COMMUNITY ISSUES

Worcester

There have been few difficult community issues in Worcester since the issue of safety guidelines was settled in the mid 1980s.

Boston – BioSquare

Crosstown is in a federal empowerment zone, although BioSquare is just outside the boundary. The nearby CrossTown Center has received $42 million in tax-exempt bonding from the Boston Redevelopment Authority and direct loans of $5 million from BRA and $7 million from Boston Connects, the nonprofit charged with implementing the empowerment zone.

Boston – University Research Park

While the issue of affordable housing was contentious prior to 1992, it seems to be a settled issue. Forest City also notes it had unexpected success in bringing a supermarket to University Park. The market helps companies attract bioscience workers to live nearby, and gives the district the genuine sense of a neighborhood, not just a project.[117]

SUMMARY OF SUCCESS FACTORS

Worcester has successfully positioned Central Massachusetts as a low-cost, low-living-hassle alternative to Cambridge and the 128 suburbs. BioSquare is attempting a low-cost strategy from within a City base.

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[113] See http://www.bu.edu/ctf/newventures/portfolio.html.
[114] Data from "Cambridge, MIT are Magnets for Biotech." Backgrounder available at http://web.mit.edu/newsoffice/tt/2002/may08/biofacts.html.
[115] See http://www.cambridgema.gov/~CDD/data/labor/top25/top25_2002.html.
[116] See http://www.techtransfer.harvard.edu/AR02_Equity.html.
[117] See "Biotech Bonanz Challenges Cambridge." Available on-line at http://www.fceboston.com/article_realestate.htm.

Supplementary Report on San Diego

Overview and Current Status

Despite the fact that it routinely ranks third in the nation as a commercial bioscience hub, the San Diego region has no university-related research park, nor a university-affiliated, bioscience-oriented business incubator. Virtually all the region's bioscience companies—both regional start-ups and inward recruitments like Novartis—have met their space needs through the private development marketplace. Nearly every developer with an active bioscience space program has significant activity in San Diego, and several such as Alexandria REIT are actually headquartered there.

Local real-estate firms and planning agencies identify several submarkets with heavy R&D use especially within the "North City" and "Central Suburban" planning zones of San Diego County, with additional uses scattered through various municipalities along the I-15 and Highway 78 corridors. In all, the Burnham Real Estate Services firm estimates, there are 21 million square feet in R&D use in the county.[118] The neighborhoods closest to the cluster of institutional research centers[119] a few miles north of downtown have the heaviest concentration of bioscience use, probably at least seven million square feet.[120] Lease rates range up to $35 p.s.f triple net, or somewhat less than for comparable space in Cambridge or the San Francisco Bay area.

The San Diego Regional Economic Development Corporation recently sponsored a study[121] that called for creation of a large (1,000-acre) Regional Technology Park aimed at production facilities for the "technology and biotechnology sectors," and also a network of smaller (200-acre) parks around the region. This recommendation was sized to fit an anticipated five percent annual growth rate in employment in these sectors, and to acknowledge minimal remaining developable land in the core of San Diego County. The report anticipates demand for R&D/industrial space in the following sectors other than biotech: aerospace, computers, microelectronics, advanced materials, robotics and telecommunications.

Market Differentiation

To understand why the county development agency is concerned with capacity, and why it is debating sites scattered throughout the county for its RTP,[122] consider that the four primary R&D submarkets in North County (including large parts within San Diego City limits) are differentiated as follows:

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[118] Burnham Real Estate Services. *Outlook 2003: San Diego County.* Available on-line at http://www.burnhamrealestate.com/OUTLOOK_2003.pdf.

[119] UCSD, Salk, Scripps, Scripps Oceanographic, Burnham, Kimmel, Neurosciences Institute, Institute for Allergies and Immunology.

[120] See http://www.phase3properties.com/sandiego.html.

[121] London Group Realty Advisors. "Market Analysis: Regional Technology Park." January 2001. Available on-line at the website of the San Diego Regional Economic Development Corporation: http://www.sandiegobusiness.org/researchpublications.htm.

[122] See http://www.phase3properties.com/sandiego.html.

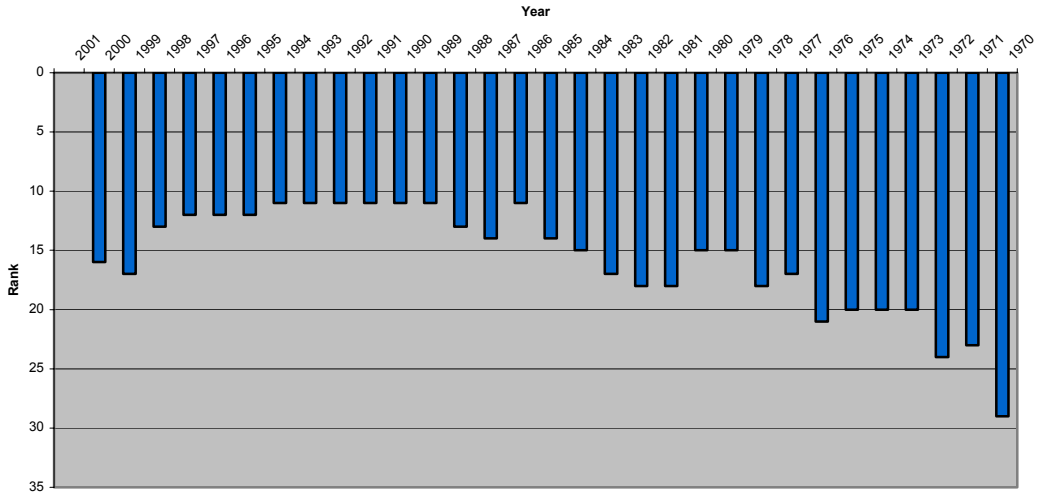
- **Torrey Pines** – Master planned for scientific research and associated manufacturing, as well as headquarters of more than 40,000 square feet. The vacancy rate is effectively zero, and developers in discussions on all remaining sites.
- **University Towne Center** – 150 acres of this commercial district, which is near a regional mall, are zoned for scientific research. Current and planned bioscience space totals somewhat under 1 million square feet, with only one developable site still available.
- **Sorrento Valley** – The region's first technology corridor, featuring multi-tenant space that has been shifting (as in Cambridge) away from IT and toward bioscience uses.
- **Sorrento Mesa** – Lower cost space suitable for later stage companies seeking a cost advantage and willing to tolerate slightly greater distance from the research institutions, with anticipated rapid conversion of existing structures to wet-lab use.

KEY TURNING POINTS

San Diego was not always known as a bioscience hub. As recently as the mid to late 1980s it was known more for its large aerospace and defense contractors than for the life sciences, or really for much entrepreneurial activity at all. What has happened since then was a convergence of many factors, including the defense downsizing that threw the region into crisis, a cost of housing that stayed substantially below the Bay Area's, and a steady accretion of research institutions within a close ride of developable land, with stunningly beautiful ocean and mountain views.

The roots of San Diego as a bioscience center date to 1924, when the Scripps Clinic was founded. The basic biomedical research program at Scripps was founded in 1955, when Frank Dixon was recruited to Scripps from the University of Pittsburgh. UCSD itself was established only in 1960 and was built on excellence in both the physical and life sciences. A strong performer in NIH funding as long ago as the early 1970s (see graph), UCSD Medical School grew its rankings even further starting in the late 1980s. Another key recruitment—Jonas Salk, in 1963—led to establishment of the Salk Institute, and the Burnham Cancer Center was founded in 1976.

Figure A9: Rank of USCD Med School in NIH Funding among all Med Schools. (Source: NIH)



By the early 1980s, all these institutions were situated within a short distance of each other in the Torrey Pines/La Jolla neighborhoods, a proximity frequently cited as key to the region's success. The history of San Diego's takeoff as a technology center has been studied extensively, most recently by consultants for the Small Business Administration[123] and for the Council on Competitiveness.[124] There is wide agreement that success—even in the biosciences—was tightly linked to the region's rise during World War II as a center of airplane manufacture and its evolution with assistance from the Navy into a center of defense avionics.

As often happens in such communities, large defense contractors enter and exit businesses in cyclical fashion, leaving occasional openings for entrepreneurs. Alumni of giant contractors like General Atomics (founded 1955 as a General Dynamics spin-off) were responsible for creation in 1969 of SAIC (an employee-owned technology firm that is now one of San Diego's larger winners of NIH funding) and in 1985 of Titan Corporation, a conglomerate with some bioscience interests.

Eventually two key spin-outs were formed, one in telecom and one in life sciences, that changed the destiny of the community:

- In 1966, Irwin Jacobs, then a professor of computer science at UCSD, started Linkabit, as a one-day-a-week faculty consultancy to the avionics sector. This fast-growing company was formally organized in 1968, and by 1972 Jacobs had left UCSD to run it. He sold Linkabit in 1980 to M/ACOM but not before Linkabit had planted the roots for about 30 subsequent telecom startups formed directly or indirectly its alumni, including Qualcomm, which Jacobs

[123] .Innovation Associates Inc. (Diane Palmintera, author). *Developing High-Technology Communities: San Diego.* Washington, D.C.: U. S. Small Business Administration Office of Advocacy. April 2000. Available online from: http://www.innovationassoc.com/.

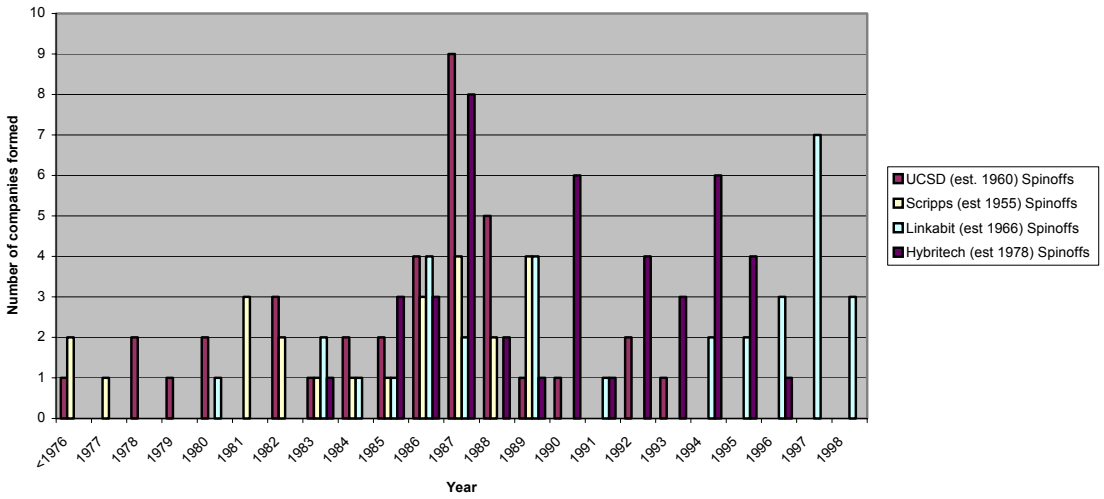
[124] Monitor Group (Prof. Michael Porter, author). *San Diego: Clusters of Innovation Initiative.* Washington, D.C.: Council on Competitiveness. May 2001. Available online from http://www.compete.org.

himself co-founded in 1985.[125] Jacobs became a key UCSD ally in the formation of the engineering school and ultimately he and his wife made a naming donation to the school.

- In 1978, UCSD scientists Ivor Royston and Howard Birndorf formed Hybritech, the first biotech spin-off from the university. The firm ultimately played a similar genitive role in the biotech sector,[126] accounting for at least 40 or 50 subsequent start-ups, especially in the wake of its sale for $1 billion to Eli Lilly, and its subsequent resale for far less to Beckman Instruments after Hybritech's entrepreneurial staff clashed with the conservative business culture of the Indianapolis-based pharmaceutical giant, and many left to start their own firms.

Business formations stemming from Linkabit and Hybritech amounted to only a trickle at first, but a surge occurred when San Diego confronted community crisis. Like many other proud technology-rich cities around the nation, San Diego was jarred by its failure to win the national competitions for the Microelectronics and Computer Consortium (1985) and SEMATECH (1988). Then, with the collapse of the Soviet Union in 1989, San Diego's major defense employers dramatically downsized or closed shop altogether (as did General Dynamics) in the early 1990s. The sense of crisis spurred self-examination that was already under way by progressive forces such as Richard Atkinson, who had become Chancellor at UCSD in 1980.

Figure A10: Distribution of Firms "Begat" by Key Institutions/Companies (Source: Interpolated from Palmintera Tables 12-15)

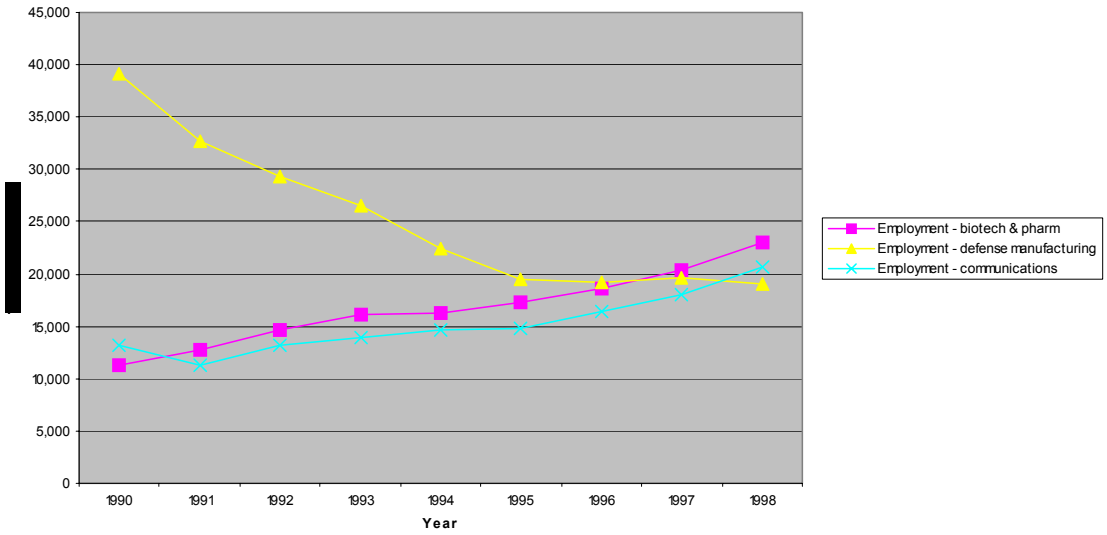


One of Atkinson's key goals was formation of an engineering school at UCSD, and his strategy was to develop and exploit university/industry partnerships. In his time at Stanford, he had formed a commitment to such partnerships. He honed this approach during his tenure at the National Science Foundation, where he established the Industry/University Cooperative Research Centers program. He pursued similar approaches throughout his tenure as UCSD Chancellor, and starting in 1995, as University of California system president.

[125] By-now familiar "genealogy" charts prepared by UCSD-CONNECT (see below) can found most easily in Table 15 of the Palmintera report, referenced above.
[126] See bioscience genealogy chart at Table 14 of the Palmintera report.

It was Atkinson who was the driving force behind the creation in 1985 of UCSD CONNECT—a mentoring, networking and advocacy organization that functions like an "incubator without walls" but imbedded in the university's extension programs. CONNECT later absorbed a separately founded Technology Financial Forum, an early experiment in introducing local entrepreneurs to venture capitalists based in the Bay Area. The potential of the CONNECT model to show the way out of a grinding and seemingly unending decline in defense employment (see graph) impressed and inspired a variety of other actors who came to play key roles in San Diego's emergence as a bioscience hub.

Figure A11: Employment in three high-tech clusters in San Diego (Source: Palmintera Table 16)



In the end, San Diego saw the start of a virtuous circle. Not only did Linkabit and Hybritech and UCSD and Scripps generate between them dozens of spin-offs through business formation by alumni, but those who got rich through this process became angel investors, venture capitalists, and even philanthropists. The community attracted further attention from outside funding interests, including both venture capitalists from the Bay Area, and national foundations such as the Kimmel Foundation, which created the Kimmel Cancer Center in 1990, and Whittaker Foundation, which created the UCSD Bioengineering Institute in the 1990s. Moreover, the region began to see cross-fertilization between its two core competencies, as companies like Nanogen (1992) emerged to apply engineering disciplines to problems in the life sciences.

LINKAGES

Connectivity in the technology community is provided by CONNECT and also the following actors:

- **The San Diego Regional Economic Development Corporation** came to view technology-led development as a key strategic goal for the region, and actively promoted academic/industrial collaboration as a key regional asset.

- **BIOCOM**, a trade association, was founded in 1991 and merged with the Biomedical Industry Council, a CEO leadership group, forming an unusually powerful and effective sectoral association.
- **The City of San Diego** starting in 1992 under Mayor Susan Golding made sustained efforts to turn around a perceived anti-business image by creating a Small Business Advisory Board, creating two enterprise zones, an designing a new incentive program.
- **The State of California** in 1994 used defense-conversion funds from the U.S. Economic Development Administration to create the San Diego Regional Technology Alliance, which applies state funding as incentive to small companies to obtain federal grants or contracts.
- **Other educational institutions** began to contribute to the regional strategy in their own way—for example, San Diego State University created a special master's degrees in biomedical regulatory affairs, and San Diego City College opened a business incubator.
- **Miscellaneous other organization** supported the program of entrepreneurial advancement, including the San Diego Chapter of the MIT Enterprise Forum, the San Diego Manufacturing Extension Center, and the San Diego Association of Governments.

ROLE OF EMERGING BUSINESS/INCUBATORS

The only university-connected incubator in San Diego belongs to San Diego City College, and is manufacturing oriented. However, UCSD has structured its Technology Transfer and Intellectual Property Services (TTIPS) office (a quasi-independent branch of the UC Office of Technology Transfer) specifically to favor spin-off formation over licensing for royalties. The TTIPS director has told Battelle he has a "higher propensity" to accept equity in a startup than other UC campuses such as Berkeley, because UCSD has embraced a regional economic-development mission and wants "to grow technology companies" in the region rather than simply maximize royalties and fees.