MASSACHUSETTS BIOMEDICAL INITIATIVES –

GROWTH OF THE LIFE SCIENCE INDUSTRY IN WORCESTER COUNTY, MA

An Interactive Qualifying Project

Submitted to

Massachusetts Biomedical Initiatives

and to the Faculty of

Worcester Polytechnic Institute

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Abstract

Worcester County, a region in Central Massachusetts, has established a series of initiatives to develop a life science cluster. To foster growth of the life science industry in Worcester County, Massachusetts Biomedical Initiatives (MBI), a biotechnology incubator, requested a study to document the current state of the life science economy, and highlight the strengths of the area. The primary objective was to determine the competitive advantage of Worcester County. This was accomplished by identifying the strengths of the life science cluster specific to Worcester County, and determining the weaknesses of that region. The analysis shows that a critical mass of institutions and infrastructure, and attraction of funds is required to maintain a vibrant life science cluster. Through comparison with relevant state data, the strengths of the life science industry in Worcester County became evident. These include the location of region, unique opportunities at local institutions, lower costs of living and renting lab space, and incubators. Finally, suggestions for remediation were offered to MBI to rectify or alleviate the weaknesses discovered.

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Executive Summary

Worcester County is emerging as a prime location for startup and growing companies. As a biotechnology incubator, Massachusetts Biomedical Initiatives (MBI) plays a large role in attracting and fostering the growth of such companies. To attract new and existing companies to the area, MBI requested a study to document the current state of the life science economy and highlight the strengths and weaknesses of Worcester County. With this information, the implications of the strengths, and suggestions to remedy or improve the weaknesses were offered to MBI.

There are several terms that had to be defined in order to gain an understanding of the parameters of the project. The most essential terms were life sciences, competitive advantage, cluster, and indicators. Life science is mainly comprised of biological studies and has expanded into a more technological and interdisciplinary field. Competitive advantage is the ability of a region to outperform its competitors using skills and resources other regions do not possess. Clusters "are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated in a particular field that compete but also cooperate" (Porter, 2000). An indicator is a term referring to economic benchmark that measures the overall productivity of a region.

First, factors that affect growth in life science industries were determined. The Index of the Massachusetts Innovation Economy, published by the Massachusetts Technology Collaborative, and the 2012 Biopharma Industry Snapshot, published by the Massachusetts Biotech Council are reports that were used as a guideline to determine such factors. These documents evaluated and compared the Massachusetts state economy to other states and countries using various measures, or indicators. Of these indicators, sixteen were chosen that would best illustrate growth in a life science economy. The indicators selected were occupations and wages, employment growth, research and development, patents, approvals of pharmaceuticals, technology licensing, small business innovation research grants and small business technology transfer research grants, business formation, mergers and initial public offerings, biomanufacturing, federal funding, private funding, capital and human resources, lab

inventory, workforce education level, and science, technology, engineering and math (STEM) degrees.

Background research was conducted to gain an understanding of the significance of each chosen indicator and to gather raw indicator data specific to the United States and Massachusetts. From this preliminary research, Massachusetts compared favorably to other states in many of the indicators. More than half of Massachusetts' key industry sectors, such as health care delivery and postsecondary education, reported growth in employment from 2011 to 2012 and wages from 2007 to 2012 (Kispert et al., 2012). In 2011, Massachusetts rose from seventh to fourth in rank in the world in patents issued relative to Gross Domestic Product (GDP). GDP is the total market value of all officially recognized final goods and services produced within a country in a given period of time (Gutierrez, 2007). For National Institute of Health Research and Development Funding per 1,000 dollar GDP, Massachusetts ranked first in the country in 2011. In 2011, Massachusetts had a higher median household income than any other state.

The second goal of this project was to offer ways to improve and grow the life science industry in Worcester County. In order to achieve this goal, data on the sixteen indicators were gathered specific to Worcester County. Through expert interviews, resources that provided information regarding Worcester County were identified. These resources included the National Institute of Health (NIH), National Science Foundation (NSF), United States Bureau of Labor Statistics, Small Business Association (SBA), United States Census, and United States Patent and Trademark Office. These resources provided data such as number of employees, total wages, STEM degrees awarded, total funding, and patents issued in Worcester County. These data were analyzed and compared to Massachusetts to identify Worcester County's competitive advantage.

The strengths identified were state of the art facilities, prestigious institutions to produce a qualified workforce, competitive employment and salaries, overall federal funding, proximity to Boston and Cambridge, lower cost of renting and living, and low vacancy rate for lab space. The following are a few examples to elaborate on some of these strengths. There are three sophisticated biotech parks in the county. There has been an overall increase in STEM degrees awarded from 2006 to 2010. From 2009 to 2010, the number of patents issued has increased by 20.34%. More than 35% of these patents were in the life sciences. Compared to Massachusetts, Worcester County has seen an increase in total number of employees from 2009 to 2011. Proximity to Boston is essential for business and gives Worcester County the ability to complement the success of the eastern part of the state by providing opportunities for companies to start or expand and remain connected to the epicenter of the biotechnology world. Unique opportunities are also offered through institutions such as the University of Massachusetts (UMass) Medical School and the Tufts Cummings Veterinary School.

However, Worcester County still has weaknesses to overcome in order to further the growth of the industry. These weaknesses include attracting funds in the forms of Angel funding and Venture capital, acquiring federal grants such as SBIR/STTRs, slow business formation, and developing pharmaceuticals and medical devices for approval. Companies in the area find it difficult to receive Angel funding because there is only one Angel Funding group, The Boynton Angels, in Central Massachusetts and it is not fully developed due to their inability to attract a sufficient number of investors. Also, Venture capital is hard to acquire because there are no Venture capital companies located in Worcester County. The process for applying for federal grants is tedious and requires a level of expertise in grant writing that only a few companies in the county have consistently found success in.

After identifying the weaknesses of the county, recommendations were offered to potentially remediate the issues facing the region. Funding, both private and federal, is crucial for sustaining academic, non-profit and health-related research and the growth of private companies. Institutions and companies in Worcester County should work to develop a community initiative that will educate companies on how to successfully write grant applications to attract federal funds. It would be beneficial to the growth of the industry if the Boynton Angel group was further developed by attracting more investors in the county. Networking and developing relationships with Angel and Venture groups in the Boston area is crucial in securing funding. Also, in recent years, large drug companies have experienced a major challenge due to the drug pipelines beginning to dry up, resulting in cheaper, generic brands taking over. A new business model is emerging that involves the relationship between academia, health care providers, drug makers, and biotechnology makers (Rothwell, 2013). Worcester County must adapt this model by utilizing one of its strengths; the Albert Sherman Center. This facility will provide the unique opportunity to develop new treatments for disease, the new focus of large pharmaceutical companies.

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1.0 Introduction

Worcester County is one of fourteen counties in Massachusetts, located in the central part of the state. It is comprised of sixty cities and towns, and the city of Worcester is the second largest city in New England. In the mid-1900s Worcester County was primarily a manufacturing economy until outsourcing and innovation crippled the industry (Pearson, 2004). In an effort to revitalize the economy, a series of initiatives were put in place. The life science industry has been extremely successful in Massachusetts especially in the Boston area and these initiatives sought to complement the successes of the eastern part of the state. Over the past few decades the industry has shown tremendous growth from a few million dollars to hundreds of millions. However, there are still obstacles that Worcester County must overcome in order to remain successful in the future and continue on a path of growth, one of which includes attracting attention and investment west of Boston. In order to attract attention of startup and established companies to Worcester County, MBI developed an Interactive Qualifying Project (IQP) to determine the competitive advantage of Worcester County Life Science Economy.

MBI is a private, non-profit organization in Worcester, MA, that specializes promoting the growth of startup biomedical companies. MBI "lowers barriers to success for emerging companies by providing cost-effective, high quality laboratory space and support services" (MBI, 2012).

MBI hopes to identify the foundation of competitive advantage in the Worcester County life science industry. The best way to achieve this would be to analyze the past and current state of Worcester County compared to other regions that are leading areas in the life science industry. The data will be used to create a blueprint which will further the momentum for future economic growth in the life science industry.

First, sixteen quantitative indicators that are benchmarks for economic growth in the life science industry were identified. An analysis of Massachusetts and United States in terms of those specific indicators was conducted, and these results were compared to Worcester County. This is important because strong indicators suggest strong clusters. A cluster is a group of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field that compete but also cooperate (Porter, 1998). Clusters are advantageous to any region as they helps develop connections between institutions, which can be useful when trying to fill specific job positions, streamline research and development processes or share techniques (Porter, 1998). The second step was to determine the strengths and weaknesses of the Worcester County cluster. This will aid in preparing a plan to improve the weaknesses and highlight the strengths in Worcester County.

2.0 Background

The term competitive advantage "is the ability gained through attributes and resources to perform at a higher level than others in the same industry or market" (Porter, 1980). In order for Worcester County to attract more life science companies, its competitive advantage must be evident. In this chapter, the significance of life science, technological innovation in biomedical research and biotechnology, business incubators, startup companies and the challenges faced by them will be examined. Additionally, the importance of competitive advantage and clusters associated with it will be explained.

2.1 Life science

Life science is a general term encompassing biological sciences, biotechnology, biomedical sciences, biochemistry, medicine, and certain environmental sciences. Although it is mainly centered on biological studies, recent advances have expanded the concept of life science to become a more technological and interdisciplinary field of study. For example, biomedical engineering and biotechnology are now leading areas in terms of technological innovation, adding new dimensions to the life sciences field and incorporating the engineering sciences (Kahn et al., 2005). In addition to conducting basic research, scientists and engineers are being encouraged to invent and innovate as well. Life science is no longer simply an area of research; it has become an area of invention and business development as well. Although startup companies are growing in Massachusetts, they face many challenges in a highly competitive business environment.

2.2 Technological innovation in biomedical research and biotechnology

Technology and innovation are the driving forces behind today's global competition. The focus of global economics has shifted from manufacturing to information and technology, leading to new developments and innovation in many markets (Bartholomew, 1997). One such industry that has seen advances is life sciences because of the emergence and achievements biomedical research and of biotechnology. Biomedical research is a general term that comprises of the life and physical sciences, aiming at preventing and treating diseases (What is

Biomedical Research?, 2012). Biotechnology is defined as the manipulation of living organisms for the production of goods and services (Bartholomew, 1997). Humans have been participating in this manipulation all throughout history to manufacture food and nourishment through selective breeding and cross fertilization (Bartholomew, 1997). However, in the 1970's and 1980s, biotechnology had made significant advances that in turn attracted substantial interest and investment in the global market (Kenney, 1986). Martin Kenney of Yale University Press describes this advancement of knowledge as:

"A 'biotechnology revolution' [that] began when developments in molecular biology made it possible to precisely alter the genetic structure of living organisms. Critical new technologies such as genetic engineering (recombinant DNA) and cell fusion (hybridoma technology) have laid the foundation for 'the new biotechnology' (hereafter referred to simply as biotechnology) and a new era of industrial advance" (Kenney, 1986).

With this revolution comes a workforce that must develop and grow the industry. It would be simple to say that large firms would generate this growth, but this is not the case in the biotechnology and biomedical field.

Surprisingly enough, universities and startup companies have been the driving forces behind biotechnology rather than large firms. Biotechnology relies heavily on basic research conducted in research institutions by graduate students and university professors leading small startups (Bartholomew, 1997). Heavy research on topics such as genetics, tissue engineering, pharmaceuticals, etc. is critical for innovation to occur and an end product to be fashioned. Large firms have a large reliance on the research done by these smaller organizations to manufacture a successful product. However, startup companies and research institutions face many challenges in these early phases because of the high level of uncertainty with the research and possible social controversy that can result from their findings.

2.3 Startup Companies

Large biotech firms rely heavily on the success of startups because very little preliminary work is done within larger companies (Audretsch, 2000). Startup companies are those that are still in the research phase and have not yet created a product (Audretsch, 2000). They consist of graduates, professors, and scientists conducting research to ultimately develop a product for larger companies to sell commercially (Audretsch, 2000). The work of these startups fuels the pipelines of the large firms because their initial research and findings allow the large firms to create a product. Large companies rely on smaller startups because liability and risk are avoided by conducting the research outside the firm. Biotechnology can be very unpredictable and, "The product development process contains unpredictable biological and technical risks. These risks arise from a core technology based upon promising yet unproven science. Entrepreneurs must be prepared for an extraordinarily long product development timeframe"` (Shimasaki, C.D., 2009). This potential risk has formed a strategic alliance between the two entities and promoted biotechnology in a great way.

The economy of biotechnology consists of regional clusters located around established institutions with access to private and federal funding, small startup companies, and larger firms. The relationship between large and small companies is significant in understanding why startups are so important to the economy of a biotechnological cluster. Tasking startups with the research phase rather than leading it internally is advantageous because it enables the startups to focus on, "moving from basic research to commercialization through technological innovation" (Audretsch, 2000). In addition to a centralized focus on research, startup companies have less liability than large firms because they have limited assets and failure is somewhat common among startups (Audretsch, 2000). Research can take up to fifteen years or more for a startup company and they must overcome many obstacles on the way to create a product. The cooperation between firms, scientists, institutions, and universities is important in overcoming these obstacles and establishing a product.

2. 3.1 Challenges Facing Startups

Startup companies typically face many challenges in their first few years of operation, so identifying and overcoming these challenges is key in their successes. There many ways in which a company can fail, including poor management, deficient marketing plan, lack of funding, failure to adapt to changing business climates, societal issues, and a poor or otherwise unsuccessful end product (Durai et al., 2006). However, along with these internal factors there are external, more routine factors such as acquiring space, securing licenses and permits, and daily household tasks including accounting, infrastructure, and physical plant. Neglect or mismanagement of these factors can lead to the quick failure of a company quickly which lacks the appropriate funding and/or resilience to see itself through a crisis.

Startup companies in the life sciences face such challenges in particular because time consuming and capital-intensive research must be conducted in order to make progressive steps for them to become successful and independent companies. If funding is not available to support this research, then an end product will not be developed. They are susceptible to all of these factors mentioned above; therefore it is important to find effective ways of reducing risk. Life sciences research can typically take many years, so budgeting and constant funding is required to maintain progress in the research (Durai et al., 2006). However, there are paths that can be taken to relieve smaller companies that may not have the personnel and financial means to handle these tasks by referring them to a third party. This third party known as a business incubator offers startups valuable resources, giving the company a greater potential for success. For example, in the life sciences field, business incubators provide startups with lab space, equipment and provide services such as taking care of licenses and permits, and covering the expenses for office and R&D space (Kahn et al, 2005, pg.3). Business incubators play an important role in the development of startup companies leading to economic growth in general.

2.4 Business Incubators

It requires a vast amount of time and investment for an entrepreneurial company to succeed and continue growing. Startup costs are substantial and can often lead to the failure of the company. However, as noted above, an effective way for companies to reduce expensive startup costs is through partnership with a business incubator. Business incubators are organizations or programs that provide startup companies with the resources and support needed to ensure success. These resources may include leasable lab space, providing equipment, and fostering collaborative opportunities with other startups. Business incubators take on the mundane tasks of paying bills, acquiring licenses and permits, and janitorial services, which allows the small company to focus on their research and the end product.

Reports have shown that this method works for small companies. According to *Business Incubation Works*, “National Business Incubation Association (NBIA) member incubators have reported that 87 percent of all firms that have graduated from their incubators are still in business” (Business Incubation Works, 2012). This is significant considering the generally high failure rate of startup. MBI has been prominent in the Worcester area for a number of years and has had many successes, focusing its attention on the life sciences sector in Central Massachusetts.

2. 4.1 Massachusetts Biomedical Initiatives Overview

MBI is a non-profit, “private, independent economic development organization dedicated to job creation and innovative healthcare throughout Massachusetts by promoting the growth of startup biomedical companies” (MBI, 2013). Since its inception, MBI developed its long term strategic business plan. This is a dynamic plan that allows MBI to make adjustments every three to five years, adapting to the needs of the current economy and predicted growth of industries.

The first objective of MBI, as stated in their Strategic Plan, is to “identify and attract entrepreneurial scientists and emerging companies, keeping existing criteria for incubation” by targeting “academic/science/ commercial institutions to identify scientists doing research” (MBI Strategic Plan Update, 2011). MBI meets this objective by setting up locations for startups in Worcester, an area densely populated by academic institutions and commercial entities and with personnel trained in the biomedical sciences and biomedical engineering. In addition to locating their facilities in close proximity to prestigious institutions, MBI seeks to recruit biomedical companies from other parts of the country and world, in hopes of attracting them to the area, as well as marketing MBI’s information through the web. This strategic approach to marketing and recruiting has led to MBI’s long term success.

MBI’s success correlates directly with the success of its tenants; to whom lab space is leased. Given this correlation, another significant objective of MBI is to provide mentor services to the tenants. The mentoring advice includes:

1. *“Emphasizing opportunities for developing new resources.”*

2. *"Offering advice to entrepreneurs as to how to develop sound business & scientific plans."*
3. *"Offering assistance in identification and recruitment of technical staff"* (MBI Strategic Plan Update, 2011).

These strategies lead not only to the operation of a successful incubator organization, but to the creation of strong new companies stemming from the MBI startup program.

2.5 What is a Cluster?

Simply stating a cluster is "bio-tech" or "manufacturing" is far too broad of a definition. This removes the idea that the term clusters create "crucial interconnections with other industries and institutions that strongly affect competitiveness" (Porter, 2000). Clusters, as defined by Porter, "are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (Porter, 2000). Porter defines the geographic scope of a cluster as relating "to the distance over which informational, transactional, incentive, and other efficiencies occur" (Porter, 2000). Clusters branch off downstream to channels and customers in addition to lateral shifting to incorporate manufacturers of complementary products and to companies in industries related by skills and technologies (Porter, 1999). Clusters combine "linked" industries in order to fuel competition, and can include suppliers of specialized inputs such as components, machinery, and services as well as providers of specialized infrastructure (Porter, 2000). Such "specialized infrastructure" encompasses universities, research labs and many other facilities. Yasuyuki Motoyama of University of California at Irvine further synthesizes part of Porter's definition of what a cluster is into four points (Motoyama, 2008):

1. Firms of a similar industry, its strategy and rivalry
2. Supply conditions (such as suppliers and extending to legal, technological, and consulting services)
3. Demand conditions (such as core customers)

4. Related and supporting industries.

Secondly, Motoyama cites how Porter believes that the "interconnectedness through collaboration and competition among these cluster elements is the source for growth, innovation, and competitiveness (Motoyama, 2008). An example of this "interconnectedness" can be found when Motoyama references the work of Chinitz from the early 60s and his explanation of the "growth of the New York region by uncovering the role of immediate goods and services, such as legal, accounting, and duplicating services as well as the competition between small enterprises, which promoted entrepreneurship." The interconnectedness amongst the small enterprises, drove competition between the intermediate goods and service companies. These companies and small industries complement each other; compete against each other, while also sharing resources such as a specialized labor force, equipment, or technology.

2.5.1 Advantages and Disadvantages of Clusters

Clusters can generate "increasing returns that can take the form of lower unit operating costs due to the concentration of specialized suppliers or the existence of pipeline economies" (Hill et al., 2000). These specialized suppliers refer to the specialized pools of labor that are present in cluster economies. The specialized pools of labor that come from universities, training programs and a skilled work force is essential for cluster development and growth. The term "pipeline economies" refer to "lower costs generated by the large flow of specialized shipments of inputs into the region or products out of the region" (Hill et al., 2000). The fact that such a high volume of shipments flow in and out of a cluster region, leads to reduced costs; similar to the concept of buying in bulk.

2.5.2 Cluster Innovation

Alternatively, returns can be generated by higher unit earnings due to product innovations or innovations in production processes that are generated by the intense local competition or the density of suppliers and customers. This intense local competition provides for "arguably the most important source of cluster economies, generated by the forces of competition in product innovation; quality enhancement; the adoption of process innovations;

and the encouragement of entrepreneurship to take advantage of perceived market, supply, or distribution gaps within the cluster" (Hill et al., 2000). This entrepreneurship stems from people working for major firms, who may recognize a need for a certain product in the industry, or recognize some "unfilled market niche" and break off and begin their own company addressing these issues. Reasons for doing so may include a more established company may not to directly associate with a new, unproven idea, and would prefer to fund a smaller startup to do the work (Hill et al., 2000). It is easier for these startups, who spin off from larger firms in the same cluster, to find "financing than it is for competitors located elsewhere because local investors and lenders will have a better understanding of the risks and opportunities to which entrepreneurs are responding" (Hill et al., 2000).

2.5.3 Worcester County Cluster

Middlesex and Suffolk County, Massachusetts are recognized as a leading innovative cluster in the life sciences industry, specifically in biotechnology and biomedical research. The success of this cluster is due largely to the outstanding reputation and achievements of institutions in the region such as Harvard and MIT as well as the surplus of hospitals and medical facilities in the area. However, as these Counties become more and more occupied, opportunities are beginning and have begun to arise in the Central and Western part of the state. In 2001, construction on two new biotech facilities began in Springfield and at the University of Massachusetts at Amherst (Peacock, 2001). Central and Western Massachusetts also have very established institutions of learning which makes them an attractive market (Peacock, 2001).

With the opening of these new facilities, established schools like WPI and UMass Memorial Medical Center, and an increased interest in expanding west, Worcester County can become a very successful cluster. Biotechnology and life sciences has great potential in Worcester County because it is very geographically concentrated around the best scientific talent which is located in Boston, California, Worcester, New Jersey, etc. (Audretsch, 2000). Also, Worcester County is an attractive market because a manufacturing cluster was once prevalent in the area and new businesses are more easily formed in existing clusters rather than isolated locations (Porter, 2000). Location relative to Boston is very important as well since Worcester County is located relatively close. These factors have made it possible to start this cluster in Central Massachusetts, but to further enhance the cluster, drivers of productivity must be identified.

2.6 Competitive Advantage

According to Edward W. Hill and John F. Brennan of Cleveland State University, "competitive advantage is revealed through the lens of a region's complement of industries and the competitive position of those industries in the national marketplace" (Hill et al., 2000). This competitiveness is the "productivity with which a state utilizes its human, capital and natural endowments to create value" (Porter, 2012). To further validate this claim that productivity is crucial for a competitive advantage Hill and Brennan present that "the most telling indicator of competitive advantage is the productivity of each worker in an industry…a direct measure would be value added per hour worked." Other factors that Hill and Brennan used to examine competitiveness include the regional industry's change in national employment share, relative earnings, local average earnings to national average earnings, and change in relative earnings. Three other variables that can be used in determining competitive advantage are exports, centrality, and employment specialization. Centrality refers to buying and purchasing relationships, and change in local employment share (Hill et al., 2000).

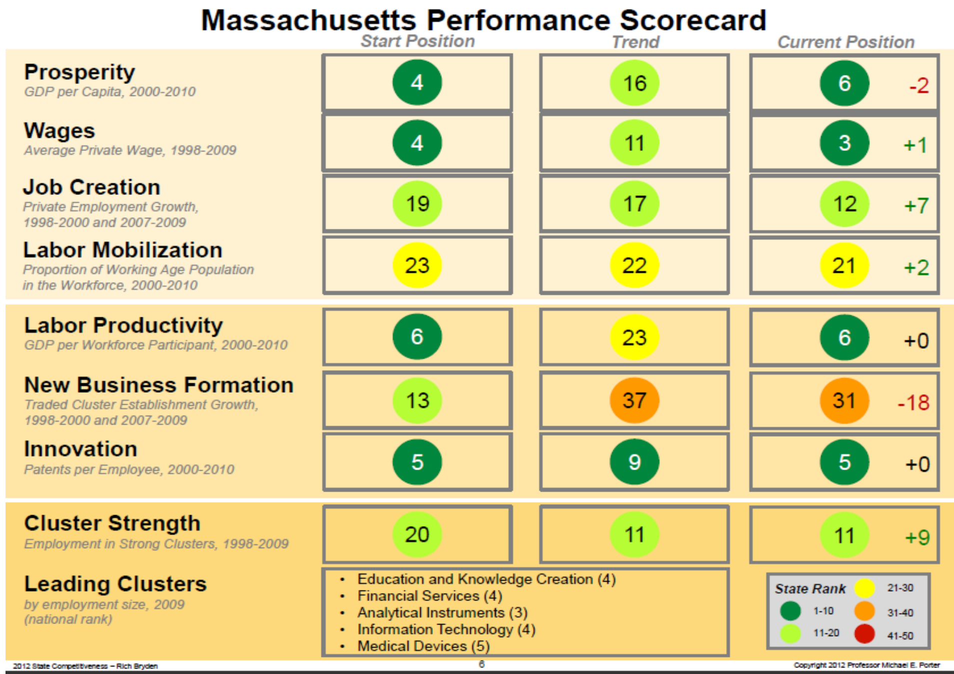
Porter (2012) argues that strong clusters drive regional performance. The specialization in strong clusters, the breadth of industries within each cluster, strength in related clusters, and presence of a region's clusters in neighboring regions collectively lead to job growth, higher wages, higher patenting rates, and greater new business formation, growth, and survival.

2.7 Evaluating a State's economy

The first step in improving key drivers of a state's economy is to evaluate its current position with a state performance scorecard (Porter, 2012). This will help explain the state's performance, strengths, and weaknesses in certain areas and indicators. Also, since this scorecard can be conducted for every state, it is much easier to compare states in a particular area or on an indicator. Figure 1 below shows the performance scorecard for Massachusetts. It shows that Massachusetts leading clusters are Education and Knowledge Creation, Financial

Services, Analytical Instruments, Information Technology, and Medical Devices. On the other hand, one of Massachusetts' weakest cluster or indicator is New Business Formation.

Figure 1: Massachusetts Performance Scorecard



(Porter, 2012)

To understand the State Performance Scorecard fully, a little background on the indicators is necessary.

2.8 Indicators

In the words of the *Index of the Massachusetts Innovation Economy* (MIE), indicators are, "quantitative measures that allow performance comparisons with other leading regional innovation economies" (Massachusetts Technology Collaborative, 2011). These indicators help examine the long-term changes and trends in regional economic fundamentals, such as manufacturing productivity, as well as variables that are subject to short-term fluctuations, such as venture capital funding. Both of those categories are critical to analyze. In this project, the team will be focusing on certain indicators that are essential to cluster building and strengthening.

The *Index of the Massachusetts Innovation Economy* (MIE), which was first released 15 years ago, examines and provides benchmarks of the state of Massachusetts' innovation ecosystem. It also signals the importance of innovation in our economy and therefore triggers attention, conversations, and media references. At the core of the Index are quantitative assessments in the form of 25 indicators. The index can document the commanding position of the Massachusetts Innovation Economy nationally and worldwide. It also presents a comprehensive view of the performance of the Commonwealth's innovation ecosystem and its impact on the state's economic prosperity through these 25 quantitative indicators. However, the focus of this paper will be on a few quantitative indicators. Those indicators are listed in Table 1 below.

These specific indicators were chosen precisely to better understand the importance of innovation in our economy and it also serves a purpose in informing evidence-based decision-making in industry, academia and government. Each of the previously mentioned indicators plays a key role in determining the strength of a particular cluster and, in the sense of the bigger picture, analyzing the growth of the life science industry in Massachusetts. To better understand and organize these indicators, they are placed in six categories, Economic Impact, Research, Technology Development, Business Development, Capital, and Talent. Table 1 shows which indicator corresponds with which category.

Table 1: Indicator Categories

Economic Impact	Research	Technology Development	Business Development	Capital	Talent
Occupations and Wages	Research and Development	Approvals of pharmaceuticals and medical devices	Business Formation	Federal Funding	Workforce Education Level
Employment Growth	Patenting	Technology Licensing	Mergers and Initial Public Offerings	Private Funding	Science Degrees Awarded
		Small Business Innovation Research & Small Business Technology Transfer	Biomanufacturing	Capital and Human Resources	
				Lab Inventory	

Economic Impact consists of two indicators: lab inventory & employment growth and occupations & wages. Employment growth and increased lab inventory can indicate competitive advantages for the MIE and potential for future economic growth. Also, employment concentrations that is higher than the national average indicates skill strengths that are unique to Massachusetts. Occupations & wages is an important indicator because shifts in this indicator could suggest shifts in job content and skill utilization. (Massachusetts Technology Collaborative, 2011)

Research also consists of two indicators: research & development (R&D) performed and patenting. “R&D performed in Massachusetts is an indicator of the size of the science and technology enterprise,” (Massachusetts Technology Collaborative, 2011). It also provides a sense of the region’s capacity for knowledge creation. Patenting is also a crucial indicator because, “high levels of patenting activity indicate an active R&D enterprise combined with the capacity to codify and translate research into unique technology with commercial potential” (Massachusetts Technology Collaborative, 2011).

Three indicators fall under the category of technology development: approvals of pharmaceuticals and medical devices, Small Business Innovation Research (SBIR) grants, and technology licensing. Approval of pharmaceuticals and medical devices is a very important indicator in Massachusetts, and in fact in the whole country, because America is one of the leading countries in manufacturing medical devices (Shah et al., 2008). These approvals indicate important relationships with research hospitals where many of such devices have to go through clinical investigations and trial. SBIR grants enables small companies to conduct proof-of-concept research on technical merit and idea feasibility and prototype development building on previous findings. Technology licensing promotes and reinforces incentives at universities, hospitals, and non-profit research institutes. This is because technology licenses “provide a vehicle for the transfer of codified knowledge in the form of intellectual property (IP),” (Massachusetts Technology Collaborative, 2011).

Business Development has two indicators: business formation and mergers/initial public offerings (IPO’s). Business formation is a useful indicator for the overall volume of job creation and cluster growth. Mergers/IPO’s indicates which important business strategies can help startup companies access capital, expand operations, and support business growth. (Massachusetts Technology Collaborative, 2011)

There are two indicators in the Capital category: federal funding for academic, non-profit, commercial and health R&D, and venture capital. Federal funding is essential for sustaining academic, non-profit, and health-related research and this research is critical for Massachusetts to advance in basic science and creating technologies so it is no surprise that this indicator is very important (National Science Board, 2012). Venture capital is, “an important source of funds for the creation and development of innovative new companies,” (Massachusetts Technology Collaborative, 2011)

Talent consists of two indicators: workforce education levels and science degrees awarded. Massachusetts' capacity to generate and support innovation-driven economic growth is dependent on a well-educated workforce (Porter, 1995). Science degrees awarded are very important because the demand for professionals in the science field is particularly high in Massachusetts (National Science Board, 2012).

2.9 Summary

By understanding key terms related to the life science and also business field, we gain the ability to evaluate Worcester County Life Science Economy. Life Science encompasses the fields of biological sciences, biotechnology, biomedical sciences, biochemistry, medicine, and certain environmental sciences. Biomedical research is an already emerging industry which continues to grow and has been a key portion of the Worcester County economy. Many companies began as small startups, which grow within business incubators and some progress into self-sustaining companies. These companies form interconnections with other industries and institutions which form clusters that affect competitiveness of a region. There are many approaches to evaluate a region’s competitiveness. Quantitative economic indicators are benchmarks to measure growth in the life science industry.

3.0 Methodology

In order to determine the competitive advantage of the Worcester County life science economy, four objectives were addressed: determining factors that drive growth in a life science industry, documenting the recent state of the life science industry in the United States and Massachusetts, and documenting the growth of the life science industry in Worcester County and making recommendations to remediate the weaknesses. Various methods that include data collection, expert interviews and secondary data analysis were conducted to achieve the objectives.

3.1 Determining factors that drive the growth in a life science industry

Two documents were used as guidelines in order to assess what factors best illustrate the growth of a life science industry. Those documents are:

1. 2011 and 2012 Index of the Massachusetts Innovation Economy, published by Massachusetts Technology Collaborative
2. 2012 Biopharma Industry Snapshot, published by Massachusetts Biotechnology Council

These documents provided the indicators (see Table 1) that corresponded with the factors that drive growth in life science industry. This IQP followed the organizational format of the Index of the Massachusetts Innovation Economy due to its clarity and effectiveness.

Background research was conducted on the determined indicators to understand their significance in the life science industry.

The indicators provided a platform through which Massachusetts economy can be compared to other states and countries, including the United States.

3.2 Documenting the state of the life sciences industry in the United States and Massachusetts

The team used expert interviews as the primary method of obtaining resources that provided raw data on the previously stated indicators. Interview protocols that catered to each interviewee's expertise were designed to facilitate the dialogue. Kevin O'Sullivan, the CEO of MBI, was the team's main adviser in selecting these experts and contacting them to arrange interviews. Candidates for interviews included the developers of the 2012 Index of the Massachusetts Innovation Economy, officials from the Massachusetts Biotechnology Council, local Worcester County life science business experts, and WPI business professors. A final list of the interviewees was determined with Mr. O'Sullivan's assistance. In the interviews, the candidates were provided the list of the quantitative indicators and were asked to provide insight into which of these indicators they felt were strong and weak in Massachusetts and United States. The interviewees were also asked to utilize their years of research experience to provide reliable resources specific to the indicators. Some of these resources included National Institute of Health (NIH), United States Patent and Trademark Office, National Science Foundation (NSF), United States Bureau of Labor Statistics, Small Business Association (SBA) and United States Census.

3.3 Documenting the growth of the life science industry in Worcester County

The resources that the interviewees provided, mentioned above, were also utilized to gather raw data on Worcester County. The interviewees were also asked to discuss what they felt were Worcester County's strengths and weaknesses in terms of the quantitative indicators.

3.4 Making recommendations to remediate the weaknesses

After the weaknesses were identified, recommendations for remediation were offered to MBI. With these recommendations, MBI can advise companies to take steps necessary to be competitive and further their growth. Recommendations were formulated through the thorough analysis of the basic background research and the raw data collected. Feedback from experts also helped determine the recommendations.

3.5 Summary

The team relied on information provided through the interviews to guide secondary data collection and analysis. These analyses generated conclusions about the Central Massachusetts life sciences cluster, and subsequent recommendations.

4.0 Results

This section organizes each indicator into the aforementioned categories, Economic Impact, Research, Technology Development, Business Development, Capital, and Talent. Each indicator section starts off with a basic background. A thorough analysis was conducted on each indicator's significance and the raw data that was collected for Massachusetts and Worcester County was organized and examined to determine if the indicator in question is a strength or weakness. One major setback was, for some indicators, the data on Worcester County was not readily available.

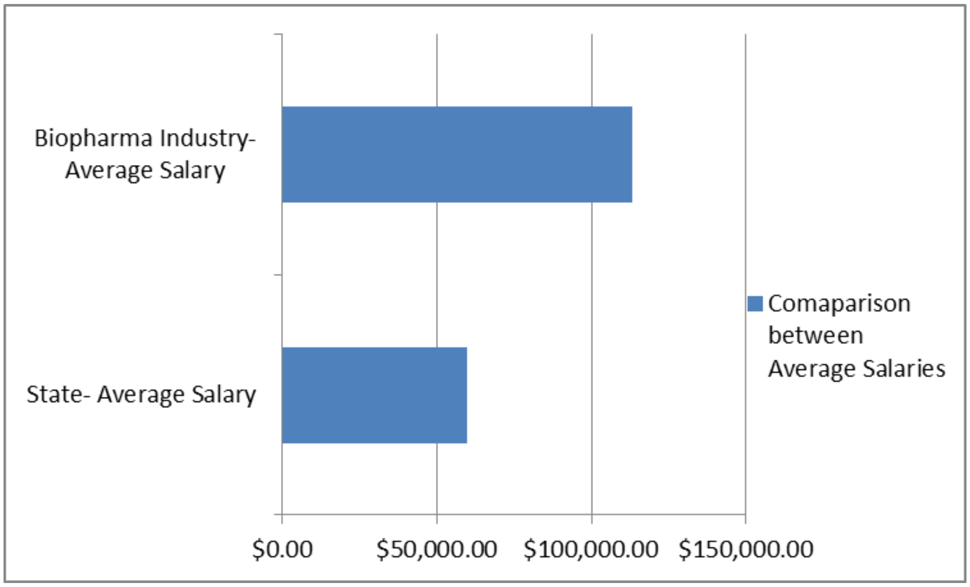
4.1 Economic Impact

4.1.1 Occupations and Wages

The Massachusetts economy contributes to a higher standard of living throughout the Commonwealth because it supports middle and high wage jobs (Abair, 2012). Employment concentrations that are higher than the national average indicate skill strengths particular to Massachusetts, its competitive advantage (Abair, 2012). Changes in occupational employment and wages suggest shifts in job content and skill utilization, as well as in the overall skill mix of the workforce across all industries, including Life Science (Abair, 2012).

The estimated average salary in the biopharma industry is 90% higher than the estimated state average salary of $59, 676 (see Figure 2). More specifically in the Life Science industry, Massachusetts has seen a 42% growth in employment from 2002 to 2011 (Abair, 2012).

Figure 2: Comparison between estimated State Average Salary and Biopharma Industry Average Salary



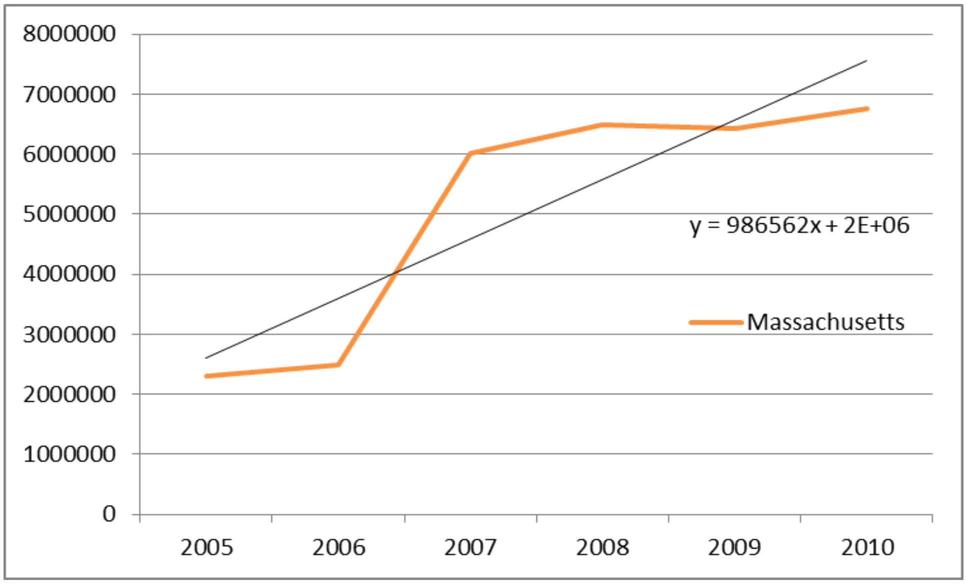
Just as with employment growth, NAICS codes were used in the Bureau of Labor Statistics' Quarterly Census of Employment and Wages Location Quotient Calculator to calculate total wages in life sciences in both Worcester County and Massachusetts (Refer to Table #2 for full list of NAICS codes and the percentage of those codes that could be used in estimating overall life science employment).

Figure 3 below shows the graphical representation of the raw data (which can be found in the Appendix C) of total wages in life sciences in Worcester County from 2005 to 2010. Surprisingly, the total wages in life sciences increased during the recession of 2007 and continued to rise until 2008. It decreased slightly from 2008 to 2009, but is back on the rise and can be predicted to stay on the positive trend for the next five years.

Figure 3: Total Wages in Life Sciences in Worcester County (2005-2010)

Shown below in Figure 4 is the graphical representation of the raw data (which can be found in the Appendix C) of total wages in Massachusetts between 2005 and 2010. When compared side by side, it is clear to see that Massachusetts follows the same trend line as Worcester County, rising from 2006-2008 with a slight depression from 2008-2009 and then a slight rise. However, as the linear trend line below shows, Massachusetts, just as Worcester County, has experienced a steady positive trend. It can be projected that the total wages will rise and continue rising for the next five years.

Figure 4: Total Wages in Life Sciences in Massachusetts (2005-2010)



4.1.2 Employment Growth

Contrary to belief, annual net job gain is not positive at existing companies even though they constantly create – and destroy – jobs. A relatively new dataset from the U.S. government called, Business Dynamics Statistics (BDS) confirms that the net job growth occurs in the U.S. economy only through startup companies. In terms of numbers, the dataset reveals that, both on average and for all but seven years between 1977 and 2005, existing firms are net job destroyers, losing one million jobs net combined per year. On the other hand, new firms add an average of 3 million jobs in their first year. A study done by the Kauffman Foundation analyzed these numbers from the BDS. This study called, Importance of Startups in Job Creation and Job Destruction also revealed that job growth patterns at both startups and existing firms are pro-cyclical, although existing firms have much more cyclical variance. Pro-cyclical is any economic quantity that is positively correlated with the overall state of the economy. On the other hand, cyclical variance AKA counter cyclical is any economic quantity that is negatively correlated with the overall state of the economy (Kane, 2010).

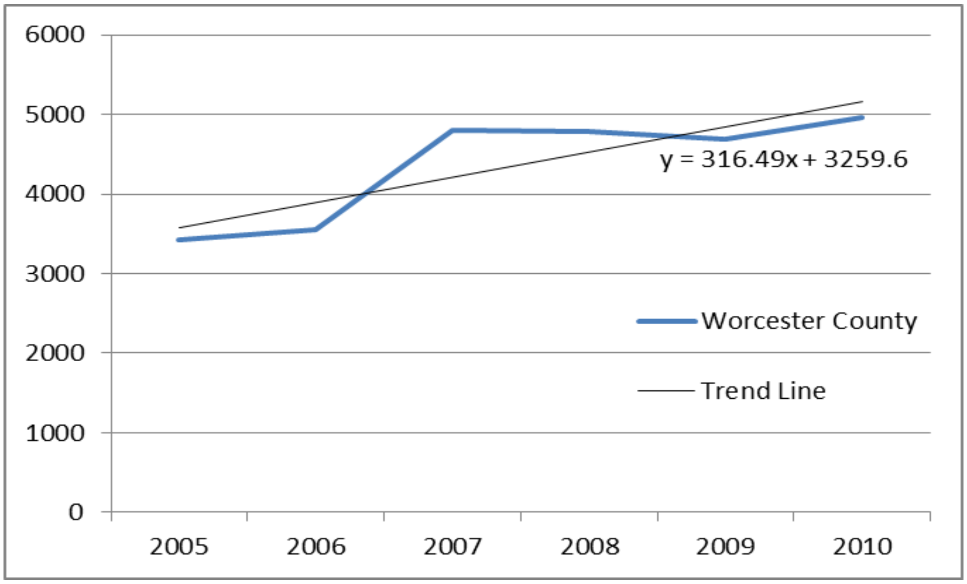
With that in mind, data on the number of employees in both Worcester County and in Massachusetts was collected and analyzed using the Bureau of Labor Statistics' Quarterly Census of Employment and Wages Location Quotient Calculator. The search was limited to several specific North American Industry Classification System (NAICS) codes which are considered to fall into the category of “Life Sciences” as outlined by Peter Abair, Director of Economic Development and Global Affairs for MassBio. However, only in certain cases can the industry claim 100% of any one NAICS code. Therefore, MassBio has determined that a percentage of some industry classifications could be used in estimating overall industry employment. Those NAICS codes and the percentage of those codes that could be used in estimating overall life science employment are shown below in Table 2.

Table #2: NAICS Codes with Life Science Employment Percentages

NAICS Code	NAICS Name	Percentage
334510	Electro-medical Apparatus	100%
334517	Irradiation Apparatus	100%
339112	Surgical and Medical Instruments	100%
339113	Surgical Appliances and Supplies	100%
339114	Dental Equipment and Supplies	100%
3254	Pharmaceutical MFG, including biologics	100%
541711	Research and Development in Biotechnology	100%
541712	R&D in Physical, Engineering, and Life Sciences	22%
334516	Analytical Laboratory Instrument MFG	30%
54138	Testing Laboratories	30%
622	Hospitals	4.5%
61131	Universities	1.9%

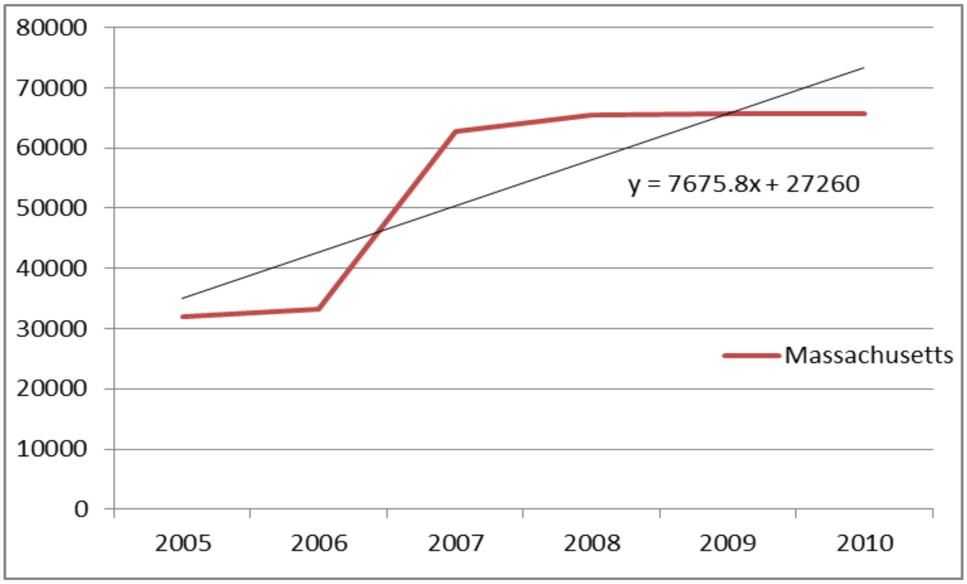
Each of those codes was looked at for Worcester County and Massachusetts between the years 2005-2010 (Refer to Appendix D). The numbers for each code were added to create one general, “Life Sciences” category for each year. Shown below in Figure 5 is the graphical representation of the total number of employees in Worcester County between 2005 and 2010. The steady increase that had started at 2006 abruptly ceased due to the recession and slowly decreased until 2009. From then on, Worcester County Employment numbers has seen a steady growth. As the linear trend line below shows, Worcester County has experienced a steady positive trend. It can be projected that this positive trend will continue for the next five years.

Figure 5: Total # of Employees in Worcester County (2005-2010)



Shown below in Figure 6 is the graphical representation of the total number of employees in Massachusetts between 2005 and 2010. When compared side by side, it is clear to see that Massachusetts follows the same trend line as Worcester County; a steady increase that started at 2006 and slowed down due to the recession of 2007. The difference from Worcester County is that Massachusetts continued at a slow increase till 2008 and from then on its employment numbers has seen a steady decrease. However, as the linear trend line below shows, Massachusetts, just as Worcester County, has experienced a steady positive trend. It can be projected that the employment growth will rise and continue rising for the next five years.

Figure 6: Total # of Employees in Massachusetts (2005-2010)



4.2 Research

4.2.1 Research and Development

Research and development is the process of taking an idea from its preliminary phases and developing products or applications that will hopefully benefit the human population (Definitions of Research and Development: An Annotated Compilation of Official Sources, 2012). Understanding where research and development is being performed and the investment in this area is important in understanding the strength of a life science cluster. If research and development is not being performed in a life science cluster, then it will have very little success. Research and development leads to receiving patents, technology licensing, and eventually revenues and is an indicator for the size of the science and technology sector of the region.

According to the 2012 Biopharma Industry Snapshot, a study done by Massachusetts Biotechnology Council, Massachusetts is a leader in research and development with the highest biotechnology research and development employment between 2007 and 2011 (Abair, 2012). Table 3 shows the biotechnology research and development employment growth from 2007 until 2011. Massachusetts clearly shows an advantage in this area leading all states in employment even the state of California which is a much larger state than Massachusetts in terms of population, size and economy overall.

Table 3: Biotechnology Research and Development Employment

	2007	2011
CA	19,134	22,592
MD	10,154	8,933
MA	24,656	28,177
MO	4,262	3,659
NJ	8,567	9,338
NY	2,679	3,677
NC	7,042	6,785
OH	2,696	3,098
PA	16,902	11,234
TX	4,229	4,299
WA	2,499	3,832

Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW)

Table 4, shown below, gives a breakdown of research and development performance in the U.S. by ranking states in 2008. Massachusetts is ranked fourth in the U.S. in this category which is mainly attributed to renowned universities and high technology industries in the state (Research and Development: National Trends and International Comparisons, 2012). Massachusetts also ranks fourth in research and development intensity which is calculated as a ratio of research and development to Gross Domestic Product (GDP). This is an important statistic to measure because it represents a state's investment in research and development. For example, California ranks first in Research and Development expenditures, but ranks ninth in research and development intensity. Likewise, New Mexico does not rank in the top ten for research and development, but is first in terms of intensity. From these two sets of data below, it is apparent that Massachusetts invests a substantial amount of money into research and development.

Table 4: Breakdown of research and development performance in the U.S. by ranking states in 2008

Location of R&D Performance by State—continued

Table 4-A

Top 10 U.S. states in R&D performance, by sector and intensity: 2008

	All R&D[a]		Sector ranking			R&D intensity (R&D/GDP ratio)		
Rank	State	Amount (current $millions)	Business	U&C	Federal intramural and FFRDC[b]	State	R&D/GDP (%)	GDP (current $billions)
1	California	81,323	California	California	Maryland	New Mexico	7.58	78.0
2	New Jersey	20,713	New Jersey	New York	California	District of Columbia	6.15	96.8
3	Texas	20,316	Texas	Texas	New Mexico	Maryland	5.92	280.5
4	Massachusetts	20,090	Massachusetts	Maryland	District of Columbia	Massachusetts	5.53	363.1
5	Washington	16,696	Washington	Pennsylvania	Virginia	Connecticut	5.10	222.2
6	Maryland	16,605	Michigan	Massachusetts	Massachusetts	Washington	4.96	336.3
7	New York	16,486	New York	North Carolina	Tennessee	New Jersey	4.28	484.3
8	Michigan	15,507	Connecticut	Illinois	Washington	New Hampshire	4.24	58.8
9	Pennsylvania	13,068	Pennsylvania	Ohio	Illinois	California	4.22	1,925.5
10	Illinois	11,961	Illinois	Michigan	Alabama	Michigan	4.12	376.2

FFRDC = federally funded research and development center; GDP = gross domestic product; U&C = universities and colleges

[a]Includes in-state total R&D performance of business sector, universities and colleges, federal agencies, FFRDCs, and federally financed nonprofit R&D.
[b]Includes costs associated with administration of intramural and extramural programs by federal personnel and actual intramural R&D performance.

NOTES: Small differences in parameters for state rankings may not be significant. Rankings do not account for the margin of error of the estimates from sample surveys.

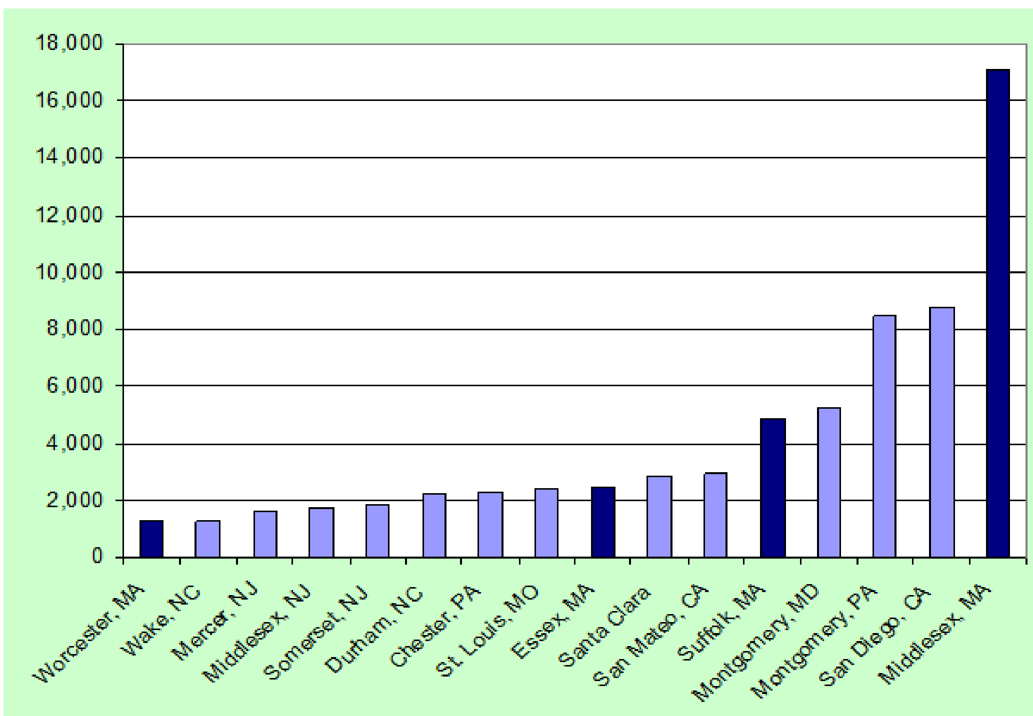
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series). State GDP data are from the U.S. Bureau of Economic Analysis. See appendix tables 4-11 and 4-12.

Science and Engineering Indicators 2012

(Research and Development: National Trends and International Comparisons, 2012)

It was important to understand the contribution Worcester County had to research and development in Massachusetts. Figure 7 presents the top sixteen counties in the country in biotechnology research and development employment. Worcester County was number sixteen in employment with 1,248 bitoechnology research and development employees. Middlesex, MA, which includes Cambridge, led all counties with 17, 090 employees. Another interesting statistic to note was that four Massachusetts counties ranked in the top sixteen in the country for research and development employment. Although Worcester county has a minor contribution to this statistic compared to other Massachusetts counties, there has still been success in the region in comparison to other counties in the country. Worcester County continues to develop its life science industry and this statistic showed that it has begun to compete with other life science clusters already.

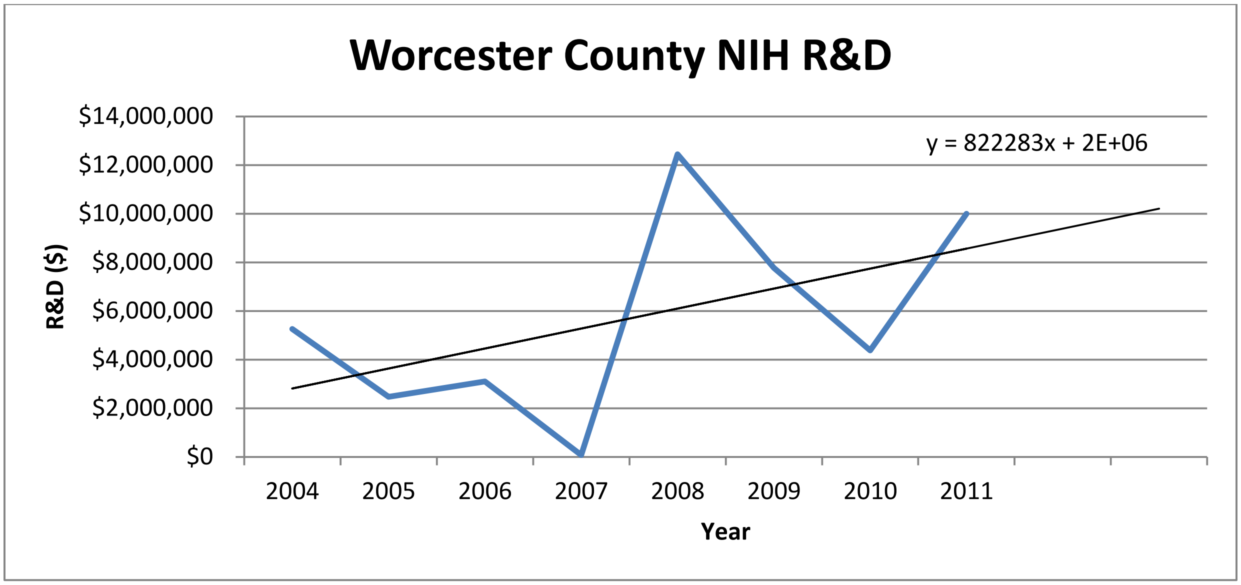
Figure 7: Top sixteen counties in the U.S. in biotechnology R&D employment



Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW) Exact employment numbers can be found in Appendix D.

Unfortunately, county data on research and development expenditrues are not readily available or documented for Massachusetts . Only the National Institute of Health provided data on research and development contracts and was able to be broken down by company or university. Although useful, this data was only responsible for a small portion of the available research and development in Massachusetts or in Worcester County. There was also funding from the National Science Foundation and Department of Defense that was not available. Although not all of the data are available, it can still be useful to follow the trends of the funding that were found and where it is being allocated to. Figure 8 shows the trends of NIH funding in Worcester County for research and development.

Figure 8: NIH funding in Worcester County for R&D



From 2004 until 2011, an upward trend is clear despite a substantial drop in funding in 2007. However, closer inspection at the data showed that most if not all of the research and development funding was distributed to the UMass Medical School and Seracare Life Sciences Inc. Also, Biomedical Research Models Inc. was also able to receive funding in 2006 and 2008 which is important to note because they have been successful in acquiring SBIR/STTR funds as well. Exact amounts for each company found on the NIH database can be found in Appendix D. Since the data presented only accounts for a portion of available research and development funds, it would be inaccurate to draw conclusions from this data. However, it was beneficial to discover to what companies and institutions these funds were being allocated to because the methods that they are using to successfully acquire funding can be studied and implemented in other parts of the county. Comparing this data to Massachusetts was not necessary because of the lack of information available at the county level.

4.2.2 Patents

The United States Government grants inventors their intellectual property right through patents "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States" (Patents, 2012). The patent is approved for a limited time in exchange that the invention is released publicly.

There is certain usefulness of patents. Through patents, an inventor can compare his/her own inventions to existing inventions, conduct competitive market analysis, track innovations and understand product design features and specifications (The New Inventors, 2011).

Three types of patents which are granted are utility patents, design patents and plant patents:

> "Utility patents may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof. Design patents may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture. Plant patents may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant"
>
> (The United States Patent and Trademark Office, 2012).

Life science patents not only gives the public knowledge about a new product, but also addresses questions about the impact of the patents on several ethical and technical issues such as access to medicines and transfer of environmentally friendly technology.

The characteristics that are significant to life science policymakers, "who are concerned not only with the substance of emerging technologies, but also with who holds exclusive rights over technologies, where and for how long" are revealed through the patent system (Taubman, 2008):

- "Legal information, including published details of what material is patented, with what legal scope, in what countries, in whose name, and when it passes into the public domain

- Technological information, such as a patent's so-called 'teaching' or technical disclosure, which is required to give a skilled reader all the information needed to put the new technology into practical effect" (Taubman, 2008)

Table 4 below shows the total number of patents issued in United States, Massachusetts and Worcester County from the year 2006 to 2010.

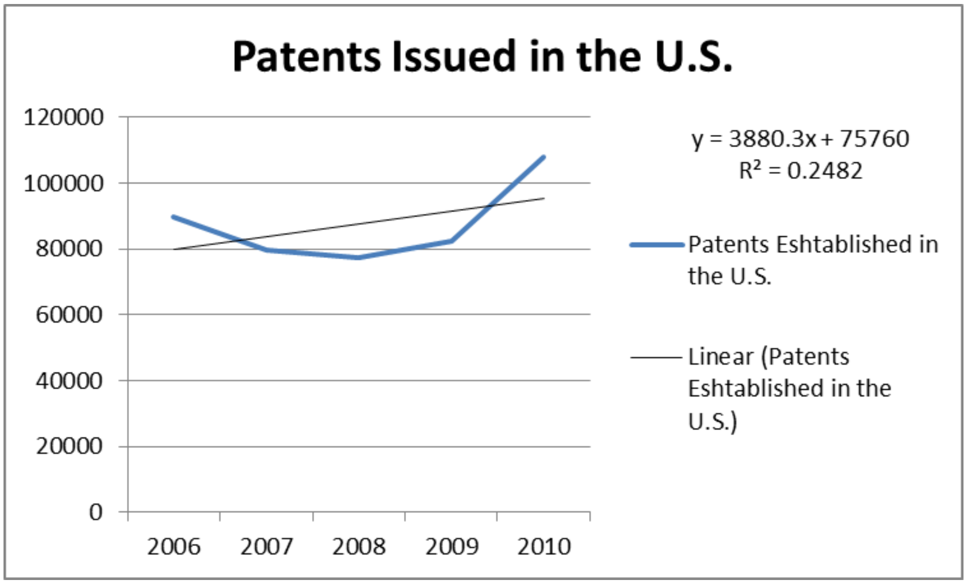
Table 4: Total Number of Patents Issued in the United States, Massachusetts and Worcester County

FIPS Code	Mail Code	State Or Territory	Regional Area Component	2006	2007	2008	2009	2010	Total
All	All	All U.S. States/Regions	All Area Components	89814	79522	77500	82379	107787	437002
		Massachusetts	All County In Massachusetts	4012	3508	3519	3697	4924	19656
25027	MA	Massachusetts	Worcester County	394	362	372	413	497	2037

(U.S. Patent and Trademark Office, 2011)

The percentage of total number of patents granted in the U.S. decreased by 11.46% from the year 2006 to 2007. From 2007 to 2008, the decrease in the number of patents granted in the U.S. was 2.54%. However, from 2008 to 2010 the total number of patents granted increased: 6.3% between the year 2008 and 2009 and 30.84% between the year 2009 and 2010. The reason for the rise is that from 2008 the economy of the U.S. was slowly recovering from the recession it experienced the year before. From 2008 to 2009, the recovery was slow, but the recovery was much faster from 2009 to 2010. During the recovery, companies and institutions had been getting more funds and employees to work on patents and thus a higher percentage of patent applications were successful during those years. Figure 9 below shows the total number of patents issued in the United States.

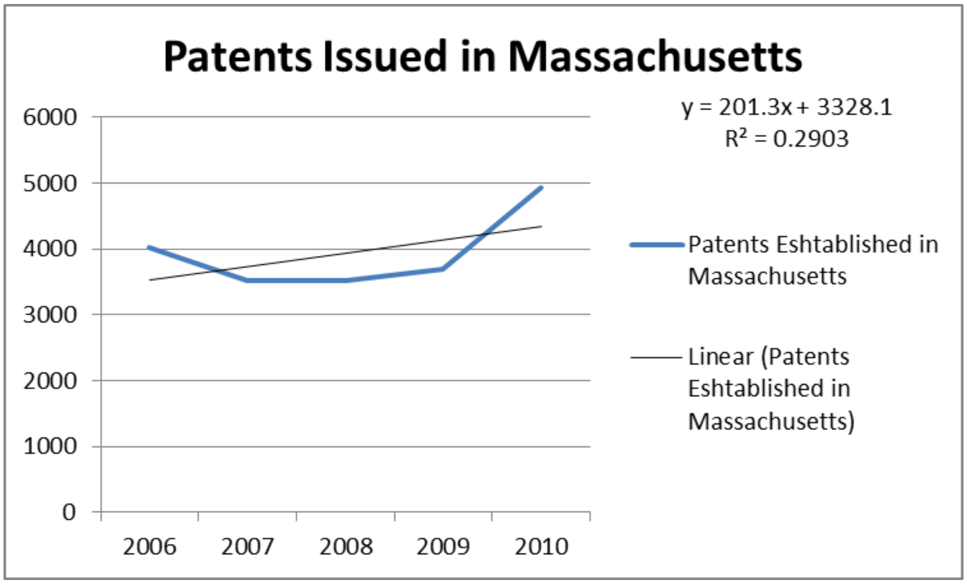
Figure 9: Total Number of Patents Issued in U.S. (2006-2010)



(U.S. Patent and Trademark Office, 2011)

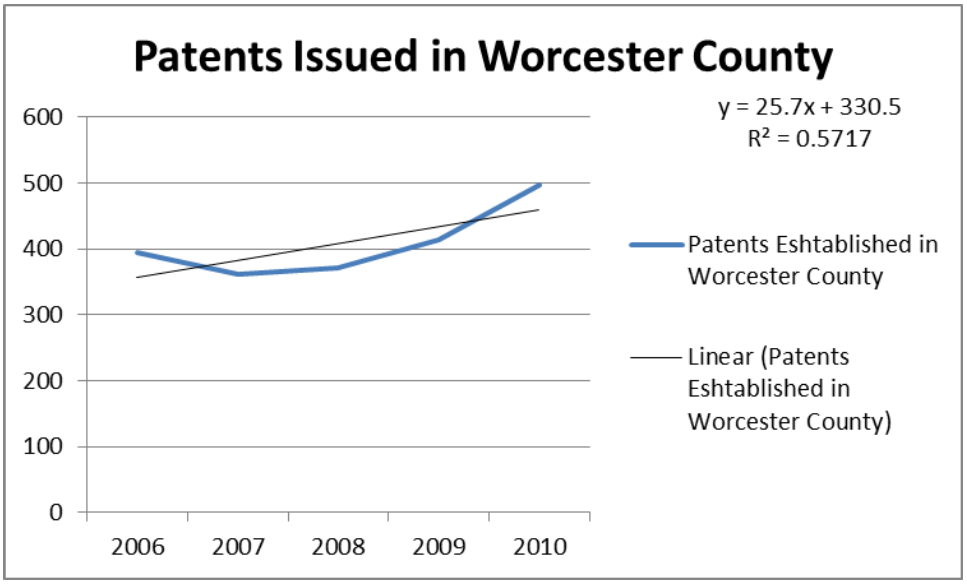
During the recession (from the year 2006 to 2007), the number of patents granted in Massachusetts decreased by 12.56%, whereas patents granted in Worcester County decreased by 8.12% during the year. After the recession of 2007, patents approved in Massachusetts increased only by 0.31% (the increase was by 11 patents), whereas patents granted in Worcester County increased by 2.76% (the increase was by 10 patents). Between 2008 and 2009 the patents granted in Massachusetts went up by 41, which is a 1.17% increase and the patents granted in Worcester County increased by 41 also, which is a steep increase of 11.02%. Patents issued in Massachusetts increased by 84 (increase of only 2.27%) from the year 2009 to 2010, and the increase in Worcester County was also by 84 patents, which is a steep rise of 20.34%. From 2007 to 2010, the percentage increase in Massachusetts patents was solely due to the increase in Worcester County patents. Figure 10 and 11 below shows the total patents established in the State of Massachusetts and in Worcester County from the year 2007 to 2012 respectively.

Figure 10: Total Number of Patents Issued in Massachusetts (2006-2010)



(U.S. Patent and Trademark Office, 2011)

Figure 11: Total Number of Patents Issued in Worcester County (2006-2010)



(U.S. Patent and Trademark Office, 2011)

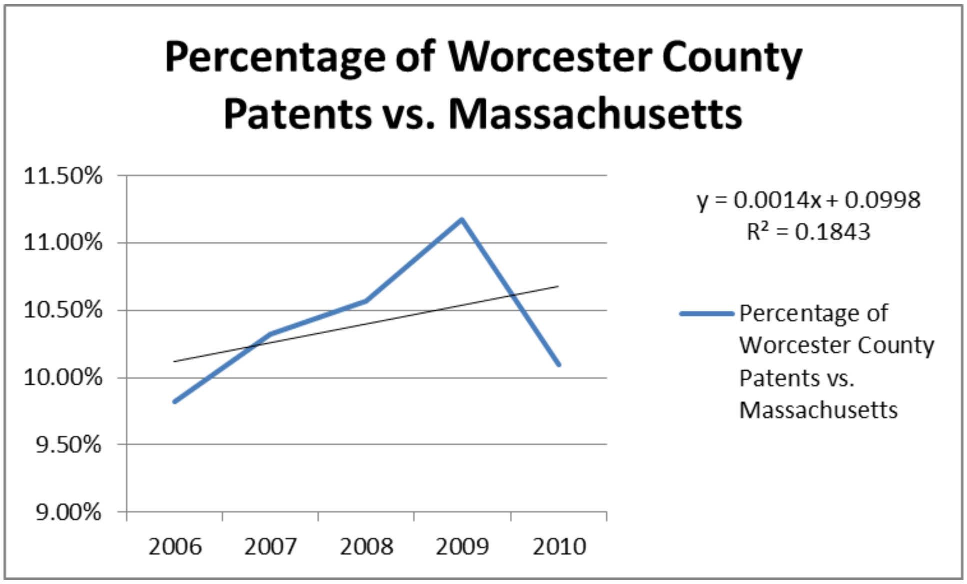
Table 5 below shows the percentage of Massachusetts Patents issued to Worcester County (U.S. Patent and Trademark Office, 2011)

Table 5: Percentage of Massachusetts Patents Issued to Worcester County (2006-2010)

2006	2007	2008	2009	2010	Total
9.82%	10.32%	10.57%	11.17%	10.09%	10.36%

Figure 12 below shows the percentage of Massachusetts patents comprising of patents granted in Worcester County.

Figure 12: Total Number of Patents Issued in Worcester County (2006-2010)



(U.S. Patent and Trademark Office, 2011)

Table 6 below shows the life science related patents issued to Worcester from the year 2006 to 2010.

Table 6: Life Science Related Patents Issued to Worcester County (2006-2010)

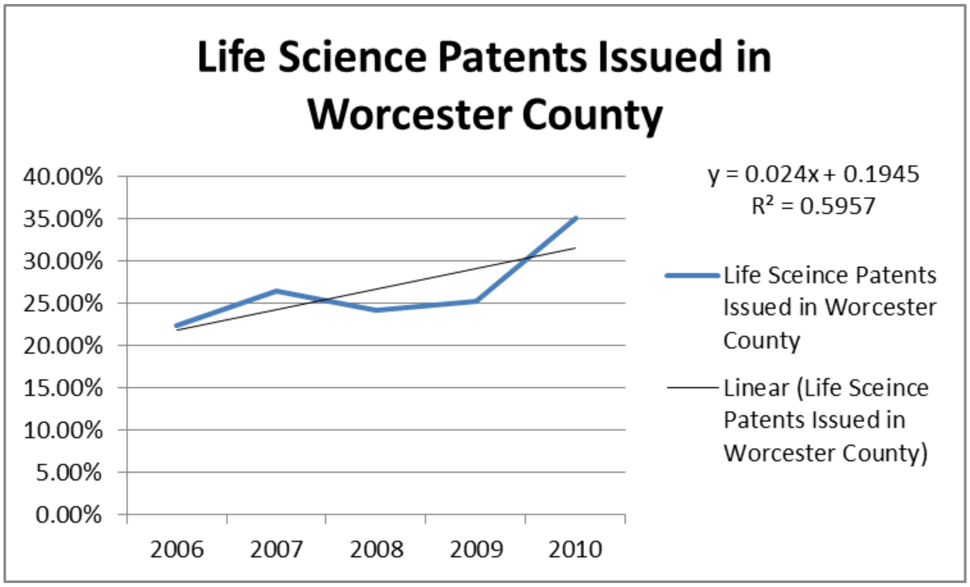
2006	2007	2008	2009	2010	Total
88	96	90	104	174	552

The percentage of Worcester County patents related to life-science from the year 2006 to 2010 is shown in Table 7 below.

Table 7: Percentage of Worcester County Patents Related to Life Sciences (2006-2010)

2006	2007	2008	2009	2010	Total
22.34%	26.52%	24.19%	25.18%	35.01%	27.10%

Figure #13: Life Science Patents Issued in Worcester County (2006-2010)



(U.S. Patent and Trademark Office, 2011)

4.3 Technology Development

4.3.1 Approvals of Pharmaceuticals and Medical Devices

Premarket Approvals (PMAs), Premarket Notifications (PMNs), and New Drug Applications (NDAs) are an important benchmark for regions because they measure the productivity of companies, institutions, and organizations in the region. PMAs are the most tedious type of marketing application required by the Food and Drug Administration (FDA). They are used to evaluate Class III medical devices, "devices used to support or sustain human health, are of substantial importance in preventing impairment of human health, or which present a potential, unreasonable risk of illness or injury" (Premarket Approval, 2012).

Approving a PMA, grants the involved party the permission to market the device because it has been deemed safe and effective for use. Massachusetts has been steady averaging around 2 or 3 PMAs per year since 2005, but none have come from the Worcester County area (Kispert, 2012). The Middlesex County area has been the leader in PMAs which is not very surprising considering the level of success the region has experienced for quite some time in the life sciences industry. A less sophisticated, but still significant benchmark of success in terms of commercialization is PMNs. These are improvements to existing products already on the market and Worcester County has found some success in this area. Table 8 shows the amount of PMNs in the Worcester County compared to the total PMNs approved in Massachusetts from 2005 to 2011. Data from 2012 is not included because it is incomplete.

Table 8: Premarket Notifications

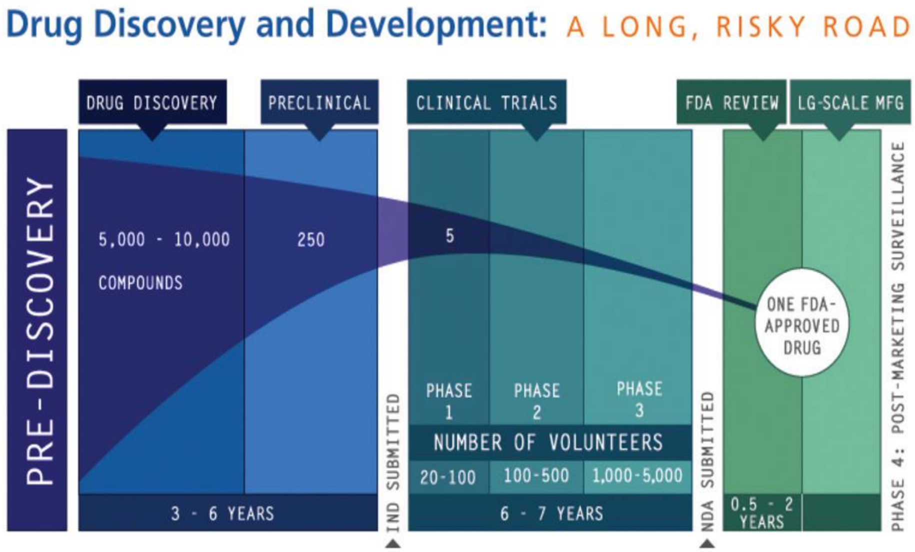
Year	Worcester County	Massachusetts
2005	11	238
2006	7	261
2007	3	250
2008	12	215
2009	7	225
2010	11	209
2011	9	208

(Massachusetts Technology Collaborative)

It is evident that Worcester County does not contribute significantly to the overall number of PMNs in Massachusetts. However, other than the year 2007, Worcester County has averaged around ten PMNs per year despite the declines of Massachusetts. Therefore, it can be concluded that the trend of PMNs in Worcester County does not follow Massachusetts trends and this data is a result of type of the companies and research being done in the county.

New Drug Applications is a lengthy, time consuming, and financially risky process. According to the Tufts Center for the Study of Drug Development it can take anywhere from ten to fifteen years for a new drug to reach the market from clinical stages (New Drug Approvals in 2011, 2012). It can take on average $1.2 billion for a drug to get to patients from the laboratory including costs of failure (New Drug Approvals in 2011, 2012). Creating a billion dollar drug is rare and is something that Worcester County has not produced yet other than the drug Humira developed by Abbvie Inc. located in Worcester County, but credit is given to the Abbot Inc. headquarters located in Illinois. Middlesex County, specifically Cambridge, Massachusetts has been the leader in NDAs producing two in 2011. Figure 14 displays the difficulty associated with moving a drug through clinical phases to market development.

Figure 14: Drug Discovery and Development



(New Drug Approvals in 2011, 2012)

Only Big Pharma companies have the resources available to push a drug to market with all these obstacles present. Worcester County is made up of primarily smaller startup companies so it is fair to assume that this is the reason for the absence of NDAs in the Worcester County area. Until larger companies begin to move westward in Massachusetts, the concentration of these NDAs will remain in the Boston area.

4.3.2 Technology Licensing

"Codified" information in the form of intellectual property, from universities, hospitals, and non-profit research organizations, can be transferred to "companies and entrepreneurs looking for to commercialize the technology" through technology licenses (Kispert et al., 2007)

The companies and entrepreneurs who want to get into contracts with the original owner(s) to receive the intellectual property have to give compensation for the license. The compensation can be:

- lump sum royalty
- royalty based on volume of production, which is known as running royalty)
- right to use licensee's technology, which is also known as cross licensing)

License royalties are typically established by comparing the "revenue generated from the sales of the products and services using the licensed intellectual property or from the achievement of milestones on the path of commercialization." In order to authenticate the original research and invention and to reinvest in new or follow-on R&D, rise in royalty returns is essential.

Through licensing of patented or trademarked technology, small firms can earn substantial revenue from markets that they could not enter on their own and large firms can have foreign connections without high commercial and legal risks.

Biotech patent owners grant licenses for many reasons:

- "to trade long-term risk and the possibility of substantial income for the certainty of a, perhaps more modest, short-term payoff
- to obtain development and marketing assistance beyond the owner's abilities
- to obtain clinical development for applications of academic discoveries
- to obtain funding for further research
- to exploit areas that would not be developed in-house by the patent owner
- to enhance reputation in a field by collaborating with a well-known company"

The owner is open to many risks while allowing licenses:

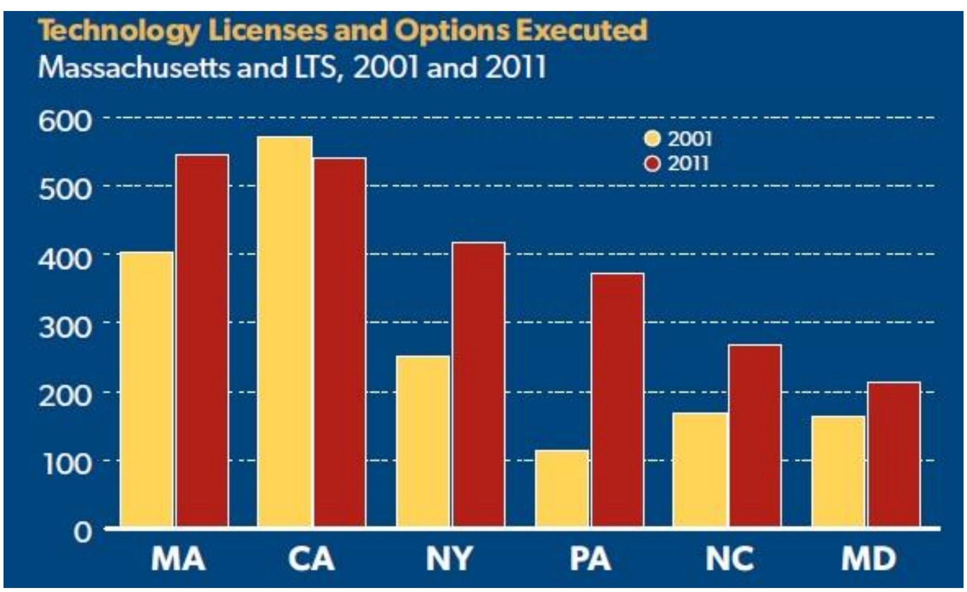
- “adding a competitor if the product is in an area the licensor already exploits
- having to depend on the choice of the licensee to realize the value of the discovery (if the licensee fails, the opportunity may be lost)
- having to share profit in the long run if the invention succeeds
- losing control over information that could be kept secret if development were done in-house” (Freeman, 2007, pg 998)

The licensee accepts a license for different reasons:

- “to ensure freedom to use a product line
- to obtain exclusivity for a product line
- to become current quickly without the cost of internal research” (Freeman, 2007, pg 999)

Massachusetts has risen to achieving the highest number of technology licenses in the nation between 2001 and 2011. There was a 36% increase in the total number of licenses in Massachusetts while there was a drop by percent in California. This was due to increase production innovation and rise in business establishments in Massachusetts (Kispert et al., 2012). Figure 15 below shows the total number of technology licenses and options executed in the United States in 2001 and 2011.

Figure 15: Technology Licenses and Options Executed in U.S.



The academic sector implemented the majority of technology licenses between the year 1996 and 2007. However, from 2008, research institutions and hospitals implemented the most number of licenses. There has been a 143% rise in licenses executed from research institutions and hospitals while there was 11% decrease in the number of licenses executed from universities (shown in Figure 17).

After the recession of 2007, revenues from technology licenses in Massachusetts dropped sharply in 2008. However, there has been slow growth from 2009 to 2011 in the total revenues earned from the commercializing intellectual property from universities, hospitals and research institutions (shown in Figure 16).

Figure 16: Revenues from Technology Licenses and Options Executed

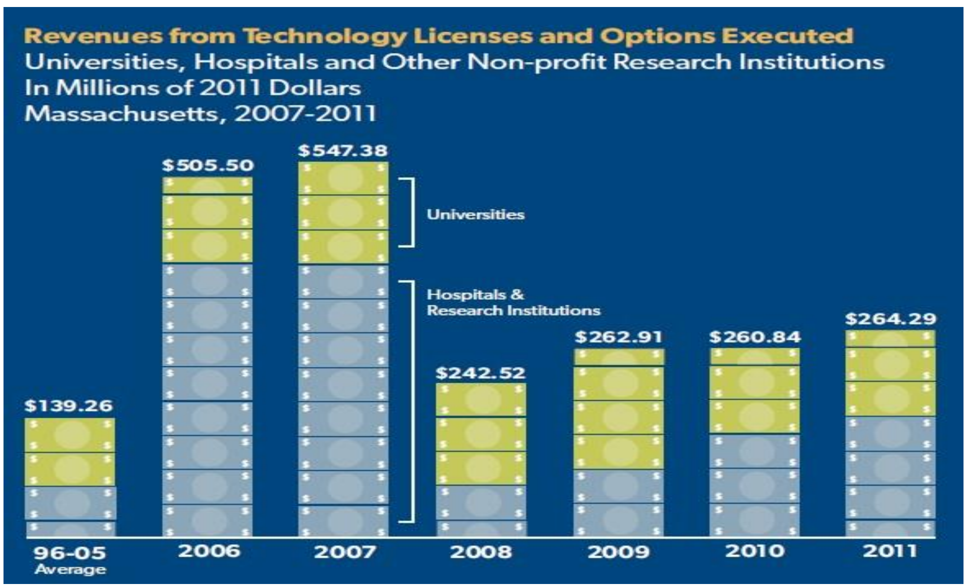


Figure 17: Technology Licenses and Options Executed in Massachusetts

Technology Licenses and Options Executed
Universities, Hospitals and Other Non-profit Research Institutions
Massachusetts - 2001 and 2011

	2001	2011
Research Institutions and Hospitals	121	294
Universities	281	251

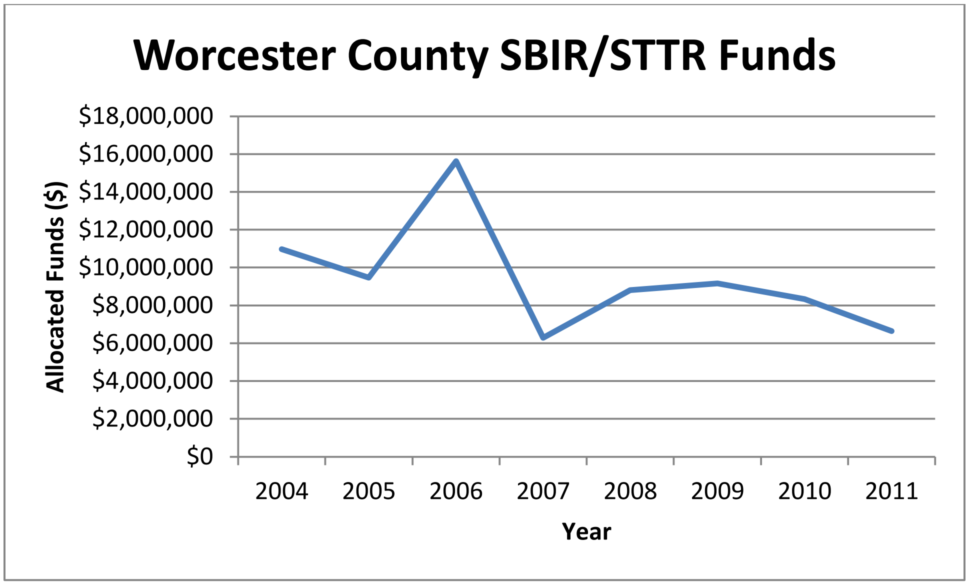
Between 2001-2011, there was a 143 percent increase in licenses for research institutions and hospitals

*

4.3.3 Small Business Innovation Research Grants/STTR

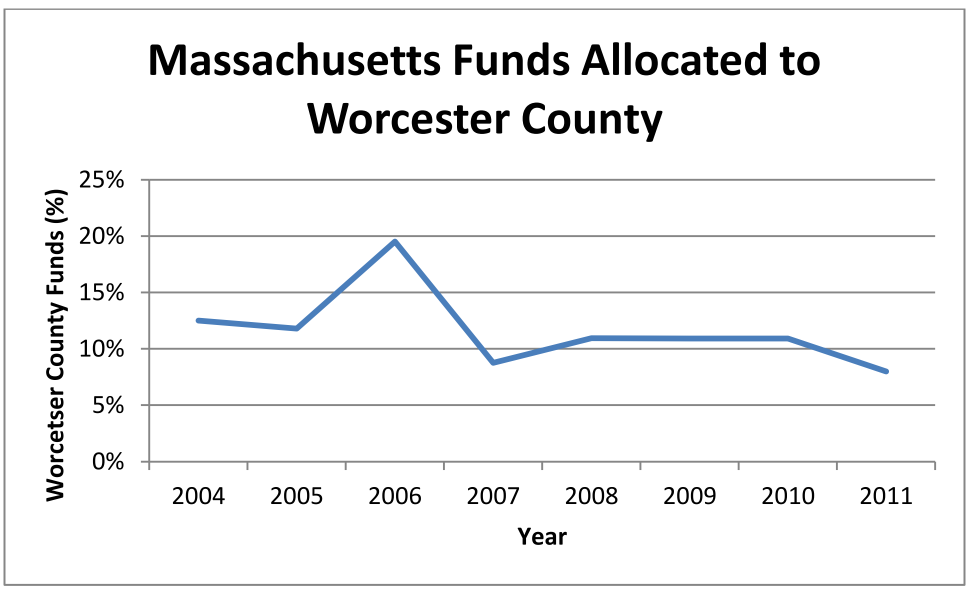
Small Business Innovation Research Grants (SBIR) and Small Business Technology Transfer Grants (STTR) are very competitive sources of funding that provide small businesses the opportunity to further conduct research. It can take many years and millions of dollars to move an idea to commercialization (New Drug Approvals in 2011, 2012). Therefore, being successful in acquiring these types of funds is important for small businesses in the life sciences industries because they keep the company alive. SBIR funds make it feasible for companies to perform Phase I and Phase II research and development. Phase I typically consists of research and Phase II enables companies to conduct development work on Phase I findings (SBIR, 2012). Appropriate funding is necessary in these phases in order to bring an idea to commercialization. STTR funds are geared towards the relationship between small business and research institutions. They are utilized with the intention of supporting the involved parties in commercializing innovative technologies (SBIR, 2012). It is apparent that securing these sorts of funds is vital to the success of a company especially in an area where small businesses play an important role in the economy. This is the case in Worcester County where many small businesses have been able to settle and thrive due to these funding programs. Figure 18 displays the National Institute of Health (NIH) and National Science Foundation (NSF) SBIR/STTR funds acquired in Worcester County. It is important to understand the trends of this data as compared to funding in Massachusetts as a whole which is displayed in Figure 19 as well as the portion of Massachusetts funds that Worcester County is responsible for presented in Figure 20.

Figure 18: NIH/NSF Worcester County SBIR/STTR Funds



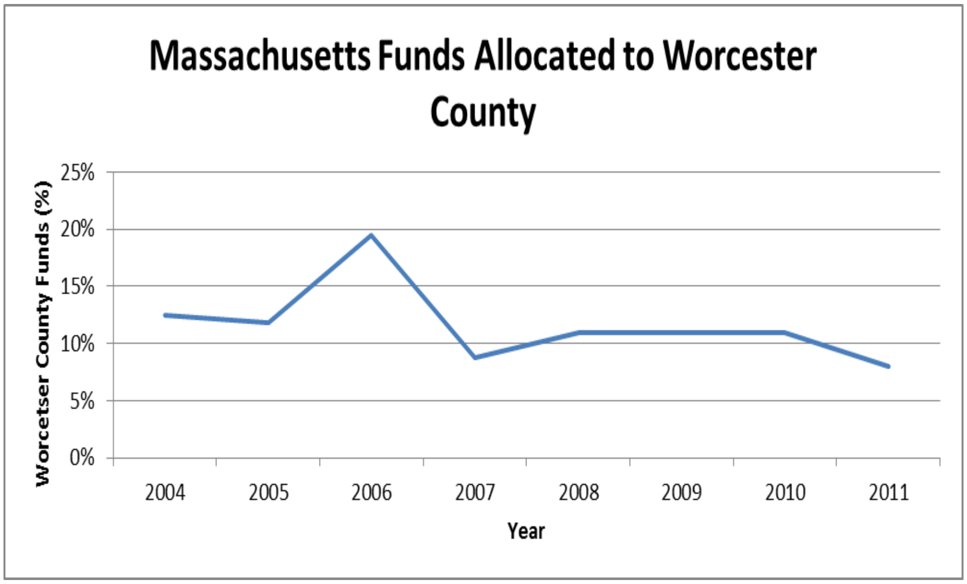
(Small Business Association, 2013)

Figure 19: NIH/NSF Massachusetts SBIR/STTR Funds



(Small Business Association, 2013)

Figure 20: Massachusetts Funds Allocated to Worcester County

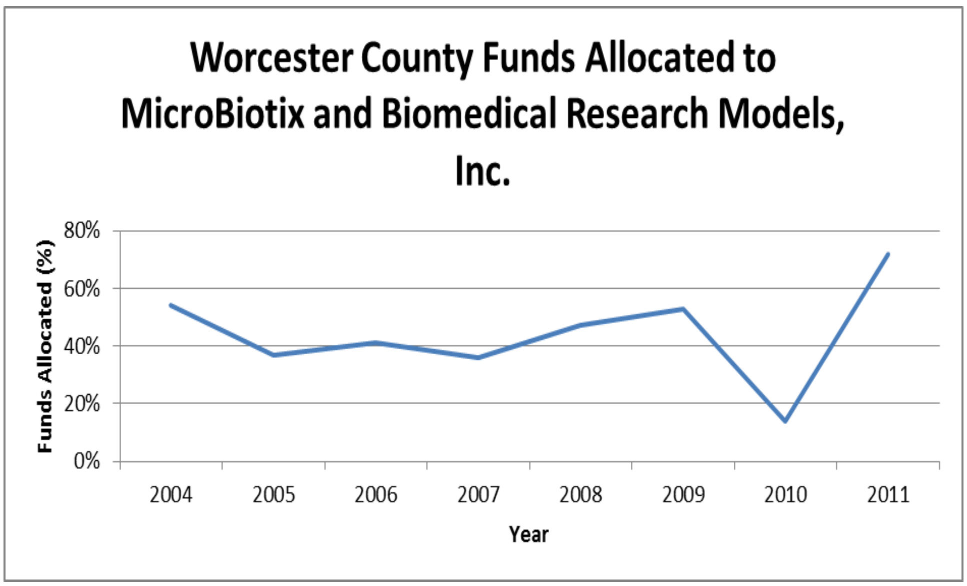


(Small Business Association, 2013)

From examining the trends of both Worcester County and Massachusetts, it is apparent that the funds allocated to Worcester County are based on the availability of funds in Massachusetts. However, in recent years, Worcester County has deviated from this pattern showing a decrease while fund allocation increased as a whole in Massachusetts. Excluding the year 2006, Worcester County funding has remained around $8 million. The project group discovered that a large percentage of funding in Worcester County has been allocated to the same companies every year. Two of these companies are MicroBiotix and Biomedical Research Models, Inc.

After discussion with the project sponsor, Kevin O'Sullivan, it was revealed that these companies employ full time grant writers that are experts in preparing grants which has led to the success of these companies in acquiring them. The largest challenge in acquiring SBIR/STTR grants is the application process because of the length and difficulty associated with it. If an inexperienced grant writer were to attempt this application process, their chance of success is much lower than that of an experienced writer that understands the process. In an interview with Dennis Guberski, CEO of Biomedical Research Models, described the difficulty associated with the grant application process. He stated that for an inexperienced writer it can take up to a month just to learn how to write a grant application and then another month to complete it. Then it can take up to three months to review the application and if accepted, another ninety days for funds to be dispersed to the company. Along with this, applicants must compete with other companies in a very competitive process. Therefore, it is advantageous to have experience in the application process to increase the chances of successfully acquiring these grants. Evaluating the data more closely has shown that this holds true for Worcester County. Figure 21 displays Worcester County SBIR/SSTR funds allocated by NIH/NSF to MicroBiotix and Biomedical Research Models, Inc., two companies with experienced grant writers.

Figure 21: Worcester County Funds Allocated to MicroBiotix and Biomedical Research Models, Inc.



Since 2004, these companies have received approximately 40% of NIH funds allocated to Worcester County for SBIR/STTR grants. In 2010, there was a dip to 14% but that was opposed the next year with a large increase to 72%. Other companies that have had success every year in Worcester County are GLSynthesis, Inc. and Grove Instruments LLC. However, many companies in Worcester County have only been able to receive funding for one or two years and lack consistent funding. This is attributed largely to the inability to write grant applications efficiently. Many companies that are not large enough to employ a full time writer are usually not consistent in acquiring SBIR/STTR funding. The project team hopes to suggest recommendations to address this issue.

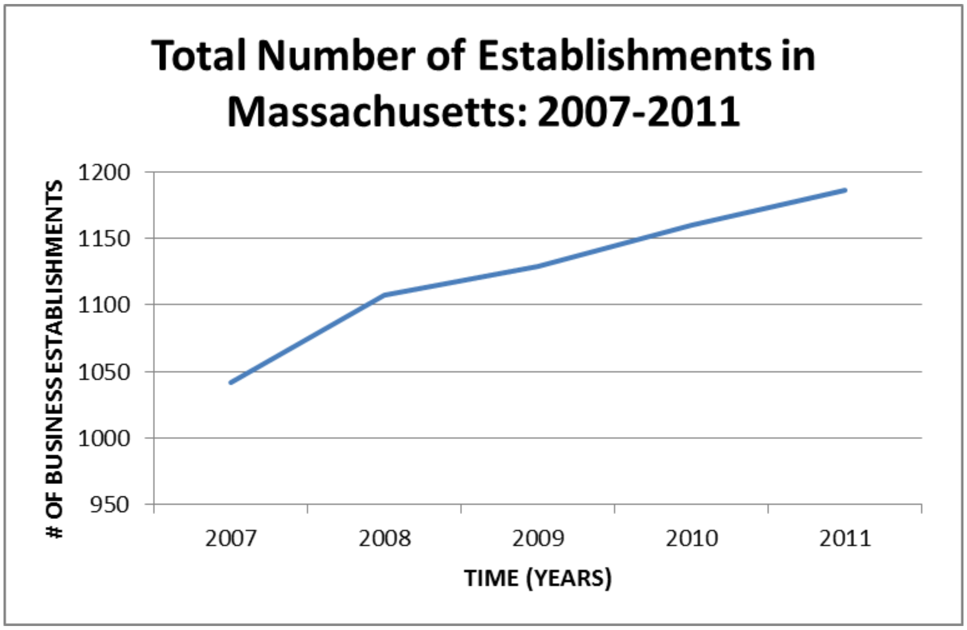
4.4 Business Development

4.4.1 Business Formation

The number of business establishments is recorded annually by the United States Department of Labor, Bureau of Labor Statistics (BLS) for all types of business industry. Each business is issued a North American Industry Classification System (NAICS), which categorizes them into a specific industry. In the BLS database, establishments can be sorted by region, state, and county. The field of life sciences was defined earlier in the employment growth section, and consists of twelve NAICS codes. Not all twelve codes can be considered completely part of the life science field, so a weight was assigned to each category, which was determined by Massachusetts Biotechnology Council.

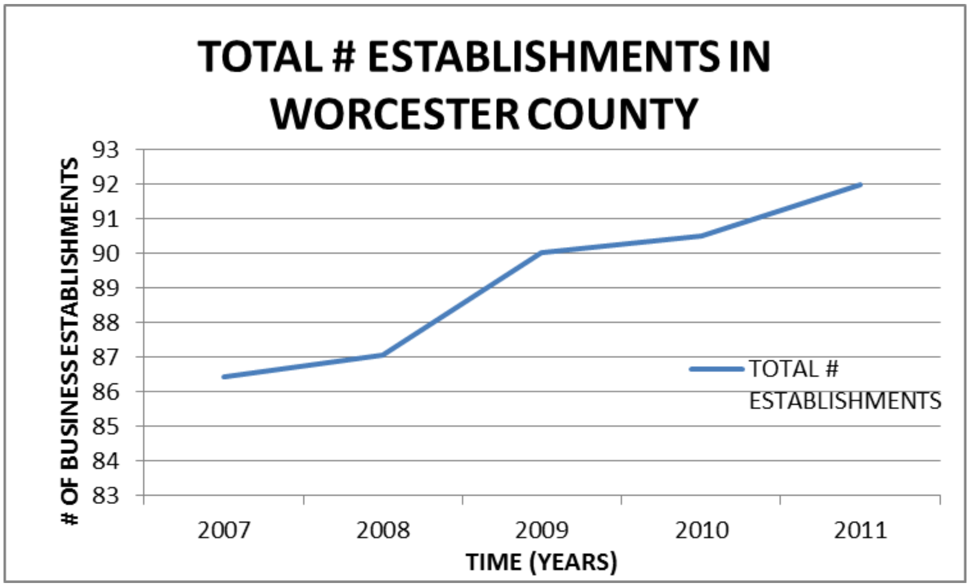
From 2007 to 2011, the total number of life science establishments increased by 12%. This was an addition of 145 establishments. The greatest increase in business formation can be seen from 2007 to 2008, which accounted for 44% of business formation increases in the 5 year time period. The next largest business formation increase occurred from 2009 to 2010, with 22% jump. Business formation was relatively slow from 2008 to 2009 and 2010 to 2011 with 15% and 18% increases respectively. Overall, business formation has slowed since 2008 (shown in Figure 22).

Figure 22: Number of Life Science Establishments in Massachusetts



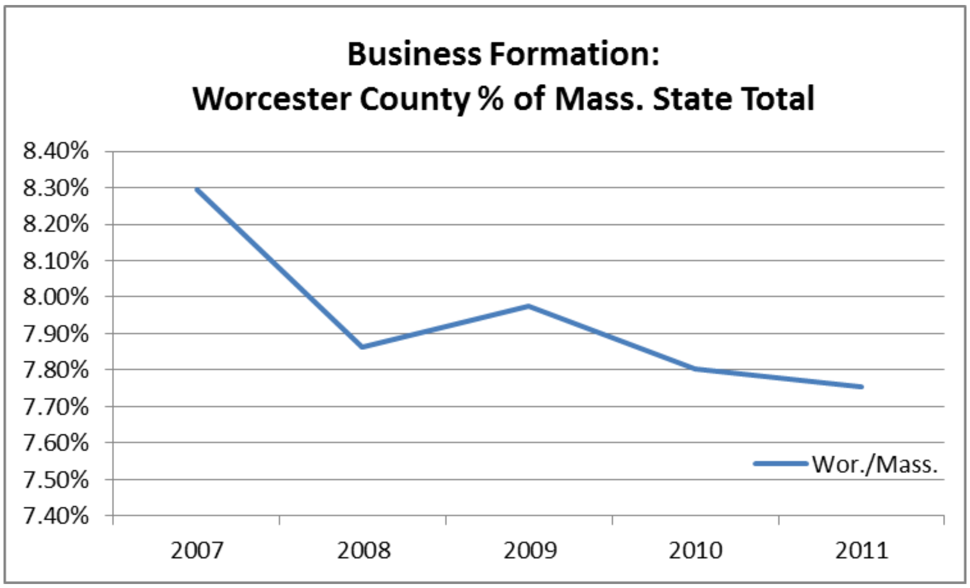
In comparison, in the same time frame, Worcester County life science establishments increased only 6.5%. Over this time frame, only 6 new businesses were formed. Contrary to the State trend, the greatest increase of business formation in Worcester County was observed from 2008 to 2009, which accounted for 50% of business formation. Over the next two years, only 2 more businesses were formed (shown in Figure 23).

Figure 23: Number of Life Science Establishments (Worcester County)



Over this 5 year period, Worcester County has accounted from 7.7% to 8.3% of the State's life science business establishments (shown in Figure 24). Worcester County has seen slight decline over this period compared to the State. Business formation data indicating slow to no growth can result from a variety of reasons. One being firms are expanding size, rather than breaking off to form new companies, or new companies forming on their own.

Figure 24: Percentage of Worcester County Establishments out of Massachusetts Total



4.4.2 Mergers/IPOs

Usually issued by smaller, younger companies, Initial Public Offering (IPOs) where shares of stock are sold to the public for the first time. This transforms the once private company into a public one. In an IPO, an underwriting firm, usually an investment bank helps the issuer determine what type of security to issue, the best offering price and the time to bring it to market (Ellis et al., 1999). There are four main reasons why a company would want to go public:

- **Raises capital**
  - For expansion efforts or to pay back debt.
- **Provides an exit**
  - For existing investors – whether the company is private equity (PE) owned, venture capital (VC) backed, or owned by a small group of individuals or a single person.
- **Gets an acquisition currency**
  - To make it easier to acquire other companies using stock once they're public since *most* private companies' stock is not highly valued. And raising debt to do deals can be easier once you're public as well.
- **Rewards employees**
  - Making employees work crazy hours for 5-10 years is tough to pull off, but the lure of an IPO that will make them all wealthy is a great incentive for them to stick around.
- **Markets themselves**
  - Especially for lesser-known companies in "boring" industries, an IPO is a great way to increase prestige and attract new investors, partners, and customers. (Lee, 2012)

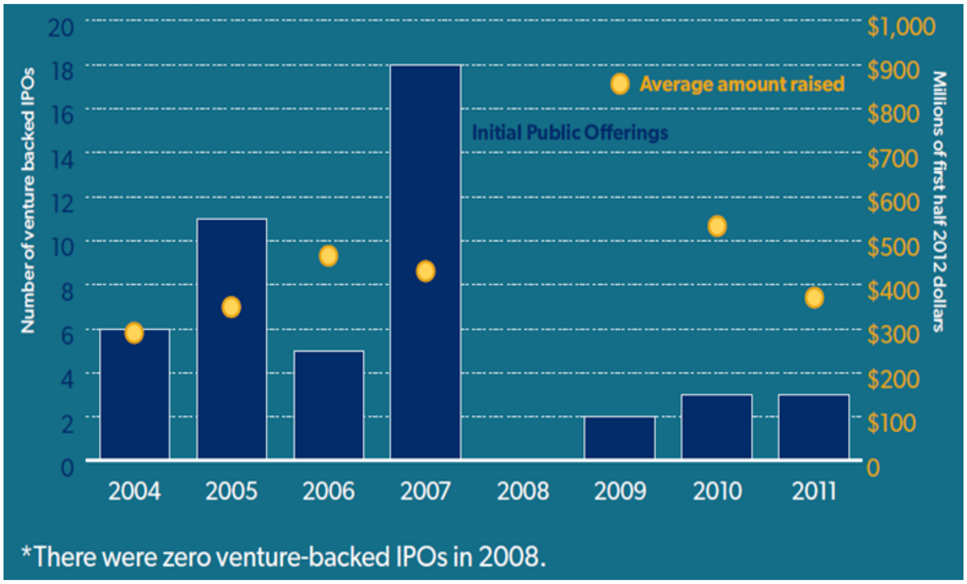
A merger, in the strictest terms, is when two firms agree to combine and go forward as a single new company rather than remain separately owned and operated. Usually a "merger of equals" does not happen very often in reality. Typically one company, the larger, more successful of the two, will buy the other and simply allow the acquired firm to proclaim that the action is a merger of equals, when in reality it is an acquisition. There are several types of mergers, horizontal mergers, vertical mergers, market-extension merger, product-merger, and conglomeration. There are many strong reasons of why companies would decide to merge. Strong companies will merge with smaller companies to create a more competitive, cost-efficient company. On the other hand, smaller companies in danger of falling apart will merge in order to gain a greater market share or to achieve greater efficiency. Mergers enhance research outcomes by bringing together technological expertise and enhancing efficiency (Wagner et al., 2009).

Mergers & acquisitions and initial public offerings represent important business strategies with which startup companies can access capital, expand operations and support business growth. Mergers and IPOs also provide opportunities for early-stage investors to liquidate their investments. “Mergers and acquisitions can alter incentives to innovate within a business by reducing competition or by allocating innovation to outsourcing via acquisitions of startup companies with proven or promising technologies” (Kispert, 2012).

Although the focus of this project is the Worcester County, there is no data on mergers and IPOs that could be found that was any more specific that state wide. Because of this, mergers and IPOs were looked at in terms of Massachusetts.

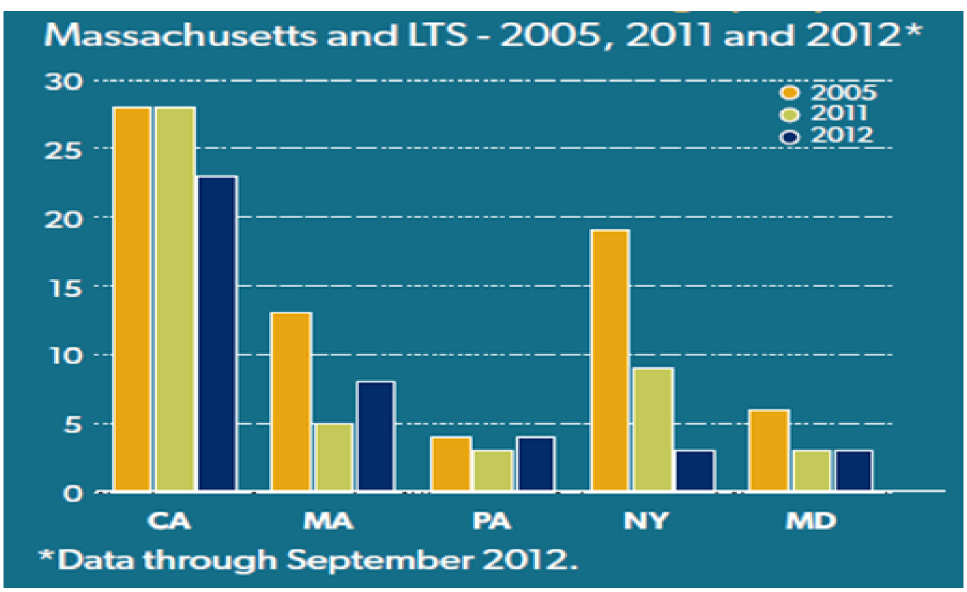
The venture-backed initial public offering in Massachusetts from 2004 to 2011 is graphically shown in Figure 25 below. After the record breaking number of venture backed IPOs (18) in 2007, the number of IPOs dropped to zero in 2008. Since then, Massachusetts has remained well below pre-recession levels. It started increasing after 2009 and continues to rise (Kispert, 2012).

Figure 25: Venture-Backed Initial Public Offerings in Massachusetts (2004-2011)



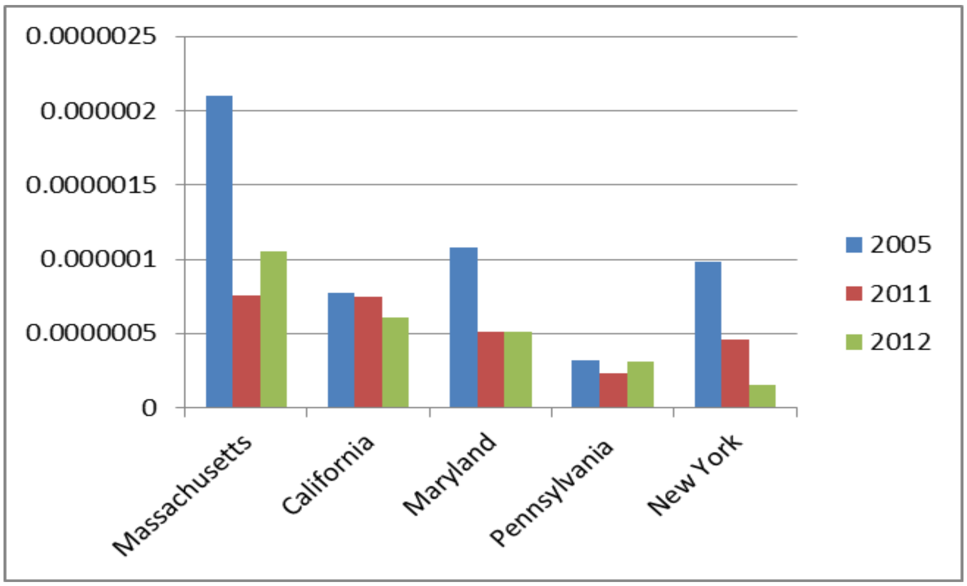
The number of 2010 venture-backed companies that went public in the U.S. was only 12.7% below the number of venture-backed IPOs in 2007. IPOs grew from five to eight between 2011 and 2012 in Massachusetts, which ranks second to California, as seen below Figure 26 (Kispert, 2012). Figure 26 also shows the number of Initial Public Offerings for the years 2005, 2011, and 2012 for New York, Pennsylvania, and Maryland.

Figure 26: Number of Initial Public Offerings



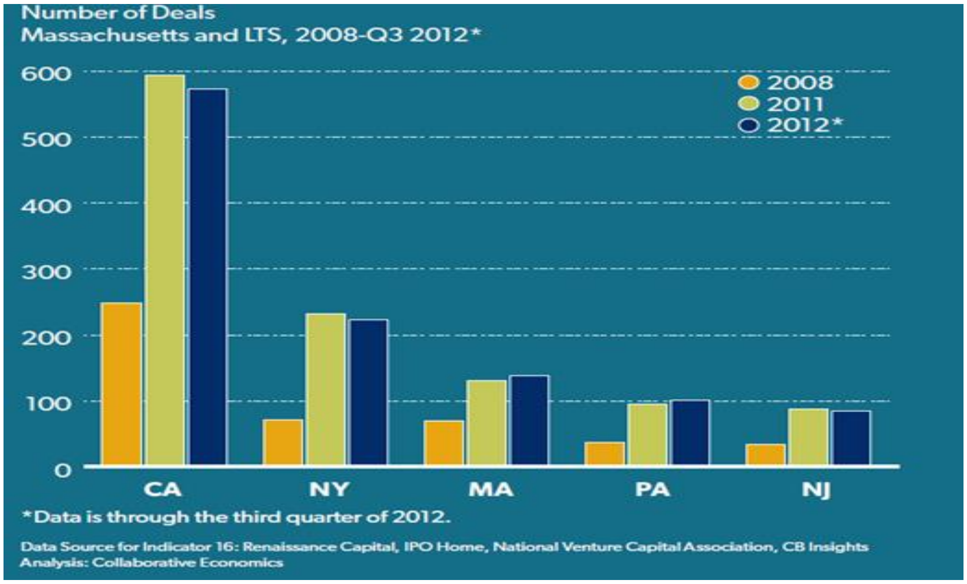
However, when the number of IPOs is compared with the population of each state, the graph looks completely different in terms of which state comes in first. As can be seen from Figure 27 below, Massachusetts comes in first when IPOs are calculated per capita. Figure 27 also shows the number of Initial Public Offerings per capita for the years 2005, 2011, and 2012 for New York, Pennsylvania, and Maryland.

Figure 27: Number of Initial Public Offerings Per Capita



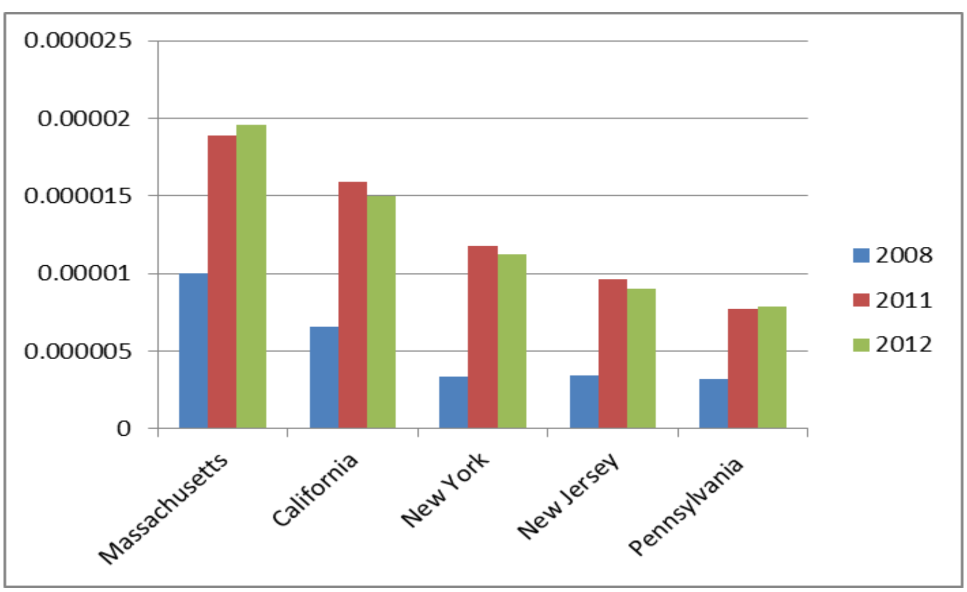
In case of Mergers and Acquistions, Massachusetts is third behind California and New York. The number of deals in 2008, 2011, and 2012 (through the third quarter) for California, New York, Massachusetts, Pennsylvania, and New Jersey is shown below in Figure 28. Although in 2008, New York and Massachusetts had the same number of deals, New York's numbers leaped up to around 230 deals, while Massachusetts went up to only around 130 deals, which is why New York is second place behind California.

Figure 28: Mergers and Acquisitions



As in the case of IPOs, mergers and acquisitions were also looked at per capita. As Figure 29 below shows, Massachusetts is once again ranked 1st in the number of deals per capita for mergers and acquisitions. Figure 29 also shows the number of mergers and acquisitions per capita for the years 2008, 2011, and 2012 for California, New York, New Jersey, and Pennsylvania.

Figure 29: Mergers & Acquisitions Per Capita



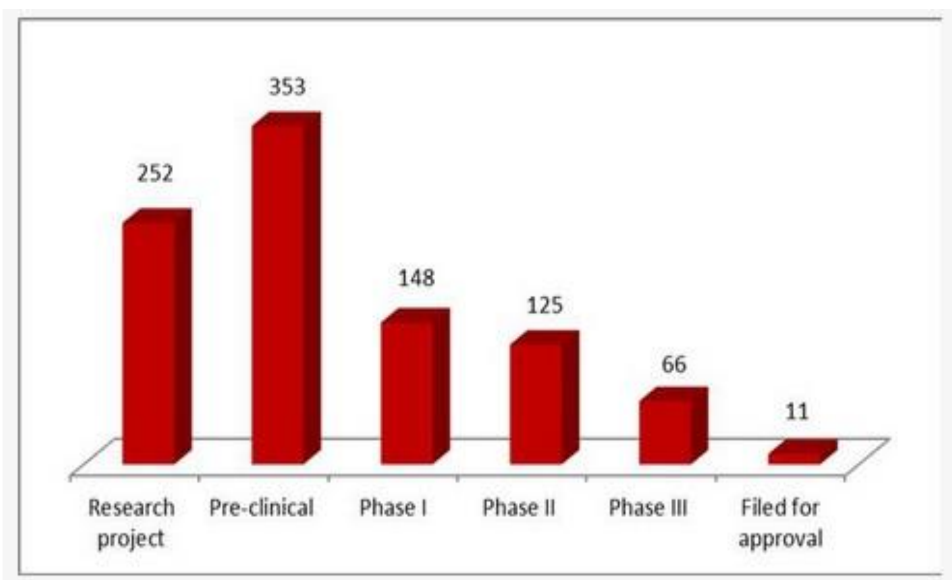
In conclusion, Massachusetts is easily one of the top states in terms of Initial Public Offerings and Mergers & Acquisitions, especially when considered per capita.

4.4.3 Biomanufacturing

Biomanufacturing represents "the production, isolation and purification of medicines made by pharmaceutical companies" (Biomanufacturing Home, 2013). Growth of biomanufacturing companies and competition among them is important to ensure sustaining production of new drugs and to validate drug development.

Massachusetts has "more than 500 biotech and pharma companies" (Massachusetts Biotechnology Council, 2011). There are about 314 companies which work on medicine development (Evaluate Pharma, 2012). Massachusetts Biotechnology Council reported in August 2012, that there were about 955 drugs in development in Massachusetts, which ranged from research project to pending approval stage. Figure 30 below shows under separate categories, the number of drugs being developed in Massachusetts.

Figure 30: Number of Drugs Developed in Massachusetts



(Massachusetts Biotechnology Council, 2011)

Worcester County has about 159 biomedical companies, which comprises of about 23.2% out of all Massachusetts pharmaceutical companies. Massachusetts has about 1553 medical equipment and devices companies, 684 pharmaceutical companies and 790 manufacturing companies (Manta, 2013).

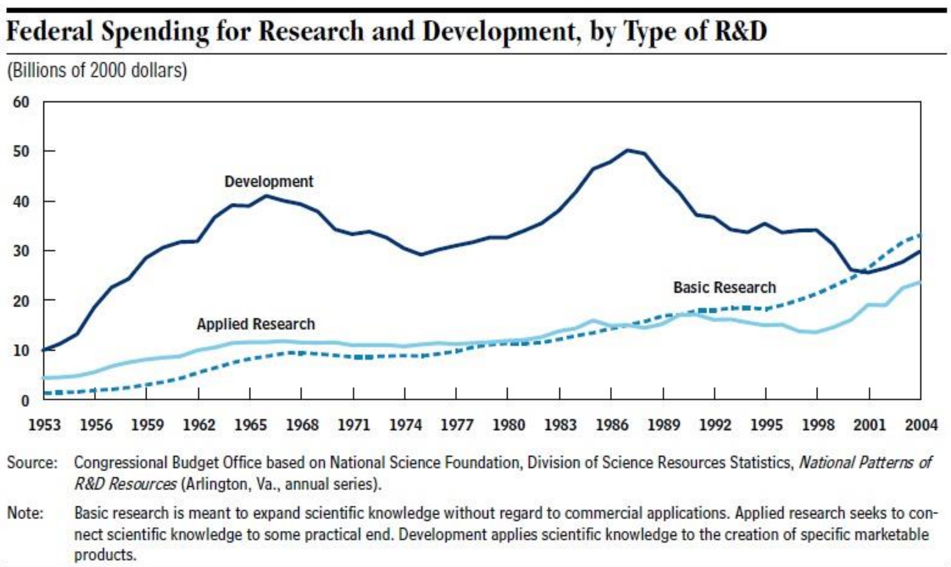
4.5 Capital

4.5.1 Federal funding for academic, non-profit, commercial and health

The U.S. government supports research and development (R&D) through various policies. The most prominent is federal performance and funding (Research and Development: National Trends and International Comparisons, 2012). The government finances R&D through spending and tax benefits that give business an incentive to increase their R&D spending (Federal Support for Research and Development, 2007). It was reported by the Congress of the United States Congressional Budget Office that in the fiscal year 2007 appropriations for R&D activities were a total of $137 billion (Federal Support for Research and Development, 2007). The federal funds are appropriately allocated, in general, depending on the areas of inquiry and projects that will potentially provide the highest returns on the investment (Federal Support for Research and Development, 2007). In order to understand the importance of multifaceted distribution of federal funds and to evaluate the effectiveness of the government's R&D spending and the benefits it may provide, it is important to distinguish between research and development.

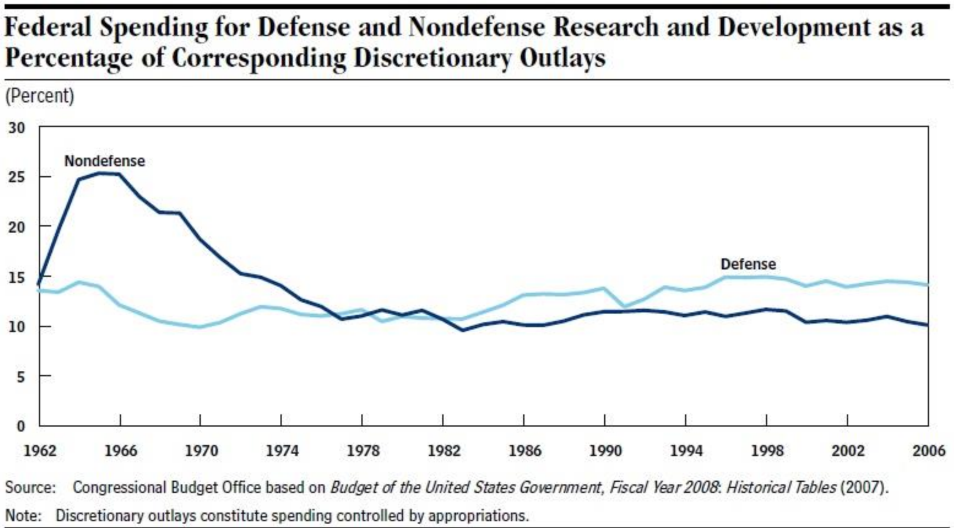
Research has large prospective for spillovers and benefits in the economy (Federal Support for Research and Development, 2007). That is why research is favorable and may be conducted without a specific commercial purpose in mind. The knowledge produced by research is valuable to both researchers in other areas and to businesses that are looking to develop "new products and production processes" (Federal Support for Research and Development, 2007). Development applies scientific knowledge to the manufacture of specific marketable goods. Benefits of development reaches directly to "innovating firms and their customers" since it occurs closer to a product's introduction (Federal Support for Research and Development, 2007). Federal funding deployed to development has certain criteria, such as focusing mainly on accomplishing public missions such as in the area of national defense (Federal Support for Research and Development, 2007). Although such funding in the development sector has spawned some commercially workable bonus technologies in the past, but the chances of that happening is unpredictable. About 50 percent of all research conducted in the United States receive and rely on federal funding and development receives only 17% of federal funds (Federal Support for Research and Development, 2007). Figure 31 below shows the total amount of federal grant spent on applied and basic research and development.

Figure 31: Total U.S. Federal grants spent on applied research, basic research and development during the year 1953 to 2004



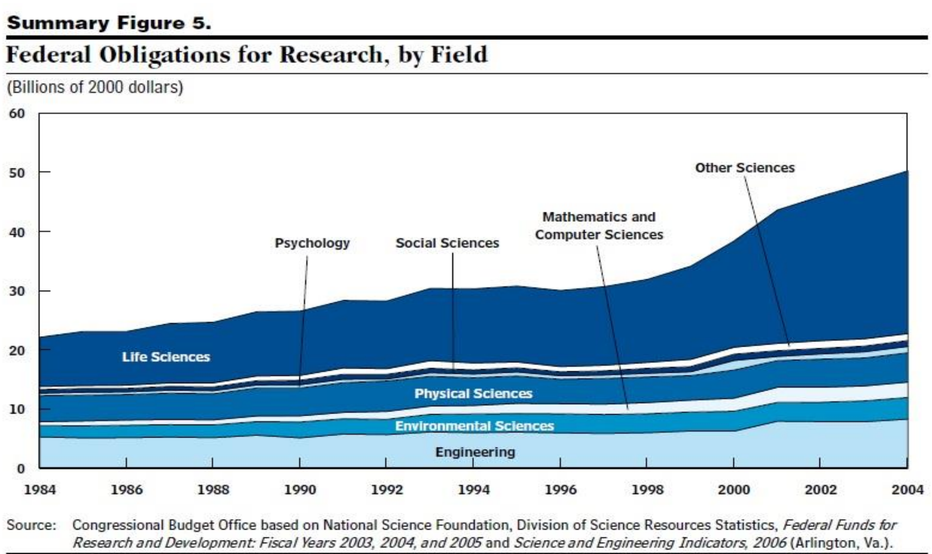
There are two types of research that get funded, which are defense-based and non-defense based research (Federal Support for Research and Development, 2007). The two broad categories that determine the allocation of the federal funds to each of the types of research are mission-oriented activities and scientific and technical knowledge that will be beneficial to the economy (Federal Support for Research and Development, 2007). Most life science research falls under non-defense type. Health-related R&D has been experiencing the greatest rise over the last two "which accounts for just over half of nondefense R&D spending" (Federal Support for Research and Development, 2007). Figure 32 shows the total United States federal spending on defense and non-defense related research and development.

Figure 32: Total U.S. Federal spending on defense and non-defense related research and development



Over the last decade, the portion of federal funding assigned to life sciences has increased significantly since life sciences offer high rates of returns. The other reason that federal funding is critical to the growth of life sciences is it gives incentives to the researchers to identify new ideas and tools that generate substantial economic returns (Research and Development: National Trends and International Comparisons, 2012) . Figure 33 below shows the total funds allocated to different fields due to federal obligations.

Figure 33: Total federal obligations for different research fields



There have been changes noticed in the funding trend for industrial, intramural and academic R&D over the same time period. In 2004, about 10 percent of government funds were allocated to industrial R&D while in the late 1950s and early 1960s; more than 50 percent were allocated for industrial R&D (Federal Support for Research and Development, 2007). Federal funding is being allocated more towards intramural and university R&D. the government funded about 10 percent (Federal Support for Research and Development, 2007). In fact, the percentage rate of federal funding for University-performed research increased more rapidly than federal funds allocated to any other sectors performing R&D. Federal funds for University R&D increased at real annual rate of 6.8 percent, and that fund is responsible for 60 percent of university R&D (Federal Support for Research and Development, 2007).

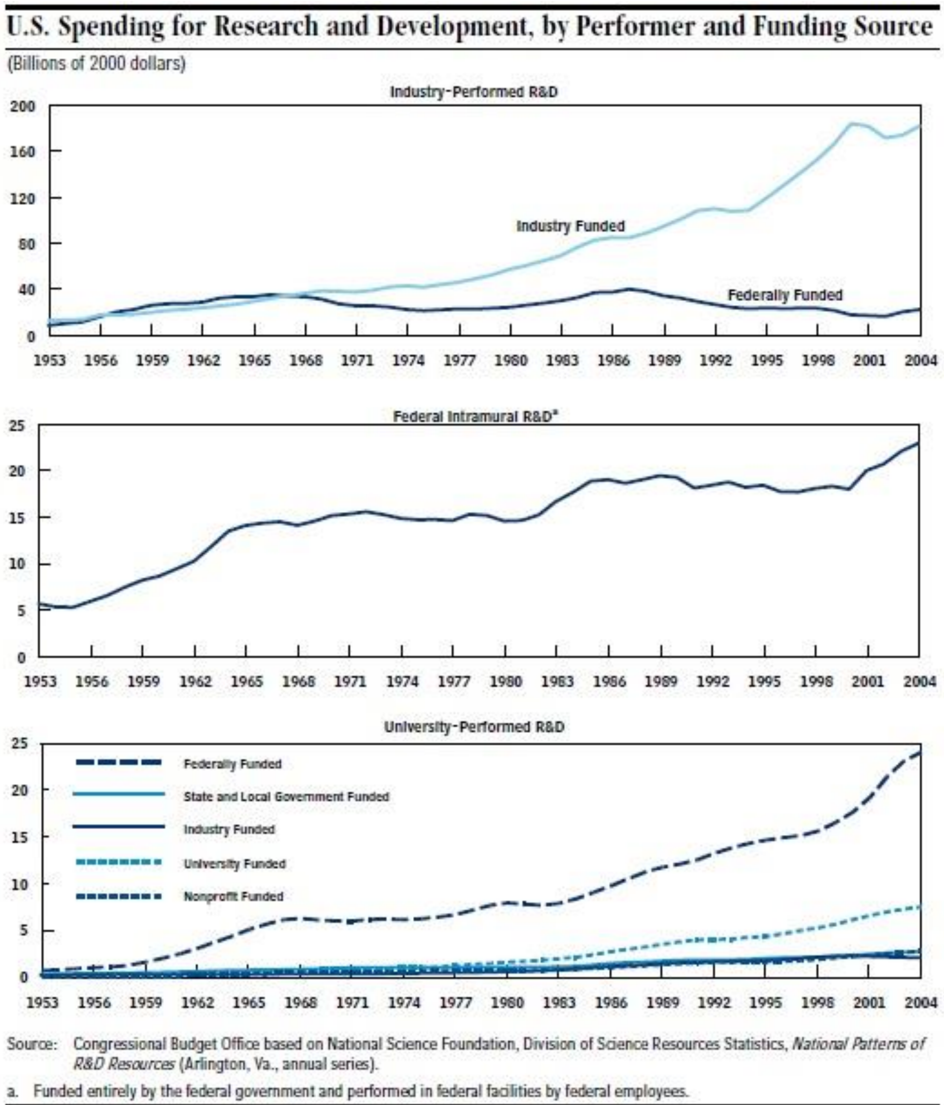
The National Institute of Health (NIH) is one of the major sources of funding to the biomedical or the life science industry. The allocations of funds are established upon three different qualifications, according to National Institute of Health, which are:

a. "Grant proposals of high scientific caliber that are relevant to public health needs that are within the NIH Institute and Center's priorities" (National Institute of Health, 2013)
b. The project should "encourages investigator-related research across the spectrum of its mission" (National Institute of Health, 2013)
c. The projects the individual or institution is conducting must be unique in the sense that they have never been done before.

NIH funds create job opportunities in the U.S. and serve "as a foundation for the medical innovation sector, which employs 1 million U.S. citizens" (National Institute of Health, 2013).

The main source of federal funding for health-related R&D is the Department of Health and Human Services (HHS). An estimate of 35.7 billion dollar was obligated for R&D and R&D plant, which is 26% of the total federal obligations, in the fiscal year 2009 returns of which about 34.6 billion dollars represented R&D activities of NIH (Research and Development: National Trends and International Comparisons, 2012). During the fiscal year 2009, the federal government was obligated to provide 4.9 billion dollars to HHS due to the American Recovery and Reinvestment Act, making this the largest appropriation of all the federal agencies returns (Research and Development: National Trends and International Comparisons, 2012). Intramural activities and FFRDCs received 21% of the total budget and Extramural performers, among which universities and colleges and other non-profit organizations are the main performers, received 79% of the total budget returns (Research and Development: National Trends and International Comparisons, 2012). The major portion of HHS R&D funding is allocated for research. In the fiscal year 2009, basic research received 53% and applied research received 47% of the total research grant returns (Research and Development: National Trends and International Comparisons, 2012). Figure 34 below shows federal spending for research and development in the United States.

Figure 34: U.S. Spending for Research and Development



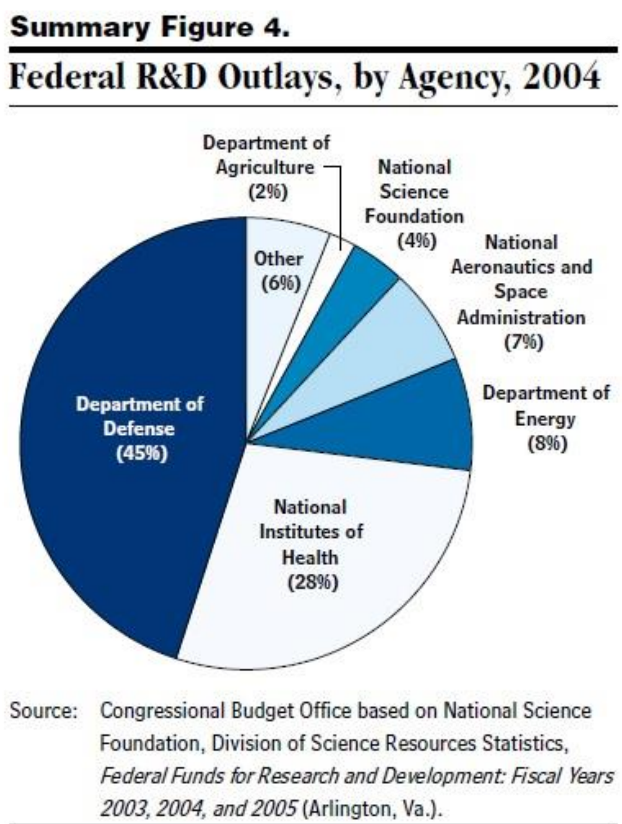
(Federal Support for Research and Development, 2007)

In the fiscal year 2009, about 6.9 billion dollars were allocated to R&D and R&D plants by the National Science Foundation (NSF), which is about 5% of the total federal budget returns (Research and Development: National Trends and International Comparisons, 2012). Mainly universities and colleges, which are part of the Extramural performers, represented 96% of the total funds allocated by NSF. In that period, American Recovery and Reinvestment Act were obligated to provide $2.2 billion to NSF for R&D and R&D plant, which accounted for the second largest funding among the agencies returns (Research and Development: National Trends and

International Comparisons, 2012). About 92% of the R&D funds went to basic research. “NSF is the federal government’s primary source of funding for academic basic science and engineering research and the second-largest federal source (after HHS) of R&D funds for universities and colleges” returns (Research and Development: National Trends and International Comparisons, 2012). However, even if NSF is not the major source for life science funding, it is still a significant source.

Therefore, in fiscal year 2009, about total of 133.3 billion dollars accounted for federal obligations to R&D and an additional 3.6 billion dollars accounted for R&D plant. “The American Recovery and Reinvestment Act of 2009 granted “$8.7 billion for R&D and $1.4 billion for R&D plant for the same fiscal year” returns (Research and Development: National Trends and International Comparisons, 2012). Figure 35 shows federal research and development, by Agency.

Figure 35: Federal R&D Outlays, by Agency



(Federal Support for Research and Development, 2007)

Universities and other non-profit research institutions are important to both the Massachusetts and Worcester County's life science economy. Basic science field and technologies are growing with the help of these institutions and the products made by them are becoming commercially available through private sectors easily. To sustain academic, non-profit and health-related research, federal funding is essential. "Awards from the National Institutes of Health (NIH) help fund the Commonwealth's biotechnology, medical device, and health services industries which together comprise the Life Sciences cluster" returns (Research and Development: National Trends and International Comparisons, 2012).

For National Institute of Health (NIH) R&D Funding per $1,000 GDP, Massachusetts came in first in 2011 but in terms of total funding to the state in came in second, behind California (Kispert et al., 2007). After the recession of 2007, NIH funding for Massachusetts increased only by 0.43%, whereas funds allocated to Worcester County increased by 3.8%. Between 2009 and 2008 the funding for R&D for Massachusetts went up by $119,137,380, which is a 5.09% increase and the funds for Worcester County increased by $12,814,804.00, which is a 9.41% increase. The NIH funding for Massachusetts increased by only 3.47% from the year 2009 to 2010, but funding for Worcester County showed a rise of 12.48%. However, from 2010 to 2011 and from 2011 to 2012, the federal funding for Massachusetts went down by 1.38% and 1.51% respectively (National Institute of Health, 2013).

A fall was also noticed in the funds allocated to Worcester County. From the year 2010 to 2011, the funds in Worcester County dropped by 1.59%. From 2011 to 2012, there was a sharp drop in the County funds by 10.35%. This is due to resolution passed by the Congress which includes a 10% across-the-board budget cut. The cut includes most of the critical medical research in the U.S. Forbes reported that "80-85% of projects submitted to NIH, many of them excellent, don't make the cut because NIH just doesn't have enough funding for them" (Salzberg, 2013). Table 9 below shows the total NIH funding received by the State of Massachusetts and Worcester County and the percentage of funds allocated to Worcester County from the year 2007 to 2012.

Table 9: NIH Funding

	2007	2008	2009	2010	2011	2012
Mass.	$2,328,733,874	$2,338,640,674	$2,457,778,054	$2,543,013,395	$2,507,870,229	$2,470,036,857
Worcester County	$131,122,438	$136,110,642	$148,925,446	$167,512,845	$164,854,428	$147,798,159
Percentage of Funds allocated to Worcester	5.63%	5.82%	6.06%	6.59%	6.57%	5.98%

The total NIH funds and the trends (rise from 2007 to 2010 and decrease from 2010 to 2011) for the State of Massachusetts and Worcester County are shown below in Figure 36 and 37 respectively from the year 2007-2012.

Figure 36: NIH Funding for Massachusetts

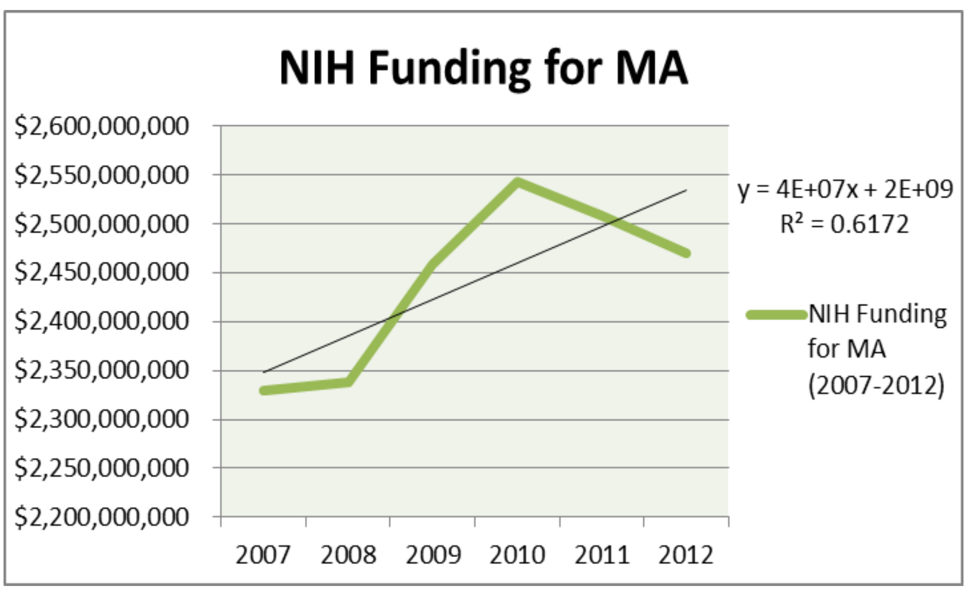
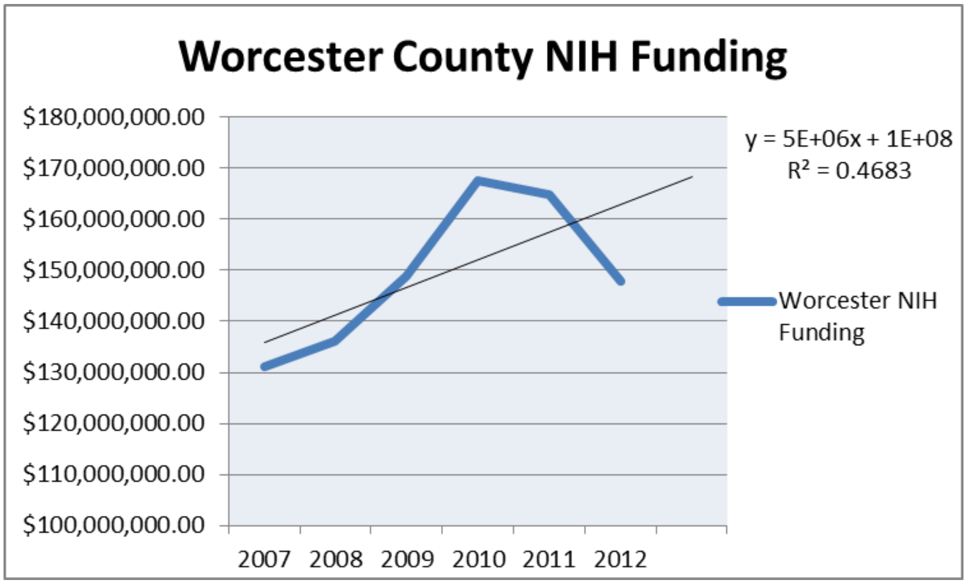


Figure 37: NIH Funding for Worcester County



The bar graph, Figures 38 and 39, below shows the total funds allocated to Massachusetts and Worcester County respectively for the year 2007 to 2012.

Figure 38: NIH Funding MA

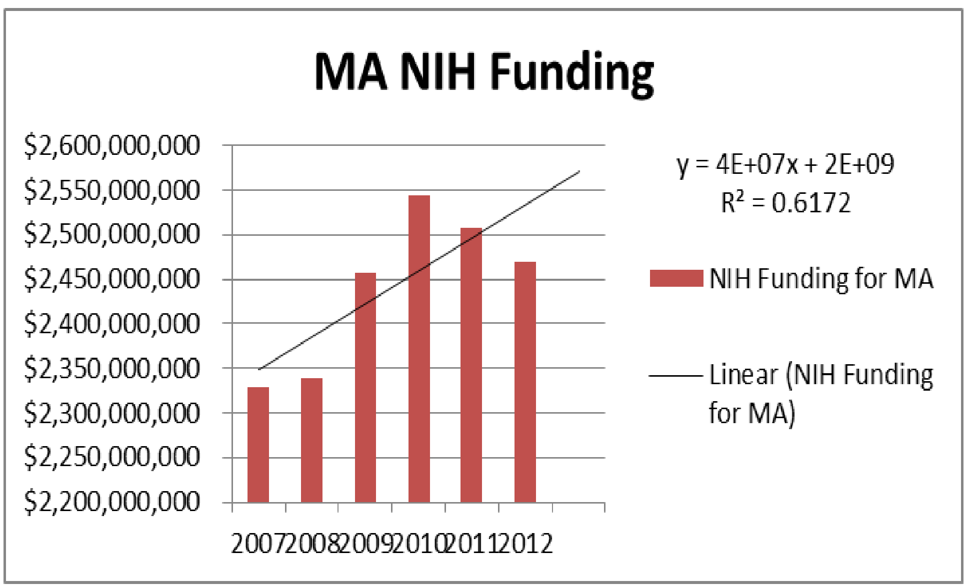


Figure 39: NIH Funding Worcester County

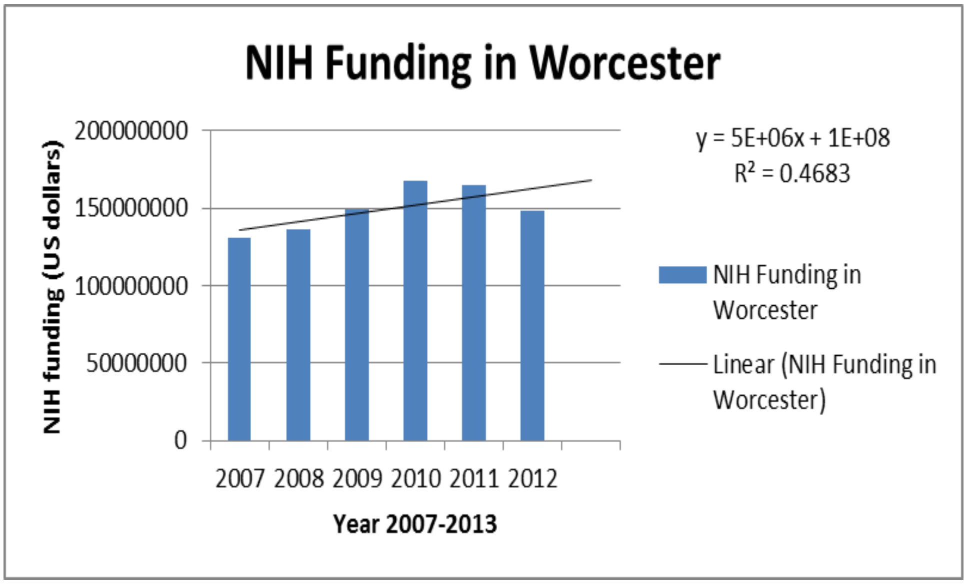
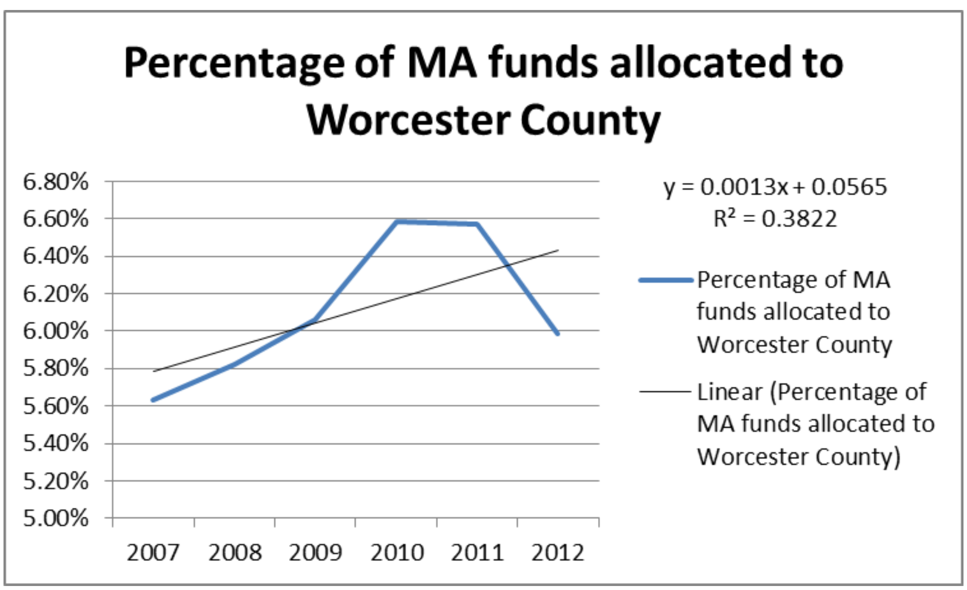


Figure 40 below shows the percentage and trend of Massachusetts NIH funds allocated to Worcester County from the year 2007 to 2012. In the year 2007, the proportion of Massachusetts funds allocated to Worcester County was 5.63%. In the year 2008, the amount of Massachusetts NIH funds allocated to Worcester County was 5.82%. 6.06%, 6.59%, 6.57%, 5.98% of Massachusetts NIH funds were allocated to Worcester County during the year 2009-2012.

Figure 40: Percentage of Massachusetts funds allocated to Worcester County



Even though Worcester County receives a fair proportionate of Massachusetts NIH funds, not many institution, organization and businesses are performing well in the federal funding grant applications. Most of the Worcester County NIH funds go to University of Massachusetts followed by Microbiotix Inc. and the GLSynthesis Inc. Table 1 below shows the proportion of Worcester County NIH funds received by different institutions and businesses during the year 2007 to 2012.

Table 10 below shows the percentage of Worcester County NIH funds allocated to the top institution and companies in Worcester County.

Table 10: Percentage of Worcester County NIH funds

Rank	Institution/ Companies	2007	2008	2009	2010	2011	2012
1	UNIV OF MASSACHUSETTS MED SCH WORCESTER	90.65%	90.22%	90.94%	91.56%	93.13%	90.78%
2	MICROBIOTIX, INC	3.66%	4.45%	4.36%	3.27%	2.46%	5.47%
3	GLSYNTHESIS, INC.	2.38%	1.72%	1.46%	1.01%	0.57%	1.16%

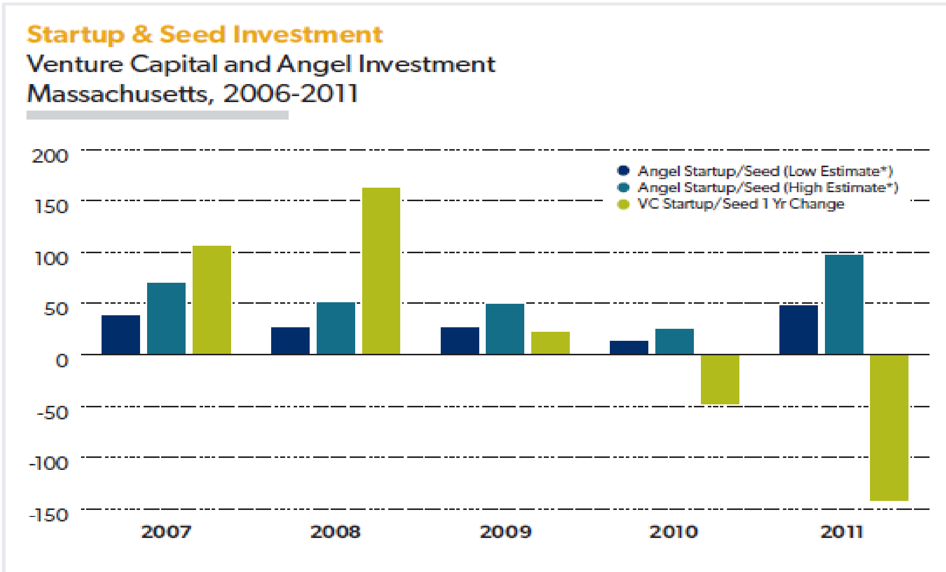
4.5.2 Private Funding

In order to turn ideas and technologies into products, companies, and jobs, sufficient funding must be available (Kispert, 2013). Funding can come from a variety of sources. Generally at a company's early stages, funding comes from family, friends, or fools. As they grow, opportunities for Angel funding are available, and after further growth is reached, Venture Capital becomes an option. These organizations invest in a variety of fields ranging from biotech, gaming companies, to security systems companies. Angel groups generally offer investments in the range of $250,000 to $500,000, in high growth and high tech industries. Many Angel groups determine how much money to invest by first predicting what the exit value of the company will be. Overall in Massachusetts, Angel funding is playing a large role by financing startup companies, as Venture Capital investment has dropped 28% since 2007 before the recession. More specifically at the startup level, Venture Capital investment has dropped 45% between the years 2009 to 2011 (Kipert, 2012).

According to the Angel Capital Association, there are 25 Angel groups in New England 15 located in Massachusetts; only one, the Boynton Angels, is located in Central Massachusetts (Angel Capital Association, 2013). Angel groups prefer to invest in companies that are relatively close to them, and with Worcester County only having one Angel group; it puts the region at a disadvantage compared to an area like Boston and Cambridge. The Boynton Angels are unable to make many investments, due to the fact that they lack a sufficient number of investors (Schaufeld, 2013).

Below is a graph on Venture Capital and Angel Investment in startup companies in Massachusetts from 2007 to 2011 from the 2012 Innovation Economy Index. (No data on Angel funding specific to Worcester County could be obtained). Since the Great Recession in 2008, the amount of Venture funding for startup companies deceased dramatically and continued to decline even until 2011. Over this five year span, both low and high estimates for Angel funding decreased for four years, but noticeable growth occurred in 2011.

Figure 41: Startup and Seed Investment in Massachusetts



4.5.3 Capital and Human Resources

Innovative ideas and products require state of the art facilities in which work can take place. A location that has specialized facilities can be considered to have a competitive advantage over other regions that lack said facilities. Worcester County features many of the state's specialized life science facilities and "today, 49 of the state's largest 100 life sciences companies are located west of Route 128" (Hurd, 2007). This indicates biotech has been expanding west of Boston, and new construction of facilities in Worcester County confirms this. Companies may be expanding west into areas in Worcester County that have been identified as "Economic Target Areas" which offers state tax incentives, 5% investment tax credit for equipment, municipal tax incentives

Gateway Park located in Worcester, MA, was built by WPI and features "Five life sciences buildings totaling 550,000 square feet of flexible, adaptable lab space designed to meet the needs of research organizations" (Facts and Figures, 2013). The Park is home to WPI's Biomanufacturing Education and Training Center, "which provides innovative workforce development solutions customized to the specific needs of your company…Serving life sciences companies from across the region and the globe, the center represents an innovative partnership of academia and industry" (Life Science and Bioengineering Center, 2013).

Massachusetts Biotechnology Research Park is a so called "Master-Planned Biotechnology Development" (Massachusetts Biotechnology Research Park and CenTech Park, 2013). Since its creation in 1985, the park has grown to be one of the country's leading centers for biotechnology research and production, with almost one million square feet of building space across 105 acres of land (Massachusetts Biotechnology Research Park and CenTech Park, 2013). The Park has five main buildings which are home to 2,000 employees (Hurd, 2007). According to *BioSpace*, Massachusetts Biotechnology Research Park anchors the western end of Massachusetts' 40-mile long "Genetown" corridor, which further supports the claim that more biotech companies are expanding out towards Worcester from Boston. The Park is home to companies such as Abbott Bioresearch Center, Athena Diagnostics, Advanced Cell Technology, and BioVest International, as well as housing offices and labs for UMass

Worcester Medical School (Worcester Business Development Corporation, 2010). More specifically the Park features UMass Worcester Medical School "labs of the departments of Biochemistry & Molecular Pharmacology, Physiology, and the Program in Molecular Medicine and of the Diabetes Endocrinology Research Center...the Meyers Primary Care Institute and the departments of Biochemistry & Molecular Pharmacology, Cell Biology, and Molecular Genetics & Microbiology and Physiology (Directions to Biotech Park, 2013). In addition to established companies occupying space, the Park "offers a range of facility options, from fully built-out wet lab space for lease in units as small as 1,000 square feet to build-to-suit opportunities on land parcels up to 35 acres" (Massachusetts Biotechnology Research Park and CenTech Park, 2013, 2013).

CenTech Park is a development similar to the Massachusetts Biotechnology Research Park, and the 121 acre site has been developed over the past ten years by the Worcester Business Development Corporation alongside the towns of Shrewsbury and Grafton, with help from Tufts University's Cummings School of Veterinary Medicine. The development received several million dollars in federal and state funds to update the infrastructure (Worcester Business Development Corporation, 2010). CenTech tenants include State Street Bank, IDEXX, Primary Colors, Verrillon, TriTech Software Systems, and UMass.

In two years, from 2007 to 2009, Bristol-Myers Squibb's built a $750 million BioPharma manufacturing facility, in Devens, MA, which at the peak of construction employed over 1,000 contractors. The facility consists of four main buildings, a central utility building, an administrative/quality control building and a warehouse/storage structure, a waste water pretreatment plant, and accommodations for future expansion (Devens, Massachusetts, 2013).

In addition to private sector facilities, Worcester County colleges and universities feature state of the art science facilities. According to the National Science Foundation, at the end of FY 2011 completed construction of science research and lab facilities at University of Massachusetts (UMass) Worcester Medical School totaled to over 535,000 square feet. In this number, includes just over 300,000 square feet of biological and biomedical science space, more than 150,000 square feet of health and clinical science space, and nearly 40,000 square feet for other science and engineering related fields (National Science Foundation, 2013). The costs of all new construction and renovation from FY 2003 to FY 2011 totaled to over $550 million (National Science Foundation, 2013). With state of the art workspace, UMass Worcester Medical School can conduct innovative work in stem-cell research and also the science of RNAi (the discovery of which (RNAi) earned Dr. Craig C. Mello the Nobel Prize)" (Hurd, 2007). With new construction, UMass Worcester Medical School has expanded its ability "to conduct clinical trials of investigative new medicines" (Hurd, 2007).

Tufts University's Cummings School of Veterinary Medicine is the only American Veterinary Medical Association accredited institution in New England (Massachusetts Veterinary Medical Association, 2013). Their campus is located just 20 minutes east of Worcester in Grafton, MA. The school has built the 41,000 square feet New England Regional Biosafety Laboratory (NE-RBL) and has spent nearly $26 million on this lab (New England Regional Biosafety Laboratory, 2011). This lab is "dedicated to the study of existing and emerging infectious, diseases, toxin-mediated diseases and medical countermeasures important to biodefense. Tufts also "has a major research program studying the development, detection and potential treatments for infectious diseases that are food- or water-borne, or that originate in animals and spread to people" (New England Regional Biosafety Laboratory, 2011). Scientists within the NE-RBL are conducting research to develop therapeutics, vaccines and diagnostic tools in a safe, secure, regulatory-compliant environment" (New England Regional Biosafety Laboratory, 2011). This school offers research and collaborative opportunities to "investigators in academia, not-for-profit organizations, industry, and government" (New England Regional Biosafety Laboratory, 2011).

There are several other well-known universities in Worcester County with large, state of the art facilities of their own, which help bolster the areas educational edge. Worcester Polytechnic Institute reported through the National Science Foundation survey of Universities Science and Engineering Facilities, that as of FY 2011 they had over 100,000 square feet of science, technology, engineering, and mathematic (STEM) space. The majority of space is devoted to various engineering fields which account for over 65,000 and 20,000 square feet is dedicated to biological and biomedical studies. As of FY 2011, College of Holy Cross reported over 130,000 square feet of STEM facility space, with 100,000 square feet dedicated to Physical Sciences such as astronomy, astrophysics, chemistry, and physics. Also in FY 2011, Clark University reported 43,000 square feet of STEM facilities, and almost 50% being used for biological and biomedical sciences. In addition to the above mentioned state of the art facilities, other institutions, such as Massachusetts College of Pharmacy & Allied Health Science, Worcester State, Assumption, and Fitchburg State possess facilities.

Worcester County's Life Science Parks, biomanufacturing facilities, and university research labs create the necessary critical mass of infrastructure for it to be considered an enticing location for biotech operations. It is imperative for Worcester County not only to maintain this infrastructure, but improve and add to it in order to maintain this strength.

Unique features to the facilities in Worcester can be easily found at Tufts University's Cummings School of Veterinary Medicine. Not only is it the only veterinary school in New England, but the programs and opportunities it offers make for a unique resource to the county. The opportunities to collaborate give a distinctive advantage to companies located in the vicinity. At UMass Medical, researchers are given the opportunity to work with the discoveries of Nobel Prize winner Dr. Craig C. Mello, a very unique advantage to conducting research here in Worcester County.

The construction of these facilities has implications not only for life science companies who occupy the building, but also for the cities and towns in which they are located by creating more tax bases and employment opportunities. All of the facilities located in the county are located within an Economic Target Area and a "job-creating project on this site (Tufts Cumming School of Veterinary Medicine) can obtain negotiated municipal property tax rates and a 5% Investment Tax Credit against state income taxes with unlimited carry-forward provisions" (Worcester Business Development Corporation, 2010). The economic designations in place yield a tremendous advantage for Worcester County.

The location of Worcester County is one of its greatest competitive advantages. It is an hour drive from Boston and Providence, cities which contain valuable resources such as an International airport, funding, and life science businesses. Within the county's limits sits one of the top engineering schools in the country, WPI. An hour to the east is MIT, the top engineering school in the country, and two hours to the west is RPI. This central location allows Worcester County businesses to draw from a specialized pool of talent (Guberski, 2013). The location of Worcester city businesses are a short distance to Union Station commuter rail. The Tufts University's Cummings School of Veterinary Medicine site is also ideal because of its proximity to MBTA commuter rail transportation (Worcester Business Development Corporation, 2010).

4.5.4 Lab Inventory

There are two main types of laboratories, wet and dry; each with its own unique advantages. Wet Laboratories are defined as laboratories where chemicals, drugs, or other biological matter are handled in liquid solutions or volatile phases, requiring water, direct ventilation, and/or specialized piped utilities. One of wet labs' most unique advantages is that it must accommodate simultaneous and separate ventilation and utility connections at individual lab modules to ensure both the reliability and accuracy of results as well as occupant safety throughout the space. Some fundamental wet laboratory features include:

- **Separate Laboratory Modules:** a wet lab space is typically divided into separate laboratory modules that contain individually controlled connections to HVAC, utilities and safety devices.
- **Constant and Reliable HVAC:** As some equipment and experiments are temperature- and humidity-sensitive, constant conditions are required in Wet Laboratory spaces to ensure that equipment can perform properly and that experiments produce accurate results.
- **Gas/Utility Services:** Utility connections in Wet Laboratory space types can include vacuum, pneumatic supply, natural gas, O_2 and CO_2, and distilled water.
- **Fume Hoods:** wet laboratories accommodate one 6'-0" chemical fume hood for each laboratory module, and provide direct 100% exhaust.
- **Laboratory Occupancy:** Occupancy Group Classification for Wet Laboratory is B2, Sprinkler protected construction, as per IBC, with a GSA Acoustical Class C1 for enclosed spaces and Class C2 for open spaces (WBDG, 2010).

On the other hand, dry laboratories refer to spaces where work is done with dry stored materials, electronics, and large instruments with few piped services. Work such as for example, computational or applied mathematical analyses that can be done on a computer to generate a model to simulate a phenomenon in the physical realm. Similar to the wet laboratories, these analytical dry laboratories also have a few fundamental features, including:

- **Constant and Reliable Temperature and Humidity**: as some equipment and experiments are temperature- and humidity-sensitive, constant conditions are required to ensure that equipment can perform properly and that experiments produce accurate results.
- **Laboratory Occupancy:** Occupancy Group Classification for Dry Laboratory is B2, Sprinkler protected construction, as per IBC, with a GSA Acoustical Class C1 for enclosed spaces and Class C2 for open spaces (WBDG, 2010).

In a study done by Colliers International, most of Worcester County is termed as "Suburban" and is compared with Boston, MA and Cambridge, MA (Kelly, 2012). The following is what the report had to say on the velocity of the Suburban Market:

"Wavering tenant demand resulted in a sizable amount of negative absorption during the third quarter. After falling to 19.1% last quarter, the suburban vacancy rate inched back up to 19.4% at the end of September. Even still, year-to-date the suburbs clocked in more than 1.1 million square feet of positive absorption, already surpassing net absorption in 2010 and 2011 combined. Given that the fourth quarter is expected to be positive, 2012 is likely to be the strongest year since 2007," (Kelly, 2012).

A crucial competitive advantage Worcester County has in terms of lab inventory is that its vacancy rate is much slower than that of Boston and Cambridge (Kelly, 2012). Local companies are becoming more and more confident in economic conditions which are bringing back tenant growth and expansion. This has encouraged several firms to proceed with relocations and expansions throughout the suburban market, which includes Worcester County (Kelly, 2012). Another reason for local companies to relocate to the Worcester County lab market is for its reasonably priced rental lab space so close to mainstream cities such as Boston and Cambridge.

The trend for new and premier Class A, amenity-rich buildings in the suburban area should continue to rise in 2013 (Kelly, 2012). In addition to the economics of rent per square foot, tenants seek value through efficiency, amenities and sustainability (Kelly, 2012).

Unfortunately, there was no county wide data available for lab space/inventory. However, that information was available specifically for Worcester, MA, shown below in Figure #4 (Kelly, 2012).

Table 11: Lab Space in Worcester, Massachusetts

Town	Address	Built	Floors	Biotech SF	Available for lease SF
Worcester	100 Barber Avenue	1920	1	10,000	0
	1 Innovation Drive	1991	4	80,000	16,610
	100 Institute Road	2005	2	16,589	0
	377 Plantation Street	1994	3	93,000	91,531
	381 Plantation Street	2000	3	94,000	35,930
	60 Prescott	1900	4	125,000	0
	85 Prescott	1900	4	12,000	0
	100 Research Drive	1994	4	166,000	0
Total				**596,589**	**144,071**

4.6 Talent

4.6.1 Workforce Education Level

A well educated work force is important because it is essential for the economic growth of a region and its ability to innovate and improve itself. Without a well skilled labor force, the abilities of the region are limited. Workforce education levels is a measure of the percentage of the labor force with a bachelor's degree or higher (Kispert et al., 2012). Using the U.S. Census Bureau from 2000 and 2008-2010 that was available in a report done by Robert Clifford of the *New England Public Policy Center*, workforce education level data were compiled for Massachusetts and Central Massachusetts. There were no data available for Worcester County but Central Massachusetts included all of Worcester County and some cities in Middlesex County (Clifford, 2012). From 2000 to 2008-2010, Massachusetts has showed overall improvement in the number of employees with a Bachelor's degree or higher in seven occupations that encompass science, technology, engineering, and math. Table 12 compiles this information along with a net change for each occupation.

Table 12: Workforce Education Levels in Massachusetts

	2000		2008-2010		Net Change	
Workforce Education Levels in Massachusetts	Less than Bachelor's Degree	Bachelor's Degree or more	Less than Bachelor's Degree	Bachelor's Degree or more	Less than Bachelor's degree	Bachelor's Degree or more
Architecture & Engineering	30,322	54,257	21,079	52,369	-9243	-1888
Life, Physical, & Social Sciences	6,078	42,915	6,781	53,672	703	10757
Computer & Mathematical	36,647	85,647	27,178	89,953	-9469	4306
Healthcare Practitioners & Technical Services	66,202	104,040	74,849	131,721	8647	27681
Healthcare Support	57,445	8,129	71,759	11,042	14314	2913
Personal Care & Service	64,168	13,654	87,164	21,966	22996	8312
Production	193,745	16,369	133,970	16,748	-59775	379
Total Degrees in Workforce	454,607	325,011	422,780	377,471	-31827	52460

(Sources: U.S. Census Bureau 2000, 2008-2010 Census and Clifford 2012)

Analyzing the data showed that employment for education levels less than a bachelor's degree had fallen while employment for the labor force with a bachelor's degree or higher had risen. This signifies a demand for more skilled and educated labor that implies an overall increase in innovation. Taking a look at Central Massachusetts workforce education levels gave insight into the contribution this region had on the state as a whole. The data for Central Massachusetts employment is tabulated below.

Table 13: Workforce Education Levels in Central Massachusetts

	2000		2008-2010		Net Change	
Workforce Education Levels in Central Massachusetts	Less than Bachelor's Degree	Bachelor's Degree or more	Less than Bachelor's Degree	Bachelor's Degree or more	Less than Bachelor's Degree	Bachelor's Degree or more
Architecture & Engineering	2,741	3,593	2,009	3,866	-732	273
Life, Physical, & Social Sciences	601	2,353	422	3,438	-179	1,085
Computer & Mathematical	1,905	3,930	1,947	5,325	42	1,395
Healthcare Practitioners & Technical Services	7,223	9,576	7,881	12,433	658	2,857
Healthcare Support	6,461	713	9,311	1,215	2850	502
Personal Care & Service	6,288	1,070	8,669	1,960	2381	890
Production	26,026	1,485	18,958	1,448	-7068	-37
Total Degrees in Workforce	51,245	22,720	49,197	29,685	-2048	6,965

(Sources: U.S. Census Bureau 2000, 2008-2010 Census and Clifford 2012)

Central Massachusetts followed a similar trend as the state increased the education level of the workforce over the past decade. Employment decreased by roughly two thousand for education levels less than a bachelor's degree and increased by almost seven thousand for employees with a bachelor's degree or more. This increase in education levels is important for the growth of the cluster in Central Massachusetts and Worcester County because it signifies a higher level of innovation and a greater demand for specialized skills. The impact that a greater demand for educated labor has on the region is higher wages, the development of more sophisticated products, and business formation. Creating a talent pool in Worcester County is essential for attracting companies large and small to locate to the area to access this resource.

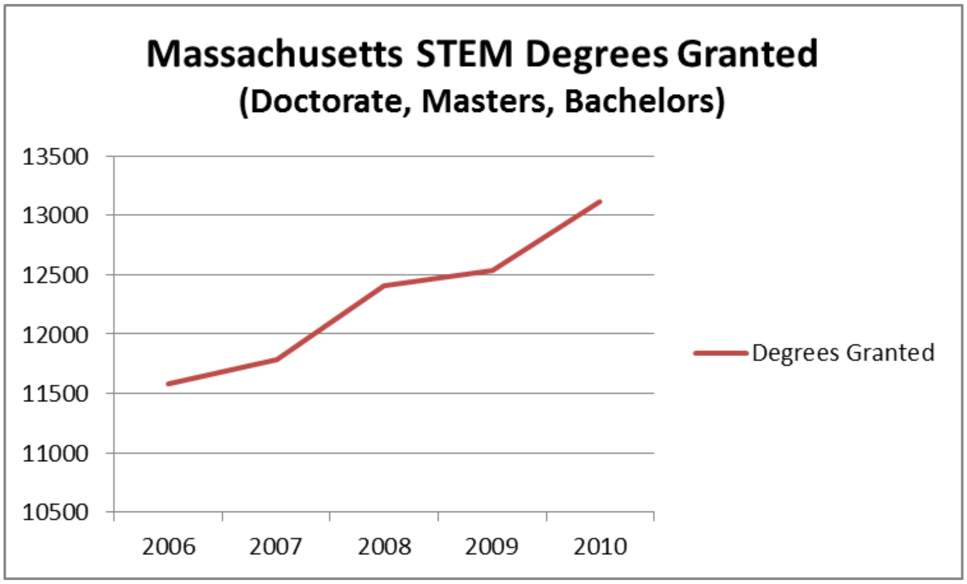
4.6.2 STEM Degrees Awarded

Science, Technology, Engineering, and Mathematic (STEM) Degrees Granted

The National Science Foundation organizes college degrees into 54 general categories, and then more specifically into level of degree. According to Massachusetts Technology Collaborative, there are 5 categories which reflect Science, Technology, Engineering, and Mathematic (STEM) degrees. Science degrees include the categories of *Biological & Biomedical Sciences, Physical Sciences*; technology degrees include *Computer & Information Science and Support Services*; engineering degrees includes *Engineering*; and mathematics degrees include *Mathematics & Statistics*. For this study, doctorate, masters, and bachelor degree data were collected and analyzed.

Below is a graph (Figure 42) documenting the number of doctorate, masters, and bachelor STEM degrees awarded to all Massachusetts colleges from 2006 to 2010. The greatest spike in degrees awarded is observed from 2007 to 2008 and a similar spike is observed from 2009 to 2010. There was a noticeably lower amount of increase in degrees awarded in 2009. The small increase from 2008 to 2009 led to a very large increase in 2009 to 2010. This observation can be made from the 2006 data. A small increase is seen from 2006 to 2007, which then is followed by a very large jump from 2007 to 2008. Possible reasons for small increases in degrees awarded could result from students choosing to stay in school longer due to poor economic situations or students needing advanced degrees to land better jobs. From this small sample size of only five years, a pattern of degree spikes is seen every two years. A larger pool of data is needed to confirm this pattern.

Figure 42: Massachusetts STEM Degrees Granted



Below is a graph (Figure 43) documenting the number of doctorate, masters, and bachelor STEM degrees awarded to all Worcester County colleges from 2006 to 2010. The colleges included in this data are colleges who offer a doctorate, masters, or bachelor degree in the STEM field from 2006 to 2010 and reported to the National Science Foundation. They include Assumption College, Atlantic Union College, Becker College, Clark University, College of the Holy Cross, Fitchburg State College, Massachusetts College of Pharmacy & Allied Health Science, Nichols College, University of Massachusetts at Worcester, Worcester Polytechnic Institute, and Worcester State College. The Worcester County data follows similar patterns to the overall state data. Similar to the state trend, the greatest spike in degrees awarded is observed from 2007 to 2008 followed by the spike from 2009 to 2010. Small increases in degrees granted are observed from 2006 to 2007 and 2008 to 2009. The trend of large spikes in degrees granted every two years holds true for Worcester County colleges.

Figure 43: Worcester County STEM Degrees Granted

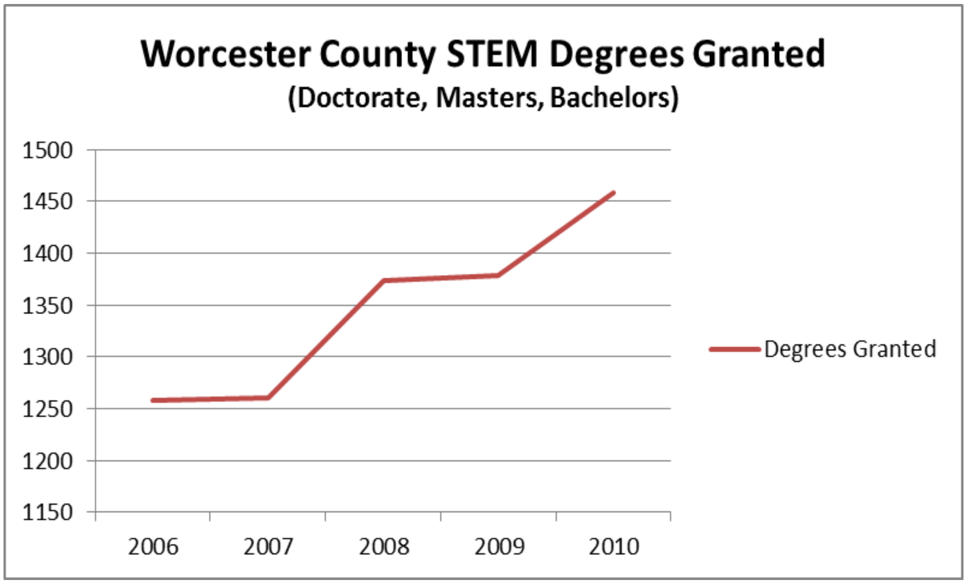
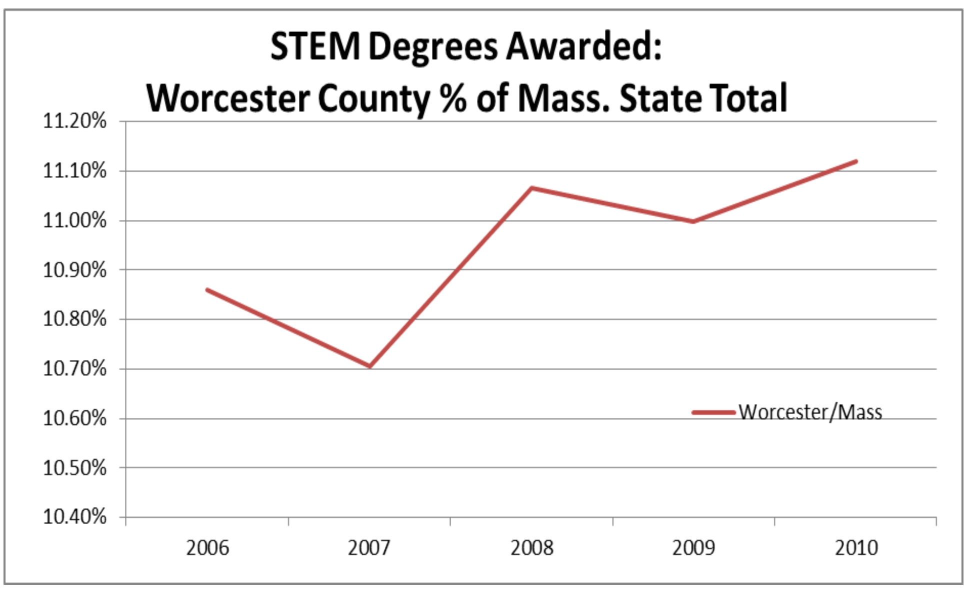
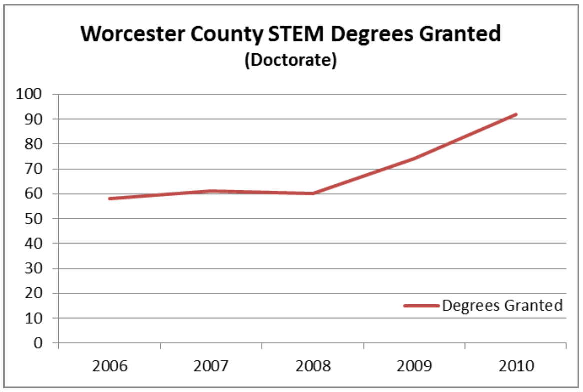


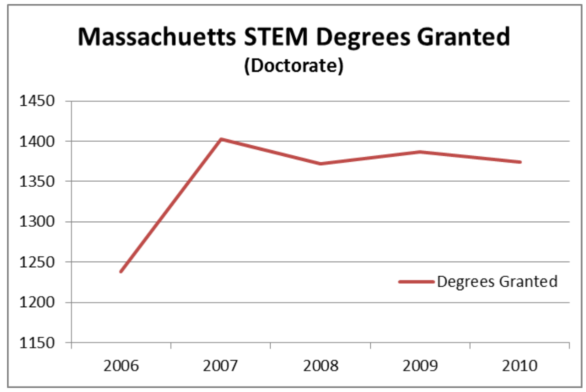
Figure 44: Worcester County % of Mass. STEM Degrees Granted



From 2006 to 2010, Worcester County accounted for about 11% of the total STEM degrees granted in Massachusetts. There is an overall increase over this time period which indicates Worcester County colleges are contributing a larger part to Massachusetts higher education.

Figure 45: STEM Doctorate Degrees Awarded in Worcester County and Massachusetts





From 2008 to 2010 a steady, large increase is observed in the amount of doctorate degrees awarded to Worcester County colleges. In contrast to the Worcester County data, the overall State data has either declined or remained the same. For the state data, a large spike occurred from 2006 to 2007, and in that time, Worcester County remained almost unchanged, concluding that Worcester County did not grow in that time period. 94% of Worcester County's growth from 2006 to 2010 occurred in the last three years. UMass Worcester Medical School accounted for 54% of doctorate degrees.

The data shows Worcester County is competing well in producing qualified people for the workforce. For local companies to compete, they must be able to hire qualified people, and this pool of candidates educated in Worcester County provides just that.

4.7 Conclusions

Analysis of the data compiled lead to an understanding of the strengths and weaknesses of the Worcester County life sciences economy. Strengths of the region included its proximity to Boston and Cambridge, infrastructure, laboratory rental costs, prestigious institutions, skilled workforce, knowledge creation, and ability to attract federal funding. Weaknesses identified included overall distribution of federal funds, ability to attract private investments, overall new business formation, and development of new drugs and sophisticated medical devices.

Locating in a region that is less than 45 miles from the “epicenter” of the biotechnology world, is an advantage not many life sciences regions possess. Worcester County anchors the west end of the Massachusetts life sciences corridor and has the ability to complement from the success of the east. Being a part of this particular regional cluster, Worcester County has the unique opportunity to attract ‘spinoff’ companies from Boston and Cambridge. State of the Art and specialized infrastructure currently in place in Worcester County, coupled with the low cost of renting lab space compared to Boston and Cambridge, will draw ‘spinoff’ companies to the area. Prestigious institutions of learning produce a qualified workforce that is needed to fill professional employment opportunities presented by this innovative industry. Worcester County has a skilled workforce and this is indicated by increased number of degrees awarded by area universities in advanced fields of science, technology, engineering, and mathematics, increased net change of workers who possess a bachelor degree or higher in the region, and an overall increased trend in employment and wages in skilled labor fields. Worcester County shows strength in overall knowledge creation, and is indicated by increases patenting activity, a vital source of innovation. Also, Worcester County demonstrated an ability to either sustain or increase its level of attraction of federal funds as the total funds for the state declined.

Weaknesses facing the region stem from insufficient funding and investments which has seemed to slow new business formation. Federal funding has been determined as a strength of the region solely based on the total volume that has been allocated. The overall distribution of funds is an issue that faces the region. In 2012, 95% of the $150 million in NIH grants was allocated to only three organizations. Angel and Venture capital has been observed to be at low levels in the county as well. The inability of the majority of companies in Worcester County to attract both public and private investments hinders both their productivity and ability to grow operations, as well as affects new business formation. This is exemplified in the fact that there have been zero new drug approvals and pre market approvals for sophisticated medical devices.

5.0 Recommendation

The life sciences industry in Worcester County will be more successful if companies improve their grant writing application process. Since many of the companies are smaller startups, they do not have the resources or expertise to hire a full time grant writer. Therefore, institutions and companies in Worcester County should work to develop a community initiative that will educate companies on how to successfully write these applications. This will ideally develop a special skillset in the region to give these smaller companies the tools they need to be competitive in acquiring federal funding on a consistent basis. One such company that has developed this skillset within their workforce is Biomedical Research Models. They have trained their employees to become successful grant writers and the benefits of doing this is reflected in the amount of funding they have attracted on a consistent basis over the last decade. Using this model for the rest of Worcester County and coupling it with innovative ideas will be an important step to take the development of this cluster to new heights.

After a review of the investment portfolios of all Massachusetts based Angel groups, the amount of investment in Worcester County based life sciences companies was determined to be smaller than that of other life sciences clusters. This lack of funding in startup, early, and expansion stage companies hinders their ability to expand to a size where they can successfully attract larger investments through Venture capital sources. An extremely important determining factor for companies securing investments results simply from a personal recommendation in support of the company, by someone the investment group respects and trusts. Marc E. Goldberg, Managing Director for BioVenture Investors, mentioned that this is one of the “secrets” of securing investments, and that the only investments he has ever made in his career, have come with a recommendation made by a trusted individual. This tip was confirmed by David Verrill, Managing Director of Hub Angel Investment Group, LLC.

Angel groups and Venture groups receive upwards of 1,000 applications for funding a year, and only extensively review approximately 100. By networking and developing relationships with Boston based Angels and Ventures, Worcester County companies will be gaining an advantage with investors to increase their likelihood of securing investments. The

Boynton Angels have a small number of investors which has minimized their ability to make numerous investments in the area. It would be beneficial to the growth of Worcester County companies if the Boynton Angel group was further developed and more investors were added.

In recent years, large drug companies have experienced a major challenge due to the expiration of patents of major drugs already on the market known as the "patent cliff" (Rothwell, 2013, pg. A10) . The patent cliff is described as "the unprecedented number of patents expired on drugs worth billions of dollars in sales" (Rothwell, 2013, pg. A10). This is allowing for generic brands to slowly replace these billion dollar drugs and slash the revenue of large companies significantly. However, what has come to be known as the "patent cliff" is dissipating as big pharma companies are beginning to pursue a new business model (Rothwell, 2013, pg. A10). This new business model involves the relationship between academia, health care providers, drug makers, and biotechnology makers (Rothwell, 2013). Worcester County should adapt this model by utilizing one of its strengths which perhaps holds the most potential for the region. On January 30th, 2013, a $400 million facility, the Albert Sherman Center, was opened at the UMass Medical School (McCluskey, 2013). The goal of this center is to encourage collaboration and bring together researchers who currently work in different locations (McCluskey, 2013, pg.A8).

The research in this building will lead to developments in new treatments for disease, which has become the focus of large pharmaceuticals that are searching for new ways to increase their revenue. Developing a partnership between these large companies and UMass Medical may prove beneficial to the life sciences economy in Worcester County because of the contributions each side can make. With recent budget cuts set to take place for federal funding, research universities will need to find other sources of funding (McCluskey, 2013, pg.A8). This partnership will provide the researchers with the funding that larger companies already possess, and in turn make up for the budget cuts that will affect the work conducted at universities like UMass Medical. Larger companies will also benefit from this collaboration because they will team up with the talent available in the universities, and with a streamlined research process, effectively develop the next big name drug that will generate billions of dollars in revenue. This relationship between academia and private investors is already being taken advantage of in the Boston/Cambridge area with local hospitals, so it would be an avenue that Worcester County may find success in.

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Appendix

Appendix A: Interview Protocol

1. Out of the fifteen indicators we have identified, which ones do you think are required to sustain the Worcester life science cluster?
    a. Why?
    b. Are there other required ones that we should identify?

2. Which indicators are unique to this Worcester region?

3. What groups/companies are involved in the Worcester County cluster?
    a. Specifically, what biotech companies?

4. How do groups/companies operate with one another in the cluster setting?

5. What other clusters can serve as a model for comparison to Worcester County?
6. Can you give us data specific to Worcester County? or, can you tell us how to access those data?

Appendix B: Peter Abair Interview

Interview Date and Time: 22 January, 2013; 11:30 AM

Purpose of the Interview:

The purpose of the interview was to gain a better understanding of the identified indicators and to determine which indicators are essential for the growth of life science industry in Worcester County, MA through an industry expert who has hands-on experience with such matters. Prior to the interview, he had already sent useful resources that would help the MBI group advance their research.

Interviewee:

Peter Abair- Director, Economic Development & Global Affairs, Massachusetts Biotechnology Council
Telephone: 617-674-5130
Email: peter.abair@massbio.org

The Massachusetts Biomedical Initiatives (MBI) group contacted Mr. Abair for a knowledgeable discussion on the sixteen indicators and their impact on the life science industry. He was identified to be a resourceful contact in terms of getting access to and gathering data specific to Worcester County. The MBI group determined that his vast knowledge on many aspects of the indicators and life science industry would be able to assist us in our research.

Interview Transcript:

MBI Group: Good Morning Mr. Abair! We are the Massachusetts Biomedical Initiatives Interactive Qualifying Project Team. I am Ehab Hamdan, Junior minoring in Civil Engineering at WPI. This is John Antonopoulos, also a Civil Engineering major here. I am Poonam Barot, majoring in Biology. I am Monolina Binny, majoring in Biology and Biotechnology here and I am also a junior. First, we would like to thank you for taking the time out of your day to speak with us and also thank you for all the information that you have given us so far. The information has proven to be very helpful.

Mr. Abair: Great!

MBI Group: Before we proceed with the interview, Is it alright if we record this?

Mr. Abair: Sure, no problem.

MBI Group: Thank you. Since you gave us a lot of information already, we will start off by asking out of the sixteen indicators we have given you, which ones will be beneficial to us and we should further look into? And, which one should we just throw out of the window and replace with other ones?

Mr. Abair: Well, I have a general idea about the purpose of the study, but if you could spend a little time describing the purpose and who the audience is for your project that will be helpful for me.

MBI Group: By March 1st, we want to have an Executive Summary to present to Kevin O'Sullivan, who is the CEO of MBI. We will be breaking down the Worcester County life science's cluster and basically tell him how the life science cluster in Worcester County is doing right now. Also suggest any recommendations we might have and identify what Worcester County is doing well in and what the County needs to improve on in terms of progress in the industry. This is the purpose of our project.

Mr. Abair: Ok, so certainly the employment growth and the trends in employment will be interesting to see overtime. At MassBio, we used to do a County-by-County basis report, but we have not done much on the County level for the last four to five years. I can dig up some of the older stuff that we did and send it your way. However, that data is of course not up-to-date with the past few years. We also used a different data source- we used the Census Bureau's County Business Patterns. The information there is good and available on a County basis, but it is also slow- almost a year and a half behind. So, it is difficult to use on a timely basis. We found it easier to use the quarterly census of employment and wages from the Bureau of Labor and Statistics because it is more directly connected to the State sources, which is called the ES202-Employment Data. The Bureau of Labor Statistics data is build off of that. So, even our older stuff that we can throw at you was based on sort of older and different data sources. I think in terms of doing employment trends, the quarterly census of employment and wages works well and the website is easy to use- it shows that Worcester has a very strong standing and is comparative to other clusters around the country. There are certainly larger clusters and when you separate Worcester from the Massachusetts clusters, we found the numbers are interesting to look at in that context because Worcester does well on its own. Worcester did develop something in a fashion as a cluster onto itself and has been part of the larger Massachusetts cluster, which has its core in Cambridge, but it has very distinct identity and its reforms over the years sort of suggest that. So, looking at those trends, such as employment trends, and number of establishments in the sector over the years as well, I think would certainly be a good place to start. It may be even, though I don't know this for a fact, the number of employees may have gone up and number of establishments may have gone down. I am not sure, but that is what I sometimes see when I look at different clusters because they have a greater concentration of employment at large or employers or not- well that's an interesting thing to take note of as well. It's good to have some big players in any cluster and it is also pretty critical to have a start-up creation happening in the early stage companies because that helps fuel innovation and growth in the future. Looking at number and size as much possible of the establishments is helpful. I think some of the workforce education levels is important for contacts, in terms of how if there is certainly an issue that the education levels in the area are going down, and that can be supportive for the industry by tracking down the industry. The FBIRR information is again useful. There is certain percentage of companies in the industry that take advantage of the FBIRR dollars and they are typically companies that are not venture-backed and they use FBIRR funds as long as they can before they have a different business strategy after that, but again these are all typically early stage companies that use the FBIRR. I didn't see that you had venture capital in the list you provided me with?

MBI Group: We had venture capital originally, but after speaking with Kevin O'Sullivan and our advisor, we found out that venture capital is not really available or offered that much in Worcester. So, that's why we are supposed to be looking at funding, specifically angel funding.

Mr. Abair: Ok, do you have a source for that at this point? It is not easy to gather so much specific data.

MBI Group: Yes right. John is doing some research on different kind of funding and he is going to start looking more specifically into the Worcester County. We just wanted to find some sources that would tell us where private funding is going to, specifically to which companies if the information is available?

Mr. Abair: There is a great national website that we use for aggregate information and you can get it on a State-basis but not below that and it's PWC [Pricewaterhouse Coopers] Money Tree™ Report. It is a terrific database but it does not break down below the State-level. So, only a handful of these will be needing industry database and there are bunch of other information out there. It is probably an area I can help out with and provide some data to you because we subscribe to an industry database called EvaluatePharma® and from that you will be able to pull up, for example, the M&A, the Merger and Acquisition data that you might be looking for under indicator thirteen, and the number of IPOs. The information is out there in other third party reports that as been done before or you can get them in one of these industry databases. And that is something I can probably pull up together for you, along with the rough statistics, and you can go take it from there. I might be able to pull this up by State-wide basis but I might probably be able to include the city or town data that the different companies are in or the mergers that different companies have and you can take the information and write with that. I would be happy to help you that and also these database costs fifteen to twenty thousand dollars each year so you would not be able to subscribe to that. So, that is something I can knock-off. Angel funding is a little more difficult to track. These databases have some of it, but we have to see what we can come up with. So, going back down to the list- approvals of pharmaceuticals and medical devices are also difficult using the free databases out there. I don't know if anybody has gone to the FDA?

MBI Group. Yes, I [Ehab Hamdan] took a look at it and didn't find a lot of information. It just said there was one approval last year in Massachusetts.

Mr. Abair: Yes it's not easy to navigate and I never spent a lot of time to figure it out. Some of these government databases are jammed, like the Bureau of Labor and Statistics makes it easy but the FDA does not. So, that is another I can look at in the industry database. The problem is our database is very Biotech Pharma oriented and there is not much medical devices information, but I can certainly give you information on the approvals but not the medical devices information.

MBI Group: Well, do you think this indicator would be helpful in understanding the Worcester County cluster or should we find another indicator to look at?

Mr. Abair: I think if you are measuring the Worcester versus other regions, one way you can do that is if you look at clusters around the country and rate of approvals for Worcester-based companies versus the rate of approvals in these other areas and that might be interesting to see. On the drug side, there has been within about two hundred and fifty to about two hundred and sixty approvals for drugs developed by Massachusetts head-quarter companies. The problem in considerate in Worcester is Abbott [Laboratories] has probably developed products out of the facilities in Worcester, but Abbott headquarters is based in Illinois. So, Worcester and Massachusetts quite does not get credit for that drug development which ends up going to Illinois in the way they track the data. So the amount of activity, let's say in the twenty years spread, is going to be limited out of Worcester. So, it is not going to be a striking number and it would be something you want to compare to other similar-sized clusters, but then also requires a lot more work. But maybe, it is something like getting all these data, then what you can do with it might be something rather limited. It might be something to know to expand in a particular direction. On the other hand, the federal research funding which again is easily available in an easy manner from the National Institute of Health website, that link is included in what I sent. That's great data and we definitely have a couple institutions there that are beneficiaries of it and that's good to track overtime to see what the trends are. I would expect that UMass at Worcester has grown its share of those dollars over the years, so that is easy to get. Though it is not broken down already, but you can cut it by institution. Knowing the institutions first who received those NIH funds in Worcester and then tracking the trends and analysis overtime. So, that's a great indicator. Patents, I think, should be helpful. I have not done any of it really and we kind of rely on third-party reports out there on that, so other than doing a web search, I don't have a good guidance on that. Licensing, again, will be pretty difficult to get information on without the industry databases. You can get that information out of UMass, for example, has its license data over the years and they would be able to provide, as well as WPI, but that does not give you what has happened in the private sector in terms of their companies developing in intellectual property and then licensing it out to other companies. I don't know where to get that information other than from one of these industry databases. That again is something which would suggest looking at trends overtime and levels of activity that speak to the vibrancy of the cluster that is based in Worcester and whether or not it is growing new technologies at a greater rate than earlier time. That is a good indicator and something I could probably assist you with, in terms of giving you some pretty rough data, which I can download and send it your way. I guess, in terms of looking at this information, what is the timeline you would be looking at? Is it 1985 and forward or do you want to look at it for the last ten to five years? What exactly, do you think of the timeline?

MBI Group: We think, the recent data from the last five years is the period we want to look at. We don't want to go back all the way to 1985.

Mr. Abair: Good. So, for indicator number 2 and 7 I should be able to gather information and send it your way. For biomanufacturing, I sent in the email, there is an organization out there called Biomanufacturing Roundtable- they pull together some information which is fairly current, like a couple years old maybe at this point. One of the nice things they discovered that New England, including Massachusetts, New Hampshire and Rhode Island have the greatest capacity of mammalian cell culture as measured by leaders of capacity that produce these products and that is sort of the cutting edge of the biomanufacturing industry and it's something we did not really know. We didn't realize that there is such concentration of that capacity here. So, along with microbial manufacturing capacity, those are the numbers Elizabeth Beckrenolds pulled together. I can ask her for that information or I can give you her contact information for that information. A conversation with her would enable you to get that information and you can cut it down to Worcester. Worcester County would certainly be avid as a manufacturer. Is Devens part of Worcester County or Middlesex?

MBI Group: We are not sure.

Mr. Abair: Devens, which is part of the Old Fort Devens, above route 2.

MBI Group: It is part of Worcester County [web search].

Mr. Abair: Well that is the largest bulk biomanufacturing facility in the Western Hemisphere I think. At least it was when it was first build. That's a lot of capacity there and then you have Abbott and some smaller contract manufacturing organizations that are probably in Worcester as well. It is a finite number though and you can get that information from Elizabeth in terms of capacity. To know what the capacity of the area is to serve the needs of commercialization and manufacturing side of the industry. We have the Snapshot to describe why that is important. The science degrees awarded is good information database is good to find that information, but I am not sure how the new layout of that database accommodates the data. I have gotten that information from that site before and used it. I have also asked UMass to provide that information and the stuff I have from them is pretty old, from 2008. So, going back to the database see if you can extract the information from there. I would start with IPEDs?? Tell me more about the Capital and Human resources, including construction, indicator. Is it expenditures?

MBI Group: Our sponsor and advisor told us to focus on facilities located in Worcester, like how many life science building are in each college and also, what is their purpose and how are they focused in the industry? Like, for example, WPI recently built two building at Gateway Park. I think, they want us to look at all of Worcester County and who is building life science buildings and what these schools are focused on, for example buildings like UMass Medical.

Mr. Abair: So, that ties into indicator number 14 as I would expect.

MBI Group: And what types of equipment are in these facilities.

Mr. Abair: In terms of lab inventory, information concerning what is available in the market is available to brokers. I could send you the contact of this one organization that does a great job for that. All these different brokers who specialize in the life sciences have good information on where the spaces are and what is in the spaces. I would recommend you get in contact with someone from CBRE, I can't recall her name at the top of my head. CB Richard Ellis is a big commercial broker; they have a specialty in the life sciences and lab market. They do really good quarterly report. I can get you in contact with the individual who develops that report and publishes it every quarter. I am sure she would be happy to provide you with Worcester-specific information on lab inventory. Lab inventory is going to be the commercially available lab and so then it would be very interesting to know and it is something I don't know in my own backyard here in Cambridge. What the research institutions hire at lab space and how much it accounts for, as in how much is it and what are the specialties and that sort of thing. But you have, again, finite number of those facilities in Worcester, so, I think it would be the same process like working with UMass, WPI and that sort of doing an accounting of what is there and having that sort of inventory, finding out what is there in the higher end of the non-profit side and on the commercial space side. It is a great thing to highlight, to understand and it is a good metric to go forward with, in terms of growth, in both of those sectors. We already sort of discussed funding, mergers, M&A activities, IPOs. Looking back five years, I can pull that information and send it your way. It will be like angel information and also the way this information will be called up is it will have Massachusetts head-quartered companies. So again, if it is a licensing deal between Abbott in Worcester and somebody out of the State that has value, we are not going to catch that because the Abbott numbers go to Illinois for no good reason. But I can pull that stuff together and send it your way. Number 12, business formation is, I think, would be great metric. Other than really looking at M&A activities, the IPOs and funding, it is really difficult to figure out who is new on the scene and what new companies are being created because some of these companies are below the radar and there are lots of virtual companies out there. Some of these companies can be formed and then gone out of business in the same year- the industry is for some early stage companies pretty fragile. I don't know a good place to go and get that information. You folks might have discovered one, but I don't know how to access that information easily. I like the idea though.

MBI Group: We will try to figure it out.

Mr. Abair: So for creating a business, you go to town hall, you get a certificate and you are in business, you are known locally. Then there is a process of corporation and that is through the Secondary State Office. It's public information but it is not provided easily. You might want to take a look at the Secondary State Office; however, I think their stuff is not updated, maybe that has changed, but that would be a place to look at. Otherwise, I think it is pretty difficult. Occupations and wages- that is easy stuff to find. The Illustrator website has that information. They also do projection, but I am not sure if they do projections on a County basis, and it is based on what happened in the last ten years and they sort of just flip it forward for the ten years and based on these projections they have new jobs in the job and occupation classifications - these are the number of replacement jobs that have to be part of that in addition to the new jobs to replace jobs that are leaving because of retirement. So that is a good website and fun to use. I think they might even break information down to Community level, but I haven't been on there in a while. Again, good indicator!

MBI Group: I [Poonam Barot] have one question on the lab inventory that we were talking about. In your Snapshot you have a slide on lab inventory growth, I was just wondering how you came up with those numbers, was there a specific site you looked at?

Mr. Abair: We did that by looking at different information from the brokers. We have able to compile all that from the year 2007. There are commercial reports that these brokers put out what the lab market looks like, so we had that amount of history. Recently, when we tried to go back to the year 2000, we did not have the hardcopy fiscal reports, the contacts of the couple researchers who put that information and we did not have any information prior to the year 2005. They were not tracking lab inventory before that. The information was mostly part of industrial space or office space. They did not break it out in terms of lab space. I will be happy to send contact information for; I can't remember the name at the top of my head. Merith and Greu? They have done a good job on that sector. She is probably a good source to know what the commercial lab space is in Worcester and probably even the addresses of the physical spaces out there. It is pretty known, I think Kevin O' Sullivan has a pretty good idea about where everything is. If you get out of Worcester, you definitely want to have a verifiable source for that because there is always something that could be beyond somebody's knowledge. There is lab space in Shrewsbury, but most of it is going to be in Worcester. So Kevin has a lot of lab space in MBI, then you have Alexandria Real Estate Equities that have pretty substantial share of the market out there in terms of commercial space. If you combine those two and the WPI facilities in Gateway that is probably going to be I would guess 75 percent of the whole market. For the other 25 percent having a third person source would be helpful.

MBI Group: Thank you. Also, I [John Antonopoulos] have a question. Another piece of our project is that after compiling all the data, Kevin wanted something where we can breakdown and advertise to companies saying this is what we have in Worcester. Do you think there are any other areas or indicators that would be enticing to them and they would want to relocate their companies to Worcester?

Mr. Abair: That is a great question. I think one of the arguments about moving to Worcester is the cost structure and capturing that in terms of employment and occupations and wages would be good. You can do that by comparing between Worcester County and Middlesex County for example and there is going to be a difference there, or Worcester and New York or New Jersey for that matter. The competition is that we are in Massachusetts, where within an hour of Cambridge and international airport and we are at x percentage less cost in terms of real estate, in terms of wages than Cambridge or Waltham for that matter. We are less expensive than core industries of Cambridge. We have all these capacity over here and we have a lot of assets and that is a potential compelling case. To see what about clusters beyond Massachusetts, what is cost in Worcester versus New Haven, which is sort of the base industry in Connecticut, New Jersey, Philadelphia are also competitive market places and Worcester will probably compare well in terms of cost to those different areas. That might be interesting information to have. So you can look at what State and government has information about wage for, let say you pick fifteen industry occupations and compare the wages in Worcester, Middlesex County, New Haven or sort of the Princeton area or New Jersey for example. I think that would be interesting if you can find anything else other than using those variables and same for lab costs. Labs in Worcester are based on per square foot area, for example in Cambridge it is 55 to 60 dollars per square foot and in Waltham it is in the 30s. That is something to compare and contrast. If you could find a good geographic based cost of living index, because that is one area I have failed in the past to really find good sources. If you can find that then you can apply that Worcester has all these resources, it has proximity to Cambridge and see if it has the same cost of living as a different cluster such as North Carolina or Saint Louis area, that would be interesting.

MBI Group: Well that is all that we want to get out of you. Thank you, we appreciate your time. Thank you for the information, it was really helpful.

Mr. Abair: Well I would love to provide you information about the contacts of drug approvals, licensing, mergers and IPOs. I know providing you the information sooner would be better, but when will you like to have it?

MBI Group: Soon as possible. We are doing this research on these indicators and by the end of the next week we should be done with the basic research on these indicators. If you are not able to give us the information until after next week, it is not a huge issue.

Mr. Abair: I should have little time this week. It might be half an hour or might be three hours to pull up the information from these databases, but it depends on being able to start the search. Sometimes it is easy to extract something and sometimes it is surprising how difficult it is to extract such information. Anyway, I will look at the information this week and get you all the contacts and I will work on the other stuff this week. Well. Feel free to call back with any questions. Glad that you have a good team there.

MBI Group: Thank you, you helped a lot. Take care.

Mr. Abair: Take care.

Appendix C: Occupations and Wages

Raw Data for Total Wages in Worcester County in Thousands (2005-2010)

	NAICS 334510 Electromedical apparatus manufacturing	NAICS 339112 Surgical and medical instrument manufacturing	NAICS 339115 Ophthalmic goods manufacturing	NAICS 3254 Pharmaceutical and medicine manufacturing	NAICS 541711 Research and development in biotechnology	NAICS 541712 Other physical and biological research	NAICS 54138 Testing laboratories	NAICS 622 Hospitals	NAICS 61131 Colleges and universities	NAICS 339113 Surgical appliance and supplies manufacturing	Life Sciences
Year	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	
2005	25345	6307	38225	96574			10798	30918	3779		211946.12
2006	17930	5492	45339	108786			12004	34741	4208		228500.06
2007	20632	6003	39905	108901	98988	12653	14669	38773	4427	1332	346282.092
2008	22944	9571	39628	119792	102552	12908	14888	43426	4637	1805	372150.348
2009	17762	6160	38745	110252	110742	13426	12853	46524	5083	2054	363600.703
2010	18526	19870	36393	125378	121838	14334	10895	47996	5052	2375	402656.996
2011	18826	22465		80871	194703	11385	3903	49387	5585		387125.891

Raw Data for Total Wages in Massachusetts (2005-2010)

	NAICS 334510 Electromedical apparatus manufacturing	NAICS 339112 Surgical and medical instrument manufacturing	NAICS 339115 Ophthalmic goods manufacturing	NAICS 3254 Pharmaceutical and medicine manufacturing	NAICS 541711 Research and development in biotechnology	NAICS 541712 Other physical and biological research	NAICS 54138 Testing laboratories	NAICS 622 Hospitals	NAICS 61131 Colleges and universities	NAICS 339113 Surgical appliance and supplies manufacturing	LIFE SCIENCES	Life Sciences
Year	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**		
2005	308181	476985	52536	778610			125401	367930	81162	119109	2309912.95	
2006	386192	487085	62567	796137			132634	396219	84678	136527	2482039.02	
2007	441556	484552	54232	1171160	2728427	276369	139781	430243	91771	199247	6017338.09	
2008	447641	504393	61448	972846	3315035	304154	151031	468829	97771	174707	6497854.13	
2009	481467	505626	60025	987965	3191178	304037	142284	487548	100858	162575	6423563.26	
2010	539548	546553	59685	1003609	3364165	375514	75103	519384	106948	164319	6754827.49	
2011	615439	553953	46729	952204	3769849	392539	69068	529238	112984	165608	7207611.44	

Appendix D: Employment Growth

Raw Data for Total Number of Employees in Worcester County (2005-2010)

	NAICS 334510 Electro medical apparatus manufacturing	NAICS 339112 Surgical and medical instrument manufacturing	NAICS 339115 Ophthalmic goods manufacturing	NAICS 3254 Pharmaceutical and medicine manufacturing	NAICS 541711 Research and development in biotechnology	NAICS 541712 Other physical and biological research	NAICS 54138 Testing laboratories	NAICS 622 Hospitals	NAICS 61131 Colleges and universities	NAICS 339113 Surgical appliance and supplies manufacturing	Life Sciences
Year	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	
2005	3265	6809	1205	7777			1947	7222	1509	2175	31908.3
2006	4258	6498	1244	7944			2013	7425	1576	2321	33279.2
2007	4539	6268	1196	9139	24565	2871	2074	7749	1612	2797	62809.7
2008	4701	6085	1134	9581	26439	3124	2151	7880	1634	2659	65387.6
2009	5163	5753	1067	9706	26759	3074	2083	7964	1620	2497	65685.4
2010	5194	6088	1041	9500	26812	3829	1002	8214	1593	2406	65679.3
2011	5689	6325	842	8537	28180	3971	931	8228	1631	2463	66796.8

Raw Data for Total Number of Employees in Massachusetts (2005-2010)

	NAICS 334510 Electro medical apparatus manufacturing	NAICS 339112 Surgical and medical instrument manufacturing	NAICS 339115 Ophthalmic goods manufacturing	NAICS 3254 Pharmaceutical and medicine manufacturing	NAICS 541711 Research and development in biotechnology	NAICS 541712 Other physical and biological research	NAICS 54138 Testing laboratories	NAICS 622 Hospitals	NAICS 61131 Colleges and universities	NAICS 339113 Surgical appliance and supplies manufacturing	Life Sciences
Year	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	
2005	246	101	887	1217			204	676	87		3419.2
2006	243	66	940	1277			223	709	95		3553.1
2007	255	72	877	1312	1061	117	241	737	98	32	4801.3
2008	219	74	752	1337	1121	128	238	779	100	41	4788.2
2009	216	73	693	1249	1174	130	208	793	106	41	4682.3
2010	218	389	641	1206	1248	140	169	797	108	43	4959.8
2011	206	471		701	1842	128	72	796	108		4323.7

Appendix E: Research and Development

Raw Data for Research and Development Contracts in Worcester County

NIH R&D contracts	2004	2005	2006	2007	2008	2009	2010	2011
UMASS Med School	$5,263,468	$2,466,338	$1,104,273		$1,178,772	$185,389	$1,041,446	$3,302,969
Biomedical Research Models Inc.			$2,000,000		$767,501			
Individual Award- Conuel, Thomas				$12,000				
Jeffrey D. Mancevice				$8,870				
Security Engineered Machinery Company				$46,800				
Seracare Life Sciences Inc.					$10,497,976	$7,587,578	$3,333,763	$6,695,460
Total	$5,263,468	$2,466,338	$3,104,273	$67,670	$12,444,249	$7,772,967	$4,375,209	$9,998,429

Appendix F: Patents

Patents in Worcester County

Class	Class Title	2006	2007	2008	2009	2010	Total
424	Drug, Bio-Affecting and Body Treating Compositions (includes Class 514)	18	17	26	20	47	128
435	Chemistry: Molecular Biology and Microbiology	13	11	12	13	19	68
430	Radiation Imagery Chemistry: Process, Composition, or Product Thereof	10	11	9	4	10	44
532	Organic Compounds (includes Classes 532-570)	6	10	5	9	10	40
128	Surgery (includes Class 600)	5	7	3	7	11	33
210	Liquid Purification or Separation	3	7	3	4	12	29
606	Surgery (instruments)	6	2	1	4	15	28
604	Surgery (Medicators and Receptors)	2	5	1	3	7	18
623	Prosthesis (i.e., Artificial Body Members), Parts Thereof, or Aids and Accessories Therefor	3	0	1	6	7	17
520	Synthetic Resins or Natural Rubbers (includes Classes 520-528)	4	3	1	3	5	16
382	Image Analysis	3	5	4	0	2	14
530	Chemistry: Natural Resins or Derivatives; Peptides or Proteins; Lignins or Reaction Products Thereof	2	3	3	3	3	14
436	Chemistry: Analytical and Immunological Testing	0	0	1	5	5	11

422	Chemical Apparatus and Process Disinfecting, Deodorizing, Preserving, or Sterilizing	0	0	1	3	4	8
73	Measuring and Testing	2	1	2	1	1	7
137	Fluid Handling	0	1	0	3	3	7
222	Dispensing (apparatus and process)	0	1	3	1	2	7
423	Chemistry of Inorganic Compounds	1	1	0	1	4	7
429	Chemistry: Electrical Current Producing Apparatus, Product, and Process	2	2	1	1	1	7
95	Gas Separation: Processes	0	3	1	1	1	6
119	Animal Husbandry	1	1	1	1	1	5
156	Adhesive Bonding and Miscellaneous Chemical Manufacture	2	0	2	1	0	5
204	Chemistry: Electrical and Wave Energy	0	2	1	1	1	5
241	Solid Material Comminution or Disintegration	1	1	1	2	0	5
607	Surgery: Light, Thermal, and Electrical Application	1	1	2	1	0	5
261	Gas and Liquid Contact Apparatus	1	0	2	0	0	3
800	Multicellular Living Organisms and Unmodified Parts Thereof and Related Processes	0	0	0	2	1	3
55	Gas Separation	1	0	0	1	0	2
351	Optics: Eye Examining, Vision Testing and Correcting	0	0	2	0	0	2
494	Imperforate Bowl: Centrifugal Separators	1	0	0	0	1	2
585	Chemistry of Hydrocarbon Compounds	0	0	0	1	1	2
602	Surgery: Splint, Brace, or Bandage	0	0	0	2	0	2

433	Dentistry	0	1	0	0	0	1
601	Surgery: Kinesitherapy	0	0	1	0	0	1
	All Life Science Patents	88	96	90	104	174	552

Appendix G: 2012 Premarket Notifications in Massachusetts

KNUMBER	APPLICANT	CONTACT	STREET1	STREET2	CITY	STATE	ZIP	DEVICE NAME	DATE RECEIVED	DECISION DATE
K122203	BOSTON SCIENTIFIC CORP.	LAURIE PANNELLA	100 BOSTON SCIENTIFIC WAY		MARLBOROUGH	MA	01752	TRUETOME	25-Jul-12	17-Aug-12
K122118	CODMAN & SHURTLEFF, INC.	KATHY STRANGE	325 PARAMOUNT DR.		RAYNHAM	MA	02767 0350	HAKIM PROGRAMMABLE AND PRECISION VALVE SHUNT SYSTEM	17-Jul-12	03-Aug-12
K122086	MICROLINE SURGICAL, INC	WILLIAM MCCALLUM	800 CUMMING CENTER	SUITE 166T	BEVERLY	MA	01915	THERMAL LIGATING SHEARS	16-Jul-12	23-Aug-12
K121839	LEMAITRE VASCULAR INC.	ANDREW HODGKINSON	63 SECOND AVENUE		BEDFORD	MA	01803	UNBALLOON NON-OCCLUSIVE MODELING CATHETER	09-Jul-12	08-Aug-12
K121974	CONFORMIS, INC.	AMITA S SHAH	11 NORTH AVENUE		BURLINGTON	MA	01803	CONFORMIS IUNI UNICONDYLAR KNEE REPLACEMENT SYSTEM	09-Jul-12	06-Sep-12
K121990	NAVILYST MEDICAL, INC.	MARION W GORDON	26 FOREST STREET		MARLBOROUGH	MA	01752	PICC CONVENIENCE KIT	06-Jul-12	03-Aug-12

K121954	NAVILYST MEDICAL, INC.	WANDA CARPINELLA	26 FOREST STREET		MARLBOROUGH	MA	01752	NMI MICROCATHETER	03-Jul-12	17-Jul-12
K121868	HOLOGIC, INC.	SARAH FAIRFIELD	250 CAMPUS DRIVE		MARLBOROUGH	MA	01752	MYOSURE LITE TISSUE REMOVAL DEVICE (1 PACK), MYOSURE LITE TISSUE REMOVAL DEVICE (3 PACK)	26-Jun-12	19-Jul-12
K121789	WUHU SNNA MEDICAL TREATMENT APPLIANCE TECHNOLOGY CO., LTD	CYNTHIA NOLTE	49 PLAIN STREET		N. ATTLEBORO	MA	02760	SHANGRING	19-Jun-12	03-Aug-12
K121776	CODMAN & SHURTLEFF, INC.	JOAN BARTLE	325 PARAMOUNT DR.		RAYNHAM	MA	02767 0350	AGILITY STEERABLE GUIDEWIRE NEUROSCOUT STEERABLE GUDIEWIRE	18-Jun-12	14-Aug-12
K121678	GYRUS ACMI, INC.	DOLAN MILLS	136 TURNPIKE RD.		SOUTHBOROUGH	MA	01772	DTAD	07-Jun-12	30-Aug-12
K121604	OBP CORPORATION	JASON SWIFT	360 MERRIMACK STREET	BUILDING 9	LAWRENCE	MA	01843	ANOSPEC DISPOSABLE ANSOSCOPE WITH LIGHT	01-Jun-12	27-Jul-12
K121367	ZOLL MEDICAL CORPORATION	CHARLES W KOLIFRATH	269 MILL ROAD		CHELMSFORD	MA	01824	ZOLL PROPAQ XM	07-May-12	21-Jun-12
K121229	SORIN GROUP ITALIA S.R.L.	BARRY SALL	195 WEST STREET		WALTHAM	MA	02451	INSPIRE 8 DUAL HOLLOW FIBER OXYGENATOR WITH WITH INTEGRATED HARDSHELL	24-Apr-12	23-Jul-12

								VENOUS/CARDIOTOMY		
K121223	PHILIPS ULTRASOUND, INC.	PENNY GRECO	3000 MINUTEMAN RD.		ANDOVER	MA	01810	QLAB WITH FHN AND VPQ PLUG-IN	23-Apr-12	15-May-12
K121184	NEUROMETRIX, INC.	RAINER MAAS	62 FOURTH AVE.		WALTHAM	MA	02451	SENSUS	18-Apr-12	02-Aug-12
K121186	BOSTON SCIENTIFIC CORP.	CORRIE GOODING	100 BOSTON SCIENTIFIC WAY		MARLBOROUGH	MA	01752	RADIAL JAW 4 PULMONARY BIOPSY FORCEPS	18-Apr-12	16-May-12
K121140	DIAMOND DIAGNOSTICS, INC	KATHY CRUZ	333 Fiske St		Holliston	MA	01746	PROLYTE ELECTROLYTE ANALYZER	16-Apr-12	22-Aug-12
K121139	COVIDIEN LLC	JAMES MCMAHON	15 CROSBY DR		BEDFORD	MA	01730	ACCUMESH DEPLOYMENT SYSTEM	16-Apr-12	02-May-12
K121131	STRAUMANN USA	ELAINE ALAN	60 MINUTEMAN ROAD		ANDOVER	MA	01810	BL, 04.1 MM RC, SLACTIVE 8MM, TIZR AND 10MM, 12, 14MM	13-Apr-12	06-Jun-12
K121127	CYNOSURE, INC.	IRINA KULINETS	5 CARLISLE ROAD		WESTFORD	MA	01886	SIDELAZE LASER BEAM DELIVERY ACCESSORY FOR CYNOSURE 1440NM WAVELENGTH LASERS	13-Apr-12	13-May-12
K121089	NAVILYST MEDICAL, INC.	LORRAINE M HANLEY	26 FOREST STREET		MARLBOROUGH	MA	01752	NMI PICC III	10-Apr-12	23-Aug-12
K121048	BOSTON SCIENTIFIC CORP.	JANIS F TARANTO	100 BOSTON SCIENTIFIC WAY		MARLBOROUGH	MA	01752	ULTRAFLEX TRACHEOBRONCHIAL STENT SYSTEM-STERILE UNCOVERED	06-Apr-12	03-Aug-12

K121060	SPINEFRONTIER, INC.	FREDY H VARELA	500 CUMMINGS CENTER	SUITE 3500	BEVERLY	MA	01915	SPINE FRONTIER INDUS ACP SYSTEM	06-Apr-12	03-Jul-12
K121040	DIAMOND DIAGNOSTICS, INC.	KATHY CRUZ	333 FISKE ST.		HOLLISTON	MA	01746	SMARTLYTE ELECTROLYTE ANALYZER	05-Apr-12	30-Aug-12
K121039	COPAN FLOCK TECHNOLOGIES	CYNTHIA SINCLAIR	49 PLAIN STREET		NORTH ATTLEBORO	MA	02760	COPAN MSWAB COLLECTION, TRANSPORT AND PRESERVATION SYSTEM	05-Apr-12	25-May-12
K121020	DEPUY SPINE, INC.	KIRSTEN LEHMULLER	325 PARAMOUNT DR.		RAYNHAM	MA	02767	VIPER SYSTEM	04-Apr-12	03-May-12
K120983	BOSTON SCIENTIFIC CORPORATION	JANIS F TARANTO	100 BOSTON SCIENTIFIC WAY		MARLBOROUGH	MA	01752	ULTRAFLEX ESOPHAGEAL NG STENT SYSTEM	02-Apr-12	02-May-12
K120992	STANMORE IMPLANTS WORLDWIDE LTD	NANCY C MACDONALD	690 CANTON STREET	SUITE 302	WESTWOOD	MA	02090	METS SMILES TOTAL KNEE REPLACEMENT	02-Apr-12	05-Sep-12
K120966	MEDOS INTERNATIONAL SARL	ROBIN DINARDO	325 PARAMOUNT DRIVE		RAYNHAM	MA	02767	DEPUY PULSE LUMBAR CAGE SYSTEM	30-Mar-12	03-Jul-12
K120944	COVIDIEN	JENNIFER SULLIVAN	15 HAMPSHIRE STREET		MANSFIELD	MA	02048	KENDALL SCD 700 SEQUENTIAL COMPRESSION CONTROLLER	29-Mar-12	31-May-12
K120897	SOFRADIM PRODUCTION	JAMES MCMAHON	15 CROSBY DRIVE		BEDFORD	MA	01730	PROGRIP LAPARSCOPIC SELF-FIXATING MESH	26-Mar-12	29-Jun-12
K120823	FRESENIUS MEDICAL CARE NORTH AMERICA, DESIGN CENTE	DENISE OPPERMANN	920 WINTER STREET		WALTHAM	MA	02451 1	BVM HEMODIALYSIS BLOOD TUBING SET WITH ATTACHED PRIMING	21-Mar-12	15-Jun-12

							457	SET AND TRANSDUCER PROTECTORS		
K120810	FIBEROPTIC FABRICATIONS INC	CAROL J MORELLO	495 MAIN STREET		WILBRAHAM	MA	01095	FIBEROPTIC LASER DELIVERY SYSTEM	16-Mar-12	28-Jun-12
K120808	MEDTRONIC INC.	ANU GAUR	35-37A CHERRY HILL DRIVE		DANVERS	MA	01923 5186	EXPORT XT CATHETER, EXPORT AP CATHETER	16-Mar-12	07-Jun-12
K120784	PULPDENT CORPORATION	KENNETH J BERK	80 Oakland St		WATERTOWN	MA	02472	TUFF-TEMP 2.0	15-Mar-12	08-Jun-12
K120686	CODMAN & SHURTLEFF, INC.	KIM FONDA	325 PARAMOUNT DR.		RAYNHAM	MA	02767 0350	ORBIT GALAXY G2 MICROCOIL DELIVERY SYSTEM	06-Mar-12	04-Apr-12
K120674	COVIDIEN	WING NG	15 HAMPSHIRE STREET		MANSFIELD	MA	02048	MAHURKAR ELITE ACUTE DUAL LUMEN CATHETER, ELITE ACUTE TRIPLE LUMEN CATHETER	05-Mar-12	04-Apr-12
K120676	MEVION MEDICAL SYSTEMS	THOMAS H FARIS	300 FOSTER ST		LITTLETON	MA	01460	S-250 PROTON BEAM RADIATION THERAPY SYSTEM	05-Mar-12	04-Jun-12
K120622	PALOMAR MEDICAL TECHNOLOGIES, INC.	SHARON TIMBERLAKE	15 NETWORK DR		BURLINGTON	MA	01803	PALOMAR VECTUS LASER	01-Mar-12	23-May-12

K120593	HOLOGIC, INC.	SARAH FAIRFIELD	250 CAMPUS DRIVE		MARLBOROUGH	MA	01752	MYOSURE CONTROL UNIT	29-Feb-12	23-Mar-12
K120611	SONY ELECTRONICS, INC.	CYNTHIA SINCLAIR	49 PLAIN STREET		NORTH ATTLEBORO	MA	02760	SONY PVM-2551MD OLED MONITOR	29-Feb-12	28-Jun-12
K120605	COVIDIEN LLC	JAMES MCMAHON	15 CROSBY DR		BEDFORD	MA	01730	PERMACOL SURGICAL IMPLANT	28-Feb-12	18-May-12
K120591	DIAMOND DIAGNOSTICS, INC	KATHY CRUZ	333 Fiske St		Holliston	MA	01746	DIAMOND TOKYO BOEKI ISE MODULE CALIBRATOR 1,2,1-2	28-Feb-12	17-Apr-12
K120589	DEPUY MITEK, A JOHNSON & JOHNSON COMPANY	DEEP PAL	325 PARAMOUNT DR.		RAYNHAM	MA	02767	MILAGRO INTERFERENCE SCREWS	28-Feb-12	24-Apr-12
K120567	GYRUS ACMI, INC.	NEIL KELLY	136 TURNPIKE RD.		SOUTHBOROUGH	MA	01772	GYRUS AMCI PK BUTTON ELECTRODE	27-Feb-12	20-Jun-12
K120586	HAEMONETICS CORP.	GREG CALDER	400 Wood Rd		BRAINTREE	MA	02184	CELL SAVER ELITE	27-Feb-12	22-May-12
K120525	PHILIPS HEALTHCARE GROUP	PENNY GRECO	3000 MINUTEMAN ROAD		ANDOVER	MA	01810 7324	QLAB QUANTIFICATION SOFTWARE	22-Feb-12	09-Mar-12
K120497	MEDICA CORP.	PHOTIOS MAKRIS	5 OAK PARK DRIVE		BEDFORD	MA	01730	EASYRA HBALC REGENT EASYCAL HBLC CALIBRATOR EASYQC HBALC MATERIAL	21-Feb-12	14-May-12

K120506	SOFRADIM PRODUCTION	JAMES MCMAHON	15 CROSBY DR		BEDFORD	MA	01730	PARIETEX COMPOSITE VENTRAL PATCH	21-Feb-12	13-Jun-12
K120517	MEDOS INTERNATIONAL SARL	EUGENE BANG	325 PARAMOUNT DR		RAYNHAM	MA	02767	DEPUY PULSE CERVICAL CAGE SYSTEM	21-Feb-12	26-Apr-12
K120505	FRESENIUS MEDICAL CARE NORTH AMERICA, DESIGN CENTE	DENISE OPPERMANN	920 WINTER STREET		WALTHAM	MA	02451 1457	FRESENIUS 2008T HEMODIALYSIS MACHINE	21-Feb-12	06-Mar-12
K120474	GYRUS ACMI, INC.	GRAHAM BAILLE	136 TURNPIKE RD.		SOUTHBOROUGH	MA	01772	GYRUS ACMI TELESCOPE STORAGE-STERILIZATION TRAY	16-Feb-12	10-Jul-12
K120449	DEPUY MITEK	YAYOI FUJIMAKI	325 PARAMOUNT DRIVE		RAYNHAM	MA	02767	HEALIX ADVANCE PEEK ANCHOR	14-Feb-12	11-May-12
K120437	BIOLITEC SIA (LATVIA)	HARRY HAYES	1349 MAIN ROAD		GRANVILLE	MA	01034	TWISTER SIDE-FIRE FIBER OPTIC DELIVERY SYSTEM	13-Feb-12	26-Apr-12
K120388	HOLOGIC, INC.	EILEEN M BOYLE	35 CROSBY DR.		BEDFORD	MA	01730	INSIGHT - FD MINI C-ARM FLUOROSCOPIC IMAGING SYSTEM	07-Feb-12	06-Apr-12
K120185	SORIN GROUP ITALIA S.R.L.	BARRY SALL	195 WEST STREET		WALTHAM	MA	02451	INSPIRE 6F HOLLOW FIBER OXYGENATOR WITH INTEGRATED ARTERIAL FILTER AND HARDSHELL VENOUS/CARDIOTOMY RESERVIOR	06-Feb-12	11-May-12
K120274	CODMAN AND SHURTLEFF, INC.	KIM FONDA	325 PARAMOUNT DR.		RAYNHAM	MA	02767	DELTAMAXX 18 MICROCOIL SYSTEM	02-Feb-12	02-Mar-12

							0350			
K120321	PHILIPS HEALTHCARE	ROB BUTLER	3000 MINUTEMAN RD		ANDOVER	MA	01810	CLEARVUE 350/550 DIAGNOSTIC ULTRASOUND SYSTEM	02-Feb-12	17-Feb-12
K120316	CONFORMIS, INC.	AMITA S SHAH	1 North Ave Ste B		Burlington	MA	01803	ITOTAL CRUCIATE RETAINING (CR) KNEE REPLACEMENT SYSTEM	01-Feb-12	19-Apr-12
K120132	PHILIPS MEDICAL SYSTEMS	MARY KRUITWAGEN	3000 MINUTEMAN RD.		ANDOVER	MA	01810 1099	SURESIGNS VS3 VITAL SIGNS MONITOR, SURESIGNS VS4 VITAL SIGNS MONITOR	27-Jan-12	14-Feb-12
K120231	BIOLITEC MEDICAL DEVICES, INC	HARRY HAYES, PH.D	1349 MAIN ROAD		GRANVILLE	MA	01034	EVOLVE HPD 980/ 1470NM MULTIWAVELENGTH DIODE LASER (EVOLVE DUAL)	25-Jan-12	24-Apr-12
K120229	CODMAN & SHURTLEFF, INC.	CATHERINE KILSHAW	325 PARAMOUNT DR.		RAYNHAM	MA	02767 0350	ENVOY DISTAL ACCESS GUIDING CATHETER	25-Jan-12	24-Feb-12
K120213	PULPDENT CORPORATION	KENNETH J BERK	80 Oakland St		WATERTOWN	MA	02472	ETCH-RITE SUPREME	24-Jan-12	30-Mar-12
K120117	CODMAN & SHURTLEFF, INC.	MEGAN HERMAN	325 PARAMOUNT DR.		RAYNHAM	MA	02767 03	CODMAN QUAD-LOCK STERILIZATION CONTAINER SYSTEM	17-Jan-12	16-Apr-12

							50			
K120095	DEPUY MITEK, A JOHNSON & JOHNSON COMPANY	SUSAN KAGAN	325 PARAMOUNT DR.		RAYNHAM	MA	02767	SIDE EFFECT WITH HAND CONTROLS, HOOK ELECTRODE WITH HAND CONTROLS, 2.3 WEDGE ELECTRODE WITH HAND CONTROLS, S90 WITH HAND	12-Jan-12	06-Apr-12
K120086	CARDIOSOLUTIONS	MICHELE LUCEY	375 WEST ST.		WEST BRIDGEWATER	MA	02379	CARIOSOLUTIONS PERCU-PRO STEERABLE INTRODCER 65CM CARIOSOLUTIONS PERCU-PRO STEERABLE INTRODUCER 80CM	11-Jan-12	24-Apr-12
K120080	SHASER, INC.	GLEN EMELOCK	32 HARRISON ST.		MELROSE	MA	02176	SHASER HRS2 HAIR REMOVAL SYSTEM	11-Jan-12	25-May-12
K120078	DEPUY MITEK INC., JOHNSON AND JOHNSON COMPANY	YAYOI FUJIMAKI	325 PARAMOUNT DRIVE		RAYNHAM	MA	02767	HEALIX ADVANCE BR ANCHOR	10-Jan-12	29-Feb-12
K120055	HAMILTON THORNE, INC.	DIARMAID H DOUGLAS - HAMILTON	100 CUMMINGS CENTER-SUITE 465E		Beverly	MA	01915	HANILTON THORNE INFRARED LASER OPTICAL SYSTEM-ZILOS-TK HAMILTON THORNE INFRARED LASER OPTICAL SYSTEM-LYKOS	09-Jan-12	24-Apr-12
K120068	CONFORMIS, INC.	AMITA SHAH	1 North Ave Ste B		Burlington	MA	01880	CONFORMIS ITOTAL CR KNEE REPLACEME	09-Jan-12	03-Feb-12

							3	NT SYSTEM (KRS)		
K120003	PULPDENT CORPORATION	KENNETH J BERK	80 Oakland St		WATERTOWN	MA	02472	NUCAL	03-Jan-12	05-Apr-12
K120017	FRESENIUS MEDICAL CARE, NORTH AMERICA	DENISE OPPERMANN	920 WINTER STREET		WALTHAM	MA	02451	FRESENIUS 2008 HEMODIAYSIS MACHINE WITH BIBAG SYSTEM	03-Jan-12	02-Feb-12
K120004	CHINA SHENYANG MED-LAND IMP/EXP CORP., LTD.	ANN D MCGONIGLE	19 SEDGEMEADOW RD		WAYLAND	MA	01778	(MULTIPLE) DIGITAL THERMOMETER	03-Jan-12	23-Aug-12

WATERTOWN	MA	02472	TUFF-TEMP 2.0	15-Mar-12	08-Jun-12	SE	DE	EBG	Summary	DE		Traditional	N	N
RAYNHAM	MA	027670350	ORBIT GALAXY G2 MICROCOIL DELIVERY SYSTEM	06-Mar-12	04-Apr-12	SE	NE	HCG	Summary	NE		Special	N	N
MANSFIELD	MA	02048	MAHURKAR ELITE ACUTE DUAL LUMEN CATHETER, ELITE ACUTE TRIPLE LUMEN CATHETER	05-Mar-12	04-Apr-12	SK	GU	MPB	Summary	GU		Special	N	N
LITTLETON	MA	01460	S-250 PROTON BEAM RADIATION THERAPY SYSTEM	05-Mar-12	04-Jun-12	SE	RA	LHN	Summary	RA		Traditional	N	N
BURLINGTON	MA	01803	PALOMAR VECTUS LASER	01-Mar-12	23-May-12	SE	SU	GEX	Summary	SU		Traditional	N	N
MARLBOROUGH	MA	01752	MYOSURE CONTROL UNIT	29-Feb-12	23-Mar-12	SE	OB	HIH	Summary	OB		Special	N	N
NORTH ATTLEBORO	MA	02760	SONY PVM-2551MD OLED MONITOR	29-Feb-12	28-Jun-12	SE	SU	GCJ	Summary	SU		Traditional	N	N
BEDFORD	MA	01730	PERMACOL SURGICAL IMPLANT	28-Feb-12	18-May-12	SE	SU	FTM	Summary	SU		Traditional	N	N
Holliston	MA	01746	DIAMOND TOKYO BOEKI ISE MODULE CALIBRATOR 1,2,1-2	28-Feb-12	17-Apr-12	SE	CH	JIT	Summary	CH		Traditional	N	N
RAYNHAM	MA	02767	MILAGRO INTERFERENCE SCREWS	28-Feb-12	24-Apr-12	SE	OR	MAI	Summary	OR		Traditional	N	N
SOUTHBOROUGH	MA	01772	GYRUS AMCI PK BUTTON ELECTRODE	27-Feb-12	20-Jun-12	SE	GU	FAS	Summary	GU		Traditional	N	N
BRAINTREE	MA	02184	CELL SAVER ELITE	27-Feb-12	22-May-12	SE	CV	CAC	Summary	AN		Traditional	N	N
ANDOVER	MA	018107324	QLAB QUANTIFICATION SOFTWARE	22-Feb-12	09-Mar-12	SE	RA	LLZ	Summary	RA		Special	Y	N
BEDFORD	MA	01730	EASYRA HBALC REGENT EASYCAL HBLC CALIBRATOR EASYQC HBALC MATERIAL	21-Feb-12	14-May-12	CS	CH	LCP	Statement	HE		Traditional	N	N
BEDFORD	MA	01730	PARIETEX COMPOSITE VENTRAL PATCH	21-Feb-12	13-Jun-12	SE	SU	FTL	Summary	SU		Traditional	N	N
RAYNHAM	MA	02767	DEPUY PULSE CERVICAL CAGE SYSTEM	21-Feb-12	26-Apr-12	SE	OR	ODP	Summary	OR		Traditional	N	N
WALTHAM	MA	024511457	FRESENIUS 2008T HEMODIALYSIS MACHINE	21-Feb-12	06-Mar-12	SE	GU	KDI	Summary	GU		Special	N	N
SOUTHBOROUGH	MA	01772	GYRUS ACMI TELESCOPE STORAGE-STERILIZATION TRAY	16-Feb-12	10-Jul-12	SE	HO	KCT	Summary	HO		Traditional	N	N
RAYNHAM	MA	02767	HEALIX ADVANCE PEEK ANCHOR	14-Feb-12	11-May-12	SE	OR	HWC	Summary	OR		Traditional	N	N
GRANVILLE	MA	01034	TWISTER SIDE-FIRE FIBER OPTIC DELIVERY SYSTEM	13-Feb-12	26-Apr-12	SE	SU	GEX	Summary	SU		Traditional	N	N
BEDFORD	MA	01730	INSIGHT - FD MINI C-ARM FLUOROSCOPIC IMAGING SYSTEM	07-Feb-12	06-Apr-12	SE	RA	OXO	Summary	RA		Special	N	N
WALTHAM	MA	02451	INSPIRE 6F HOLLOW FIBER OXYGENATOR WITH INTEGRATED ARTERIAL FILTER AND HARDSHELL VENOUS/CARDIOTOMY RESERVIOR	06-Feb-12	11-May-12	SE	CV	DTZ	Summary	CV		Traditional	N	N
RAYNHAM	MA	027670350	DELTAMAXX 18 MICROCOIL SYSTEM	02-Feb-12	02-Mar-12	SE	NE	HCG	Summary	NE		Special	N	N
ANDOVER	MA	01810	CLEARVUE 350/550 DIAGNOSTIC ULTRASOUND SYSTEM	02-Feb-12	17-Feb-12	SE	RA	IYN	Summary	RA		Traditional	Y	N
Burlington	MA	01803	ITOTAL CRUCIATE RETAINING (CR) KNEE REPLACEMENT SYSTEM	01-Feb-12	19-Apr-12	SE	OR	JWH	Summary	OR		Traditional	N	N
ANDOVER	MA	018101099	SURESIGNS VS3 VITAL SIGNS MONITOR, SURESIGNS VS4 VITAL SIGNS MONITOR	27-Jan-12	14-Feb-12	SE	CV	DXN	Summary	CV		Special	N	N
GRANVILLE	MA	01034	EVOLVE HPD 980/ 1470NM MULTIWAVELENGTH DIODE LASER (EVOLVE DUAL)	25-Jan-12	24-Apr-12	SE	SU	GEX	Summary	SU		Traditional	N	N
RAYNHAM	MA	027670350	ENVOY DISTAL ACCESS GUIDING CATHETER	25-Jan-12	24-Feb-12	SE	NE	DQY	Summary	CV		Special	N	N
WATERTOWN	MA	02472	ETCH-RITE SUPREME	24-Jan-12	30-Mar-12	SE	DE	KLE	Summary	DE		Traditional	N	N
RAYNHAM	MA	027670350	CODMAN QUAD-LOCK STERILIZATION CONTAINER SYSTEM	17-Jan-12	16-Apr-12									
			SIDE EFFECT WITH HAND CONTROLS, HOOK ELECTRODE WITH HAND CONTROLS, 2.3											

Appendix H: 2011 NIH/NSF Small Business Innovation Research Grants/STTR

Title	Contract Number	Agency	Branch	Program	Year	Phase	Award Amount	SBC	Street	Street 2	City
SBIR Phase I: Development of a Long Life Microchannel Plate Photomultiplier Tube for High Flux Applications through the Innovative Application of Nanofilms	1046903	NSF	NSF	SBIR	2011	1	149991	Arradiance, Inc.	142 North Road	Suite F-150	Sudbury
IgA Protease as Therapy to Reverse IgA Nephropathy	4R44DK083147-02	HHS	HHS	SBIR	2011	2	871770	IGAN BIOSCIENCES, INC.	198 TREMONT ST		Boston
SBIR Phase I: Cost-Effective Anastomotic System Featuring Compliant Anastomoses	1046481	NSF	NSF	SBIR	2011	1	149979	Sterling biomedical	2 DURHAM DR		Lynnfield
SBIR Phase II: A Novel Antimicrobial Polymer for Medical Devices	1058279	NSF	NSF	SBIR	2011	2	418443	Sterling biomedical	2 DURHAM DR		Lynnfield
SBIR Phase II: Novel Antioxidants to Improve Thermo-Oxidative Stability of Biolubricants and Biodiesel	1138520	NSF	NSF	SBIR	2011	2	500000	Polnox	225 Stedman Street	Unit 23	Lowell
SBIR Phase I: Thin-Film Spectrally-Tunable Optical Filter with Wide Bandwidth for Visible and Near Infrared Spectrum	1046556	NSF	NSF	SBIR	2011	1	150000	Raydex Technology, Inc.	655 Concord Ave, Unit 704		Cambridge
SBIR Phase I: Development of a Commercial Culture of Dehalococcoides for anaerobic treatment of PCBs	1113457	NSF	NSF	SBIR	2011	1	150000	BCI	39 Clarendon Street		Watertown
SBIR Phase I: Novel volumetric	1047120	NS	NSF	SBIR	20	1	149615	Metamagnetics	36 Station St		Sharon

efficient design and packaging of a broadband integrated circulator-antenna (BICA)		F			11			Inc.		
SBIR Phase I: Ultra-low profile wideband metamaterial antennas based upon advanced textured ferrite materials	1113687	NSF	NSF	SBIR	2011	1	145881	Metamagnetics Inc.	36 Station St	Sharon
SBIR Phase II: System for Location-Based Mobile Consumer Analytics	1127482	NSF	NSF	STTR	2011	2	498395	Cadio	38 Ossipee Rd, Suite 2	Somerville
Attomole-Level High-Throughput Genomics	4R44HG005279-02	HHS	HHS	SBIR	2011	2	1502971	HELICOS BIOSCIENCE CORPORATION	ONE KENDALL SQUARE	Cambridge
Improving self delivering properties of RNAi compounds through medicinal chemistr	1R43GM096548-01	HHS	HHS	SBIR	2011	1	273824	RXI PHARMACEUTICALS CORPORATION	60 PRESCOTT ST	Worcester
Novel RNAi therapy for ALS and other Neurodegenerative Disorders	1R43NS074671-01	HHS	HHS	SBIR	2011	1	304559	RXI PHARMACEUTICALS CORPORATION	60 PRESCOTT ST	Worcester
SBIR Phase I: Next Generation Electrical Impedance Myography for Neuromuscular Disease Assessment	1046826	NSF	NSF	SBIR	2011	1	149956	CONVERGENCE MEDICAL DEVICES, INC.	400 TradeCenter, Suite 5900	Woburn
A device for rapid, painless, bedside muscle evaluation of children	1R43NS073188-01A1	HHS	HHS	SBIR	2011	1	289901	CONVERGENCE MEDICAL DEVICES, INC.	400 TradeCenter, Suite 5900	Woburn
The Hearthside Book Club: Pioneering Dementia-Level-Appropriate Reading Materials	1R43AG039907-01	HHS	HHS	SBIR	2011	1	149397	HEARTHSTONE ALZHEIMER CARE, LTD	130 New Boston Street Suite 103	Woburn
Minimally Invasive Pediatric VAD for	4R44HL099192-02	HH	HHS	SBIR	20	2	1122294	ABIOMED, INC.	22 CHERRY HILL DRIVE	Danvers

Treatment of Acute Heart Failure		S			11						
SBIR Phase II: High Performance Supercapacitors Based on Nano-engineered Electrodes	1058570	NSF	NSF	SBIR	2011	2	487872	Agiltron Corporation	15 Cabot Road		Woburn
Infant Breath	1R43HD065380-01A1	HHS	HHS	SBIR	2011	1	149939	Agiltron Corporation	15 Cabot Road		Woburn
A Portable High Resolution Detector for Rapid Field Arsenic Test in Drinking Wate	2R44EH000385-02	HHS	HHS	SBIR	2011	2	499140	Agiltron Corporation	15 Cabot Road		Woburn
RandD-OTHER R and D-B RES	N43ES110008	HHS	HHS	SBIR	2011	1	147753	Agiltron Corporation	15 Cabot Road		Woburn
Information Technology Enabled Treatment of Adolescent Depression	2R44MH085350-02	HHS	HHS	SBIR	2011	2	949734	VERITAS HEALTH SOLUTIONS, LLC	800 West Cummings Park	Suite 2950	Woburn
Optical Surgical Probe for Assessing Human Oral Mucosa Graft Vascularization	1R43DE021935-01	HHS	HHS	SBIR	2011	1	196853	Radiation Monitoring Devices, Inc.	44 Hunt Street		Watertown
Device for Measuring Capillary Blood Flow and the Onset of Shock	1R43HL106851-01A1	HHS	HHS	SBIR	2011	1	220639	Radiation Monitoring Devices, Inc.	44 Hunt Street		Watertown
High Performance, Low Cost PET Scintillators	1R44EB012443-01A1	HHS	HHS	SBIR	2011	1	189406	Radiation Monitoring Devices, Inc.	44 Hunt Street		Watertown
Instrument to Identify Hazardous Children's Products that Could Cause Lead Poison	2R44ES015439-02	HHS	HHS	SBIR	2011	2	951056	Radiation Monitoring Devices, Inc.	44 Hunt Street		Watertown
Simultaneous PET-MR Small Animal Imaging	4R44NS066521-02	HHS	HHS	SBIR	2011	2	1187392	Radiation Monitoring Devices, Inc.	44 Hunt Street		Watertown
Multibeam Healing for Laser	9R44RR031472-03	HH	HHS	SBIR	20	2	1592997	Radiation	44 Hunt Street		Watertown

Micromachining in Manufacturing		S			11			Monitoring Devices, Inc.		
Global Proteomic Screening by MALDI Spectrometric Imaging of Protein-Bead Arrays	1R43CA161965-01	HHS	HHS	SBIR	2011	1	299730	AMBER GEN, INC	313 PLEASANT ST	Watertown
Alzheimer's Disease Therapeutic	4R44AG034760-02	HHS	HHS	SBIR	2011	2	2409606	APHIOS CORPORATION	3 E GILL ST	Woburn
TAS:: 75 0896::TAS SBIR PHASE I TOPIC NCCAM 002	N43CO110117	HHS	HHS	SBIR	2011	1	94448	APHIOS CORPORATION	3 E GILL ST	Woburn
SBIR PHASE 1 TOPIC 43	N43HB110034	HHS	HHS	SBIR	2011	1	149440	APHIOS CORPORATION	3 E GILL ST	Woburn
SBIR Phase II: Force-Controlled Robotic Arm Capable of Sub-Millimeter Precision	1058474	NSF	NSF	SBIR	2011	2	481971	Barrett Technology Inc	625 MOUNT AUBURN ST	Cambridge
Integrated molecular diagnostic system for the point-of-care	1R41AI092913-01	HHS	HHS	STTR	2011	1	482810	BIOHELIX CORPORATION	500 Cummings Center	Beverly
Monolithic Media and Technology for Bioprocessing	1R43GM099199-01	HHS	HHS	SBIR	2011	1	146027	BIOLINK PARTNERS	109 SCHOOL STREET	Watertown
Developing small molecule therapeutics for lupus	1R41AR060620-01	HHS	HHS	STTR	2011	1	583195	BIOMEDICAL RESEARCH MODELS, INC.	67 MILLBROOK, ST, STE 422	Worcester
Rapid Testing of Drug-Resistant BCR-ABL(+)Leukemia Cells	1R43CA153614-01A1	HHS	HHS	SBIR	2011	1	199691	BioSense Technologies Inc.	4 ARROW DR	Woburn
A Bioactive Prosthetic Vascular Graft	2R42HL087466-02A1	HHS	HHS	STTR	2011	2	748950	BIOSURFACES	200 Homer Avenue, Unit 1P	Ashland
Development of Specific Gene Silencing Methods and Reagents	1R43GM096635-01	HHS	HHS	SBIR	2011	1	312194	BOSTON BIOMEDICAL, INC.	333 PROVIDENCE HWY	Norwood
New Communication	9R44DC012275-	HH	HHS	SBIR	20	2	1023545	CHAMELEON	14 PARKMAN ST	Natick

Technology for Suddenly Speechless Hospitalized Patients	02A1	S			1 1			ADAPTI VEWARE , LLC		
VASCULAR SENSOR FOR WOMEN'S REPRODUCTIVE HEALTH RESEARCH	1R43HD0 65520- 01A1	H H S	HHS	SBIR	2 0 1 1	1	147185	CORPOR A SYSTEM S, INC.	14 SUMMER STREET	Malden
SBIR Phase I: Titanium Automotive Powertrain Componenets For Increased Fuel Efficiency And Reduced Emissions	1045207	N S F	NSF	SBIR	2 0 1 1	1	150000	DYNAM ET TECHNO LOGY, INC.	Eight A Street	Burlington
Cell-based Model for Electrical Stimulation Safety Studies	1R43NS07 3195-01	H H S	HHS	SBIR	2 0 1 1	1	280846	EIC Laborat ories, Inc.	EIC LABORA TORIES, INC. 111 DOW NEY ST	Norwood
On-Site Multiplexed GMO Detector to Facilitate Traceability	1R43FD00 3958-01	H H S	HHS	SBIR	2 0 1 1	1	149997	EIC Laborat ories, Inc.	EIC LABORA TORIES, INC. 111 DOW NEY ST	Norwood
A sensor-based remote monitoring system to prevent falls in older adults	1R43AG03 9214- 01A1	H H S	HHS	SBIR	2 0 1 1	1	339409	ENVIRO NMENT AND HEALTH GROUP, INC.	1280 MASSACHUSETT S AVE, #505	Cambridge
Self-Directed Online Training Program for Multicultural Dementia Caregivers	1R43AG04 1571-01	H H S	HHS	SBIR	2 0 1 1	1	292485	ENVIRO NMENT AND HEALTH GROUP, INC.	1280 MASSACHUSETT S AVE, #505	Cambridge
SBIR Phase I: Novel Emergency Communication System for Mines	1046812	N S F	NSF	SBIR	2 0 1 1	1	150000	FERRO SOLUTI ONS, INC.	5 Constitution Way	Woburn
SBIR Phase I: Magneto-electric- MEMs-enabled wireless power for medical implants	1113641	N S F	NSF	SBIR	2 0 1 1	1	150000	FERRO SOLUTI ONS, INC.	5 Constitution Way	Woburn
Prevention of Tumor Recurrence Following Surgical Resection (Phase II)	2R44CA13 5967- 02A1	H H S	HHS	SBIR	2 0 1 1	2	1415731	FIFTH BASE, LLC	200 Upland Road	Newton
Rapid sensitive low-cost test for resistant microbes causing hospital infections	2R44AI08 0016- 03A1	H H S	HHS	SBIR	2 0 1 1	2	2906840	FIRST LIGHT BIOSCIE NCES, INC.	1 OAK PARK DR	Bedford
Oral Antibody	1R43DK08	H	HHS	SBIR	2	1	145306	AVAXIA	26 PEMBERTON	Wayland

Therapy for Celiac Disease	0526-01A1	HS			011			BIOLOGICS, INC.	RD		
Electrochemical Home Monitoring System for Lithium Blood Level	2R44MH090582-02	HHS	HHS	SBIR	2011	2	1022417	Giner, Inc.	89 Rumford Avenue		Newton
Advanced Gas Sensor	2R44OH009016-02A1	HHS	HHS	SBIR	2011	2	848562	Giner, Inc.	89 Rumford Avenue		Newton
Novel Glycosylated Delta Opioid Receptor Agonists for Chronic Inflammatory Pain	2R44DA026653-02	HHS	HHS	SBIR	2011	2	992331	BIOUSIAN BIOSYSTEMS, INC. (BBI)	51 FOLLEN RD		Lexington
Development of a Fiberless Transflectance Noninvasive Glucose Monitor	2R44DK083797-02	HHS	HHS	SBIR	2011	2	994342	GROVE INSTRUMENTS, INC.	100 Grove Street	Suite 315	Worcester
Silicone Coatings for Biostable Chronic Neural Prostheses	2R44NS060377-02A2	HHS	HHS	SBIR	2011	2	2078683	GVD CORP.	45 Spinelli Place		Cambridge
Motivational Interviewing: An Experiential Online Training Tool	1R43MH092951-01A1	HHS	HHS	SBIR	2011	1	202983	CENTER FOR SOCIAL INNOVATION, LLC	200 Reservoir Street		Needham
Online Tool To Recognize and Respond to Elder Homelessness	1R43AG041537-01	HHS	HHS	SBIR	2011	1	147360	CENTER FOR SOCIAL INNOVATION, LLC	200 Reservoir Street		Needham
Confirmatory Immunoblot Test for Chagas' Disease	2R44AI080021-03	HHS	HHS	SBIR	2011	2	2410129	IMMUNETICS, INC.	27 DRYDOCK AVE.		Boston
A Clinical Decision Support Tool for Electronic Health Records	1R43DA031489-01A1	HHS	HHS	SBIR	2011	1	322562	INFLEXXION, INC.	320 NEEDHAM STREET, SUITE 100		Newton
Web-based Self-Management of Chronic Pain in Parkinsons Disease	1R43NS071731-01A1	HHS	HHS	SBIR	2011	1	177251	INFLEXXION, INC.	320 NEEDHAM STREET, SUITE 100		Newton
Pain Assessment Interview and Clinical Advisory System	2R44DA026359-02A1	HHS	HHS	SBIR	2011	2	1339877	INFLEXXION, INC.	320 NEEDHAM STREET, SUITE 100		Newton
Staying Off Substances: A Tailored Early Recovery Program	2R44DA026645-02A1	HHS	HHS	SBIR	2011	2	1584781	INFLEXXION, INC.	320 NEEDHAM STREET, SUITE 100		Newton

for Teens										
MyStudentBody-Community College: A Health Website for Students	2R44DA027190-02	HHS	HHS	SBIR	2011	2	1370736	INFLEXXION, INC.	320 NEEDHAM STREET, SUITE 100	Newton
Hydrogel Particle-Based microRNA Profiling for Discovery and Cancer Diagnostics	2R44CA141980-02A1	HHS	HHS	SBIR	2011	2	2000001	ELUCIGEL TECHNOLOGIES	1 KENDALL SQ BLG 1400W FL 3	Cambridge
SBIR Phase I: Vibration-Based Cleaning for Ash Removal from Diesel Particulate Filters	1046952	NSF	NSF	SBIR	2011	1	150000	Filter Sensing Technologies, Inc.	Po Box 425197	Cambridge
SBIR Phase I: Novel proteolysis-based tools for metabolic engineering of amino acid producing strains	1113506	NSF	NSF	SBIR	2011	1	150000	Ginkgo BioWorks	7 Tide St Unit 2B	Boston
Interactive Sensor Technology to Measure Adherence to Prescribed Therapeutic Foot	1R43DK093236-01	HHS	HHS	SBIR	2011	1	395082	Biosensics, LLC	101 MONMOUTH ST, APT 504	Brookline
Virus-Targeted Therapy for Malignancies	1R43CA153474-01A1	HHS	HHS	SBIR	2011	1	288895	PHOENICIA BIOSCIENCES, INC.	45 Beaver Rd	Weston
in vivo Studies of Clinical Stage Globin Modulators	1R41HL110727-01	HHS	HHS	STTR	2011	1	304344	PHOENICIA BIOSCIENCES, INC.	45 Beaver Rd	Weston
Novel Diagnostic Sequencing System for HIV Resistance Testing	2R44AI074232-03A1	HHS	HHS	SBIR	2011	2	2952955	INTELLIGENT BIO-SYSTEMS, INC.	34 Bear Hill Rd.	Waltham
SBIR Phase I: Classroom VideoAnalyst: Automated Video Content Analysis for Classroom Evaluations	1047232	NSF	NSF	SBIR	2011	1	149883	INTUVISION	10 Tower Office Park ste 200	Woburn
Automated Molecular Diagnostics for Rapid Detection of Dengue Viremia Using Whole	4R44AI085892-02	HHS	HHS	SBIR	2011	2	1707133	IQUUM, INC.	700 Nickerson Rd	Marlborough
SBIR Phase II:	1058417	N	NSF	SBIR	2	2	499868	LUMAR	15 Ward Street	Somerville

Nanometer-Level Fidelity in Maskless Lithography		S F			0 1 1			RAY LLC		
Validation of an In Vitro Human Airway Model	2R44ES01 4312-02	H H S	HHS	SBIR	2 0 1 1	2	835982	MATTEK CORPOR ATION	200 HOMER AVE	Ashland
Validation of Human Vaginal Tissue Assay for Endocrine Disruptors	2R44ES01 5641-02	H H S	HHS	SBIR	2 0 1 1	2	993515	MATTEK CORPOR ATION	200 HOMER AVE	Ashland
Human Corneal Model for Ocular Irritation Assay	9R44ES02 0074-02	H H S	HHS	SBIR	2 0 1 1	2	924517	MATTEK CORPOR ATION	200 HOMER AVE	Ashland
Identification of Serologic Biomarkers in Sarcoidosis	1R43AI09 2886-01	H H S	HHS	SBIR	2 0 1 1	1	301893	MEDICA L DISCOV ERY PARTNE RS, LLC	715 ALBANY ST., ROOM L803	Boston
A NOVEL BIS-INDOLE COMPOUND AGAINST CATHETER COLONIZATION	1R41AI09 6702-01	H H S	HHS	STTR	2 0 1 1	1	599998	MICROB IOTIX, INC	ONE INNOVATION DR	Worcester
Type III Secretion Inhibitors for Anti-Infective Therapy	2R44AI06 8185-03A1	H H S	HHS	SBIR	2 0 1 1	2	3000000	MICROB IOTIX, INC	ONE INNOVATION DR	Worcester
Quinoline-based Inhibitors of BoNT/A LC	1R43AI09 2964-01	H H S	HHS	SBIR	2 0 1 1	1	599718	MICROB IOTIX, INC	ONE INNOVATION DR	Worcester
SBIR Phase I: A Nanosensor-based device for rapid microbial detection in water samples	1046990	N S F	NSF	SBIR	2 0 1 1	1	150000	Nanobio sym, Inc.	200 Boston Ave, Suite 4700	Medford
A Rapid Point-of-care Diagnostic for Neisseria gonorrhoeae STDs	1R43AI09 6768-01	H H S	HHS	SBIR	2 0 1 1	1	600000	Network Biosyste ms, Inc.	830 Winter Street	Waltham
SBIR Phase I: Synthetic respiration for improved bio-fuels production.	1046634	N S F	NSF	SBIR	2 0 1 1	1	148960	NEW ENGLAN D BIOLABS , INC.	240 County Road	Ipswich
Isolation of functional IgGs in the cytoplasm of a novel E. coli expression host	1R41AI09 2969-01A1	H H S	HHS	STTR	2 0 1 1	1	213422	NEW ENGLAN D BIOLABS , INC.	240 County Road	Ipswich
NOVEL ENZYME REAGENTS FOR	4R44GM0 95209-02	H H	HHS	SBIR	2 0	2	903660	NEW ENGLAN	240 County Road	Ipswich

EPIGENETICS STUDIES.		S			11			D BIOLABS, INC.		
Improving Pediatric Developmental Screening and Communications: A CME	1R43HD063173-01A1	HHS	HHS	SBIR	2011	1	138891	NEW ENGLAND RESEARCH INSTITUTES, INC.	9 GALEN ST	Watertown
Benzodiazepine Analogs as Novel Treatments for Catatonia	1R43MH095315-01	HHS	HHS	SBIR	2011	1	686852	ORGANIX, INC.	240 SALEM ST	Woburn
Device for Automating Zebrafish Processing	2R44GM090598-02	HHS	HHS	SBIR	2011	2	833379	PHYLONIX PHARMACEUTICALS, INC.	100 INMAN ST, STE 300	Cambridge
Advanced Laser Source for High-speed Adaptive Optics OCT	1R43EY021396-01	HHS	HHS	SBIR	2011	1	215122	Physical Sciences Inc.	20 New England Business Center	Andover
Compact Hydrogen Peroxide Sensor for Sterilization Cycle Monitoring	1R44EB013517-01	HHS	HHS	SBIR	2011	1	196723	Physical Sciences Inc.	20 New England Business Center	Andover
SBIR Phase II: Novel Polymeric Membrane for Hydrocarbon Separation	1048608	NSF	NSF	SBIR	2011	2	409578	Porogen Corporation	6C Gill Street	Woburn
Emergency Operations Plans for Individuals with Disabilities	1R41HD069070-01A1	HHS	HHS	STTR	2011	1	260855	PRAXIS, INC.	13 WEST STREET	Belmont
Developmental Disabilities Dentistry Online	1R42DE020979-01A1	HHS	HHS	STTR	2011	1	1192970	PRAXIS, INC.	13 WEST STREET	Belmont
Risk Management in Developmental Disabilites	4R42HD063179-02	HHS	HHS	STTR	2011	2	1304624	PRAXIS, INC.	13 WEST STREET	Belmont
Methods and Instrumentation for Hydrostatic Pressure-Enhanced Tissue Fixation	1R43GM090582-01A1	HHS	HHS	SBIR	2011	1	160978	PRESSURE BIOSCIENCE, INC.	14 Norfolk Ave	South easton
SBIR Phase I: Engineered Ligands for Enhanced Stability of Colloidal Quantum Dots in Lighting and Display	1047180	NSF	NSF	SBIR	2011	1	149823	QD VISION, INC.	29 Hartwell Avenue	Lexington

Applications											
Fully Compensated Dynamic Shim System for In Vivo MRI and MRS	9R42RR031457-02	HHS	HHS	STTR	2011	2	748196	RESONANCE RESEARCH, INC.	5 FORTUNE DR		Billerica
TAS::75 0849::TAS	N43CO110062	HHS	HHS	SBIR	2011	1	199391	RESONANCE RESEARCH, INC.	5 FORTUNE DR		Billerica
SBIR Phase II: Chip-Scale Micromechanical Gyroscope for Angular Roation Detection, Stability and Control	1058078	NSF	NSF	SBIR	2011	2	499625	Sand 9, Inc.	One Kendall Square	Suite B2305	Cambridge
SOFTWARE FOR AUDITORY PROSTHESIS RESEARCH	2R44DC010524-02	HHS	HHS	SBIR	2011	2	1149472	SENSIMETRICS CORP.	14 SUMMER STREET		Malden
Plasma synthesized doped boron nanopowder for magnesium diboride superconductors	2R44EB007139-02	HHS	HHS	SBIR	2011	2	1030516	Specialty Materials, Inc.	1449 MIDDLESEX STREET		Lowell
ACES: A Product to Suppress or Enhance Critical Components in Acoustic Signals	1R43DC011475-01A1	HHS	HHS	SBIR	2011	1	298678	SPEECH TECHNOLOGY/APPLIED RESEARCH CORP.			Bedford
Nano-Crystalline Ceramic Coatings for the Reduction of Sliding Resistance of Orth	1R43DE022218-01	HHS	HHS	SBIR	2011	1	114173	Spire Corporation	One Patriots Park		Bedford
High Resolution Neuro-MRI	9R44MH097272-02	HHS	HHS	SBIR	2011	2	829759	STERN MAGNETICS, LLC.	5 Fortune Drive		Billerica
SBIR Phase II: A Multithreaded Storage Engine using Highly-Concurrent Fractal Trees	1058565	NSF	NSF	SBIR	2011	2	500000	Tokutek, Inc.	1 Militia Drive, Suite 11		Lexington
A point-of-care device for generating nitric oxide for inhalation	1R43AI091160-01A1	HHS	HHS	SBIR	2011	1	152430	WHALEN BIOMEDICAL, INC	11 MILLER ST		Somerville
Artificial Lung Based on a Novel Microfluidic Technology	2R44HL091593-02A1	HHS	HHS	SBIR	2011	2	1519727	Infoscitex Corporation	303 Bear Hill Road		Waltham
Microfabricated	2R44NS05	H	HHS	SBIR	2	2	3003413	Infoscite	303 Bear Hill		Waltham

Implantable Flowmeter for CSF Shunts Phase II	6628-02A1	HS			011			x Corporation	Road		
Wearable Device for Continuous Hemodialysis	2R42DK072646-02A1	HHS	HHS	STTR	2011	2	1949759	Infoscitex Corporation	303 Bear Hill Road		Waltham
Novel serotonergic, pro-cognitive antipsychotic therapies	1R43MH092962-01	HHS	HHS	SBIR	2011	1	699792	Galenea Corporation	300 Technology Square		Cambridge
In vitro tools for preclinical analysis of cognitive therapies for schizophrenia	1R43MH093029-01A1	HHS	HHS	SBIR	2011	1	628877	Galenea Corporation	300 Technology Square		Cambridge
SBIR Phase I: A low-cost real-time bio-electrochemical nitrate sensor for surface water monitoring	1046608	NSF	NSF	SBIR	2011	1	150000	Cambrian Innovation, Inc.	27 Drydock Ave.	2nd Floor	Boston
SBIR Phase I: High Efficiency Thin Film Photovoltaics	1045862	NSF	NSF	SBIR	2011	1	146045	Realtime Dx, Inc.	106 North Hancock Street		Lexington
SBIR Phase I: Compliant Nonlinear Quasi-Passive Orthotic Joint	1046005	NSF	NSF	SBIR	2011	1	147000	Adicep Technologies	26 Sweeny Ridge Road		Bedford
SBIR Phase I: Intraoperative detection and ablation of microscopic residual cancer in the tumor bed	1046761	NSF	NSF	SBIR	2011	1	147505	Lumicell Diagnostics, Inc	1000 WINTER ST STE3800		Waltham
Engineered imaging nanoparticle for realtime detection of cancer in the tumor bed	1U43CA165024-01	HHS	HHS	SBIR	2011	1	212752	Lumicell Diagnostics, Inc	1000 WINTER ST STE3800		Waltham
TAS::75 0849::TAS SBIR TOPIC 307 PHASE I NOVEL IMAGING AGENTS TO EXPAND THE CLINICAL TOOLKIT FOR CANCER DIAGNOSIS, STAGING, AND TREATMENT	N43CO110122	HHS	HHS	SBIR	2011	1	248461	Lumicell Diagnostics, Inc	1000 WINTER ST STE3800		Waltham
SBIR Phase I: Cloud-Enabled	1047053	NS	NSF	SBIR	20	1	150000	Affectiva	411 Waverle	Building 3,	Waltham

Analysis Of Facial Affect		F			11				y Oaks Rd.	Suite 329	
SBIR Phase I: Computer-Aided Mosaic Design and Construction	1047077	NSF	NSF	SBIR	2011	1	150000	Artaic LLC	21 Drydock Avenue		Boston
SBIR Phase I: High-Throughput Agile Robotic Manufacturing System for Tile Mosaics	1113606	NSF	NSF	SBIR	2011	1	150000	Artaic LLC	21 Drydock Avenue		Boston
SBIR Phase I: Environmental Biofilm Decontamination and Enhanced Energy Efficiency with Engineered Phage	1113071	NSF	NSF	SBIR	2011	1	150000	Novophage	783 Cambridge Street		Cambridge
SBIR Phase I: Epitaxially Grown GaSb Thin Films on GaAs Substrates For Near-Field Conversion of Heat to Electricity	1113125	NSF	NSF	SBIR	2011	1	149848	MTPV	8 Saint Mary's Street	Room 609	Boston
SBIR Phase I: Spray-Formed Soft Magnetic Material for Efficient Hybrid-Field Electric Machines	1113202	NSF	NSF	SBIR	2011	1	150000	Persimmon Technologies	300 Bridge Street		South hamilton
SBIR Phase I: Improved Cold Thermal Energy Storage for Refrigeration Applications	1113206	NSF	NSF	SBIR	2011	1	147539	Promethean	222 Third St		Cambridge
SBIR Phase I: Realizing Broadband Frequency Sound Absorption in Micro-Slit Panels	1113541	NSF	NSF	SBIR	2011	1	150000	American Acoustical Prod	311 Hoppingbrook Road		Holliston
Prevention of Retinopathy of Prematurity with a Novel Bifunctional Redox Reagent	1R43EY021379-01	HHS	HHS	SBIR	2011	1	220613	RADIKAL THERAPEUTICS, INC.	8 SOLVIVA RD		West tisbury
Bifunctional Modulation of Redox Imbalance for Treatment of Septic Shock	1R43GM096475-01	HHS	HHS	SBIR	2011	1	243702	RADIKAL THERAPEUTICS, INC.	8 SOLVIVA RD		West tisbury
Novel Means to Establish Free Radical Balance in	1R43HL106810-01A1	HHS	HHS	SBIR	2011	1	231328	RADIKAL THERAPEUTICS,	8 SOLVIVA RD		West tisbury

the Neonatal Premature Lung					1			INC.		
Vasodilating Nitroxide for Therapy of Limb Ischemia-Perfusion Injury	1R43HL108370-01	HHS	HHS	SBIR	2011	1	225163	RADIKAL THERAPEUTICS, INC.	8 SOLVIVA RD	West tisbury
Bifunctional Redox Agent for the Treatment of PPHN	1R43HL110374-01	HHS	HHS	SBIR	2011	1	237906	RADIKAL THERAPEUTICS, INC.	8 SOLVIVA RD	West tisbury
Tr1-Specific Tolerance: a Novel Treatment of Multiple Sclerosis	1R43NS076002-01	HHS	HHS	SBIR	2011	1	625465	RADIKAL THERAPEUTICS, INC.	8 SOLVIVA RD	West tisbury
Repolarization of Activated Th1 Cells: a Novel Means to Treat IBD	1R43AI092832-01	HHS	HHS	SBIR	2011	1	263034	RADIKAL THERAPEUTICS, INC.	8 SOLVIVA RD	West tisbury
Crystalline Endolysin Treatment for Tuberculosis in TB/HIV co-infected patients	1R43AI095120-01	HHS	HHS	SBIR	2011	1	541150	PROCRYSTA BIOLOGIX, INC.	12 MICHIGAN DR	Natick
Dendritic Cell-Targeted HIV Vaccine Product	1R43AI095159-01	HHS	HHS	SBIR	2011	1	297572	CELLDEX THERAPEUTICS, INC.	119 4th Avenue	Needham
Development of Tissue Scaffold of High Strength and Porosity	1R43AR060591-01A1	HHS	HHS	SBIR	2011	1	138591	BIO2 TECHNOLOGIES, INC.	12R CABOT RD	Woburn
Amelioration of Claustrophobia and Disruptive Patient Motion in MR Imaging	1R43AT006296-01A1	HHS	HHS	SBIR	2011	1	640032	HYPNALGESICS, LLC	157 IVY ST	Brookline
MMP Inhibitor For Orofacial Pain	1R43DE022207-01	HHS	HHS	SBIR	2011	1	250000	AQUILUS PHARMACEUTICALS, INC.	225 MYSTIC VALLEY PKWY	Winchester
Development of a discovery platform based on microfluidics and fluorescent cell f	1R43DK092122-01	HHS	HHS	SBIR	2011	1	695816	NIVARTA, INC.	139 WOODPECKER RD	Stoughton
High Resolution Scanning Magnetometry	1R43EB013958-01	HHS	HHS	SBIR	2011	1	150043	MOMENT TECHNOLOGIES, LLC	120 Second Ave	Boston
Robotic System for Minimally Invasive Neurosurgical Endoscopic	1R43EB014063-01	HHS	HHS	SBIR	2011	1	99730	STERLING POINT RESEARCH, LLC	53 Oxford Street	Winchester

Procedures											
Develop and Test an Online Biohazard Simulator to Train Skilled Support Personnel	1R43ES020140-01	HHS	HHS	SBIR	2011	1	98719	GRYPHON SCIENTIFIC, LLC	973 Hale Street		Beverly
Vision-QOL-CAT: A Functional Health CAT for those with Visual Disorders	1R43EY021390-01	HHS	HHS	SBIR	2011	1	98632	JOHN WARE RESEARCH GROUP, INC.	1 INNOVATION DR, STE 400		Worcester
Long-Acting Mucus-Penetrating Steroid Particles for Treatment of Eye Inflammation	1R43EY021705-01	HHS	HHS	SBIR	2011	1	255595	KALA PHARMACEUTICALS, INC.	135 Beaver Street		Waltham
Mucus-Penetrating Antibiotics for Lung Infections Associated with Cystic Fibrosis	1R43HL106899-01	HHS	HHS	SBIR	2011	1	180415	KALA PHARMACEUTICALS, INC.	135 Beaver Street		Waltham
Development of an Instrument to Determine Protein Stability at any Desired Temper	1R43GM096751-01	HHS	HHS	SBIR	2011	1	134793	AVIA BIOSYSTEMS, LLC	775 EAST FALMOUTH HIGHWAY	SUITE 193	East falmouth
Development and Commercial Optimization of Circular DNA Conversion for Opti-pore	1R43HG006212-01	HHS	HHS	SBIR	2011	1	181725	NOBLEGEN BIOSCIENCES, INC.	58 ELSINORE ST		Concord
Steerable Oxygen Sensing Catheter for Cardiac Resynchronization Therapy (CRT) Pro	1R43HL102983-01A1	HHS	HHS	SBIR	2011	1	188628	OXUS MEDICAL, INC.	19 RADMORE ST		Worcester
12-lead MRI-Compatible ECG for physiological monitoring and scanner synchronizati	1R43HL110427-01	HHS	HHS	SBIR	2011	1	191624	E-TROLZ, INC	1600 OSGOOD ST, STE 2-17		North andover
Intramural drug infusion balloon for preventing vascular restenosis	1R43HL110530-01	HHS	HHS	SBIR	2011	1	194164	MEDI-SOLVE COATINGS, LLC	14 TECH CIRCLE		Natick
Development of HeartLander as an epicardial injection delivery system	1R43HL114022-01	HHS	HHS	SBIR	2011	1	98519	HEARTLANDER SURGICAL, INC.	90 WILDWOOD DR		Westwood
Forced Exercise: A New Therapy for the Treatment of Parkinson's	1R43NS067744-01A1	HHS	HHS	SBIR	2011	1	196238	EXERCYCLE COMPANY	31 HAYWARD ST, STE B1		Franklin

Disease										
Continuous Countercurrent Tangential Chromatography	1R43RR031935-01A1	HHS	HHS	SBIR	2011	1	183000	CHROMATAN CORPORATION	85 NEEDHAM ST	Dedham
High Throughput Manufacturing for Three-Dimensional Microfluidic Devices	1R44EB012415-01	HHS	HHS	SBIR	2011	1	67200	FEMTOFAB, INC.	812 Memorial Dr. #1908	Cambridge
A FAP-Activated Proteasome Inhibitor for Killing Solid Tumors	1R41CA156930-01A1	HHS	HHS	STTR	2011	1	245638	ARISAPH PHARMACEUTICALS, INC.	100 HIGH STREET	Boston
High-throughput portable software for fragment-based drug design	1R41GM097907-01	HHS	HHS	STTR	2011	1	98055	ACPHARIS, INC.	160 N MILL ST	Holliston
Noninvasive neonatal glucose monitor	1R41HD069207-01	HHS	HHS	STTR	2011	1	462835	FLUOROMETRIX CORPORATION	24 TIMBER EDGE RD	Stow
TAS::75 0893::TAS RAPID LARGE SCALE PRODUCTION OF PROTEIN THERAPEUTICS	N43DA110015	HHS	HHS	SBIR	2011	1	150000	ANTAGEN PHARMACEUTICALS, INC.	650 ALBANY ST UNIT 112	Boston
MA Total							$83,008,312			
Worcester Total							$6,642,896			
Biomedical Research Models and Microbiotix Inc. Total							$4,782,911			
Percentage of Worcester County Funds to Biomedical Research Models and Microbiotix Inc. Total							72%			

Appendix I: Business Formation

	NAICS 61131 Colleges and universities (1.9%)	NAICS 622 Hospitals (4.5%)	NAICS 541380 Testing laboratories (30%)	NAICS 334516 Analytical laboratory instrument mfg. (30%)	NAICS 541712 Other physical and biological research (22%)	NAICS 541711 Research and development in biotechnology	NAICS 339115 Ophthalmic goods manufacturing	NAICS 339113 Surgical appliance and supplies manufacturing	NAICS 339112 Surgical and medical instrument manufacturing	NAICS 334517 Irradiation apparatus manufacturing	NAICS 334510 Electromedical apparatus manufacturing	NAICS 3254 Pharmaceutical and medicine manufacturing	TOTAL # ESTABLISHMENTS
Year	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	**Annual**	
2001	1	1	7	2					5			9	25
2002	1	1	8	2			6		5			9	32
2003	1	1	7	2			6		5			11	34
2004	1	1	8	2			4	4	6	1	6	9	43
2005	1	1	8	2			3	4	6	1	7	9	42
2006	1	1	8	2			3	4	5	1	7	8	39
2007	1	1	8	2	5	41	3	5	5	1	6	10	86
2008	1	1	7	2	6	40	3	5	5	1	6	11	87
2009	1	1	7	2	6	40	5	5	5	1	6	12	90
2010	1	1	6	2	6	40	5	5	6	1	7	11	91
2011	1	1	5	2	6	44	3	5	6	1	8	10	92

	NAICS 541712 Other physical and biological research (22%)	NAICS 541711 Research and development in biotechnology	NAICS 334516 Analytical laboratory instrument mfg. (30%)	NAICS 622 Hospitals (4.5%)	NAICS 61131 Colleges and universities (1.9%)	NAICS 3254 Pharmaceutical and medicine manufacturing	NAICS 339115 Ophthalmic goods manufacturing	NAICS 339113 Surgical appliance and supplies manufacturing	NAICS 339112 Surgical and medical instrument manufacturing	NAICS 334510 Electromedical apparatus manufacturing	NAICS 334517 Irradiation apparatus manufacturing	NAICS 541380 Testing laboratories (30%)
2007	102	580	25	10	3	95	13	63	85	42	17	8
2008	120	631	24	10	3	91	14	65	87	39	16	7
2009	132	649	23	9	3	87	17	61	83	42	16	7
2010	147	673	23	9	4	82	17	59	85	41	14	6
2011	165	686	24	9	4	78	14	59	82	45	15	5

Appendix J: Biomanufacturing

Number of biomanufacturing Companies located in Worcester County:

1. **Company Name**	**Address**	**Town/City, State, Zip Code**	**Phone Number**
2. ABBOTT Bioresearch Center, Inc.	100 Research Drive	Worcester, MA 01606	508-849-2500
3. Abco Welding & Industrial Supply, Inc.	31 Sword St	Auburn, MA 01501	508-791-9293
4. ACMI Corporation	136 Turnpike Road	Southborough, MA 01772	508-804-2600
5. Advanced Cell Technology Inc	One Innovation Drive	Worcester, MA 01605	508-756-1212
6. Aearo Co.	90 Mechanic Street	Southbridge, MA 01550	508-764-5500
7. Albright Technologies Inc	25 Litchfield St	Leominster, MA 01453	978-466-5870
8. Alpha Analytical Labs	8 Walkup Drive	Westborough, MA 01581	508-898-9220
9. Alpha-Beta Technology Inc (ABTI)	One Innovation Drive	Worcester, MA 01605	508-798-6900
10. Analox Instruments Usa Inc	104 Sunset Ln	Lunenburg, MA 01462	978-582-9368
11. Antigen Express Inc	100 Barber Avenue	Worcester, MA 01606	508-852-8783
12. AO SOLA	14 Mechanic Street	Southbridge, MA, 01550	508-764-5000
13. Araios Inc.	One Innovation Drive	Worcester, MA 01605	617-413-3020
14. Arrhythmia Research Technology Inc.	25 Sawyer Passway	Fitchburg, MA 01420	978-345-5000
15. Athena Diagnostics, Inc	377 Plantation Street	Worcester, MA 01605	508-756-2886
16. Ats Laboratories Inc			
17. Attogen Inc.	100 Barber Ave	Worcester, MA 01606	
18. Auralgesic Company, Inc.	16 Johnson Way	Rutland, MA 01543	508-886-6749
19. Avecia Biotechnology, Inc.	125 Fortune Ave	Milford, MA 01757	508-532-2500
20. Averica Discovery Service Inc.	One Innovation Drive, Biotech III	Worcester, MA 01605	508-757-4600
21. Averion International Corp	225 Turnpike Road	Southborough, MA 01772	508-597-6000

22. Bioactives LLC	1 Dix Street	Worcester, MA 01609	617-489-0424
23. BioDynamics, Inc.	29 Prospect Street	West Boylston, MA 01583	508-835-6258
24. Biohybrid Technologies	910 Boston Turnpike Road	Shrewsbury, MA 01545	508-842-4460
25. Biomeasure, Incorporated	27 Maple Street	Milford, MA 01757	508-478-0144
26. Biomedical Polymers Inc	42 Linus Allian Ave	Gardner, MA 01440	978-632-2555
27. Biomedical Research Models, Inc	10 New Bond Street	Worcester, MA 01606	508-852-0606
28. BioPal, Inc.	80 Webster Street	Worcester, MA 01603	508-770-1190
29. Biopartners Inc	10 Andy Rd	Worcester, MA 01602	508-755-4645
30. BioReliance Biotech Inc.	381 Plantation Street	Worcester, MA 01605	508-791-8000
31. Biosource, Inc.	1200 Millbury Street Suite 7F	Worcester, MA 01607	508-363-2367
32. BioValve Technologies Inc.	One Innovation Drive	Worcester, MA 01606	508-421-9500
33. BioVest International, Inc.	377 Plantation St, Biotech 4	Worcester, MA 01605	508-793-0001
34. Blue Sky Biotech, Inc.	60 Prescott Street	Worcester, MA 01605	508-831-1295
35. Boston Medical Products, Inc.	117 Flanders Road	Westborough, MA 01581	508-898-9300
36. Brendan Bioscience, LLC	3A Business Way	Hopedale, MA 01747	508-473-8899
37. Brochu Bio-Lab Services	400 Thompson Road	Webster, MA 01570	508-943-9750
38. BURLE Electro-Optics, Inc.	PO Box 1159, Sturbridge Bus. Park	Sturbridge, MA 01566	508-347-4000
39. Cellthera Inc.	431 High Street	Southbridge, MA 01550	508-765-0276
40. Central Coating Co, Inc.	165 Shrewsbury St	West Boylston, MA 01583	508-835-6225
41. CereMedix, Inc.	One Innovation Drive	Worcester, MA 01605	508-459-5924
42. Charles River	57 Union St	Worcester, MA 01608	508-890-0100
43. Coley Pharmaceutical Group, Inc.	93 Worcester St.	Wellesley, MA 02481	781-431-9000
44. Consistent Cardiogram Corp	25 Winthrop Street	Worcester, MA 01604	
45. Cool Laser Optics	57 E Main Street	Westborough, MA 01581	508-870-0066
46. Crescent Innovations Inc			
47. Cryogenic Institute of New England	90 Ellsworth St	Worcester, MA 01610	508-459-7447
48. Cyberkinetics	100 Foxborough Blvd.	Foxborough, MA 02035	508-549-9981

Neurotechnology			
49. Databased Inc			
50. Dosco Sheet Metal & mfg	6 Grafton St	Millbury, MA 01527	508-865-9998
51. Doss Plastics, Inc.	94 Ashland Ave.	Southbridge, MA 01550	508-764-3211
52. Eac			
53. East Acres Farms Inc.	236 Blackmer Rd.	Southbridge, MA 01550	508-765-0535
54. Eastwest Pharmaceutical International	33 Hemingway St	Shrewsbury, MA 01545	508-791-8544
55. ECI Biotech, Inc	85 Prescott Street	Worcester, MA 01605	508-752-2209
56. Eden Research plc			
57. Emuge Corporation	1800 Century Dr	West Boylston, MA 01583	508-595-3619
58. Entegrion Inc.			
59. EpigenDX	15 Harris Ln	Ashland, MA 01721	508-881-6810
60. Filtrona Extrusion Inc	170 Bartlett St	Northborough, MA 01532	508-393-2553
61. Fisher Scientific	8 Forge Pkwy	Franklin, MA 02038	508-553-5000
62. Funnel Insruments LLC	79 Hecla St	Uxbridge, MA 01569	508-278-0800
63. Gene-IT	25 Winthrop Street	Worcester, MA 01604	508-754-7300
64. Genetex Optics Inc	183 West Main	Dudly, MA 01571	508-943-3860
65. Genzyme Genetics	3400 Computer Drive	Westborough, MA 01581	508-898-9001
66. GLSynthesis, Inc	One Innovation Drive	Worcester, MA 01605	508-845-9484
67. GlucaDel Consulting			
68. GlycoSolutions, Corp.	25 Winthrop Street	Worcester, MA 01604	508-756-6418
69. Gyrus Acmi	136 Turnpike Road	Southborough, MA 01772	508-8042600
70. Hematech	377 Plantation St.	Worcester, MA 01605	508-792-0682
71. Hightech Precision Moulders LLC	30 Patriots Circle	Leominster, MA 01453	978-534-5000
72. Hypnion Inc	381 Plantation Street	Worcester, MA 01605	508-438-2800
73. Hypromatrix, Inc.	100 Barber Ave	Worcester, MA 01606	508-856-7900
74. Imaging Diagnostics, Inc.	98 Pratts Junction Rd	Sterling, MA 01564	978-422-8601
75. Imaging Diagnostics, Inc.	99 Pratts Junction Rd	Sterling, MA 01565	978-422-8602
76. Indigene Pharmaceuticals, Inc.	115 Flanders Rd.	Westborough, MA 01581	508-389-1701
77. Infonetics Corp.	2 Flint Meadow Ln.	Shrewsbury, MA 01345	508-845-9824
78. Informatics & Computing Resources Center			

79. Infussafe	13 Massachusetts Ave	Harvard, MA 01451	978-805-3183
80. Innovend	30 Patriots Cir	Leominster, MA 01453	978-534-5000
81. Insight Neuroimaging Systems, LLC	111 Canterbury St	Worcester, MA 01610	508-799-6464
82. Integrated Pharmaceuticals Inc	310 Authority Dr	Fitchburg, MA 01420	978-696-0020
83. JR Medical Technology	123 Briar Wood Ave	Southbridge, MA 01550	508-764-2121
84. Kinefac Corp	156 Goddard Memorial Drive	Worcester, MA 01603	508-754-6891
85. Laser Therapeutics Inc	101 Waterside Dr	Centerville, MA 02632	508-790-9300
86. Latham Laboratories Inc	Worcester Biotechnology Park	Worcester, MA 01605	
87. Lex Company	178 Lincoln Street	Worcester, MA 01605	
88. LINOS Photonics, Inc.	459 Fortune Blvd.	Milford, MA 01757	508-478-6200
89. Liporx Pharmaceuticals Inc	One Innovation Drive	Worcester, MA 01605	
90. Luxtec Corporation	326 Clark St.	Worcester, MA 01606	508-856-9454
91. Mar-lee Companies	190 Authority Dr	Fitchburg, MA 01420	978-343-9600
92. Mar-lee Companies, Inc	180 Authority Dr	Fitchburg, MA 01420	978-348-1291
93. Mass Biotechnology Research Park	One Innovation Drive	Worcester, MA 01605	508-755-2230
94. Mass Histology Service	31 Huron Ave	Worcester, MA 01605	508-853-9363
95. Massachusetts Biomedical Initiatives	60 Prescott Street	Worcester, MA 01605	508-797-4200
96. Mass Micro Laboratories, Inc.	25 Winthrop Street	Worcester, MA 01604	508-752-0858
97. Medcon Biolab Technologies	50 Brigham Hill Rd	Grafton, MA 01519	508-839-4203
98. Medical Equipment Specialists Inc	14 Lake Ave	Worcester, MA 01604	508-757-3390
99. Microbiotix Inc	One Innovation Drive	Worcester, MA 01605	508-757-2800
100. Micron Products Inc	25 Sawyer Passway	Fitchburg, MA 01420	978-345-5000
101. Miniature Tool & Die, Inc.	15 Trolley Crossing Rd	Charlton, MA 01507	508-248-0111
102. Mossman Associates Inc	9 Village Cir	Milford, MA 01757	508-488-6169
103. Mtm	134 Flanders Rd Ste 325	Westborough, MA 01581	508-366-8334

Laboratories Inc			
104. Netoptix Corp	PO Box 550, Sturbridge Buisness Park	Sturbridge, MA 01566	508-347-9191
105. New England Peptide Inc	65 Zub Lane	Gardner, MA 01440	888-343-5974
106. New World Laboratories	25 Winthrop Street	Worcester, MA 01604	
107. News Technical Gases	31 Sword Street	Auburn, MA 01501	508-791-9293
108. NOVAGENESIS	One Innovation Drive, Biotech III	Worcester, MA 01605	508-797-6682
109. NP Medical, Inc.	101 Union Street	Clinton, MA 01510	978-365-2500
110. NuGenesis Technologies Corporation	1900 West Park Drive	Westborough, MA 01581	508-616-9876
111. Oliver M Dean Inc	125 Brooks St	Worcester, MA 01606	508-856-9100
112. Omega PharmServices, Inc.	113 Cedar St. Suite S-6	Milford, MA 01757	508-482-9330
113. OPCO Laboratory Inc	704 River Street	Fitchburg, MA 01420	978-345-2522
114. OPTIM, Inc.	64 Technology Park Road	Sturbridge, MA 01566	800-225-7486
115. Optimum Technologies, Inc.	68 West Street	Southbridge, MA 01550	508-765-8100
116. Pgm Plastics Inc	774 Crawford St	Fitchburg, MA 01420	978-342-6767
117. Pharm Development Consulting			
118. Physical Research	451 Worcester Road; Route 20	Charlton, MA 01507	508-865-9103
119. Phytera Inc	377 Plantation Street	Worcester, MA 01605	508 792-6800
120. Plant Pharmaceuticals Inc	One Innovation Drive	Worcester, MA 01605	
121. PolyCarbon Industries, Inc.	435 Lancaster Street	Leominster, MA 01453	978-772-2111
122. PolyOrg, Inc.	10 Powers Street	Leominster, MA 01453	978-466-7978
123. Precision Optics Corporation	22 E Broadway	Gardner, MA 01440	978-630-1800
124. ProFoldin			
125. Pyrosequencing Inc	2200 West Park Drive, Suite 320	Westborough, MA 01581	508-389-9911
126. Q-One Biotechnologies, Ltd.	381 Plantation Street	Worcester, MA 01604	508-791-8000
127. Radius Product Development	200 Union St	Clinton, MA 01510	978-368-3200
128. REM Inc			
129. RenalPlant Corporation	5 Leonard Drive	Southborough, MA 01722	508-624-0150
130. RES-TECH	22 Marshall Street	Clinton, MA 01510	978-368-0146

Corporation			
131. Rocheleau Tool & Die Co Inc	117 Industrial Rd	Fitchburg, MA 01420	978-345-1723
132. RXi Pharmaceuticals Corporation	1 Innovation Drive	Worcester, MA 01605	508-767-3861
133. Saint-Gobain Abrasives Inc.	1 New Bond St.	Worcester, MA 01606	508-795-5000
134. Schott Fiber Optics, Inc	122 Charlton Street	Southbridge, MA 01550	800-343-6120
135. Seatech Bioproducts Corp	159 Memorial Drive; Unit C	Shrewsbury, MA 01545	508-842-9292
136. Select Engineering Inc	260 Lunenburg St	Fitchburg, MA 01420	978-345-4400
137. SelectX Pharmaceuticals, Inc.	One Innovation Drive, Biotech III	Worcester, MA 01605	508-798-0216
138. SeraCare Diagnostics	25 Birch Street	Milford, MA 01757	508-478-5510
139. Shire Biologics Inc	30 Bearfoot Road	Northborough, MA 01532	508-351-9944
140. SquiCor Labs Inc.	80 Optical Drive	Southbridge, MA 01550	360-450-4140
141. Steelcraft	115 W. Main Street	Millbury, MA 01463	508-865-4445
142. Steris-Isomedix Services	435 Whitney Street	Northborough, MA 01532	508-393-9323
143. Stethographics Inc	21 Wayside Rd	Westborough, MA 01581	508-320-2841
144. Targeted Cell Therapies	60 Prescott Street	Worcester, MA 01605	508-517-8400
145. Techman International Corp	16B Sturbridge Road	Charlton, MA 01507	508-248-2900
146. Technical Innovation Center, Inc.	100 Barber Avenue	Worcester, MA 01606	508-799-6700
147. T M Electronics	45 Main Street	Boylston, MA 01505	508-856-0500
148. TranXenoGen, Inc.	800 Boston Turnpike	Shrewsbury, MA 01545	508-936-4200
149. Valeritas, LLC	800 Boston Turnpike (Route 9)	Shrewsbury, MA 01545	508-845-1177
150. Valmed, Inc.	221 Spring Street	Shrewsbury, MA 01545	508-845-3438
151. Vascular Sciences	44 Edward Drive	North Grafton, MA 01536	508-887-9486
152. Verax Biomedical Incorporated	377 Plantation St, Biotech 4	Worcester, MA 01605	508-755-7029
153. Viking Systems	134 Flanders Rd	Westborough, MA 01581	508-366-8882
154. Vista Medical Technologies	134 Flanders Road	Westborough, MA 01581	508-366-3668

155. VivaScan Corp.	560 Prospect St	West Boylston, MA 01583	508-852-1600
156. Water Corporation	34 Maple Street	Milford, MA 01757	508-478-2000
157. Welgen, Inc.	25 Winthrop Street	Worcester, MA 01604	888-493-5436
158. WesaGen Inc			
159. Zoaan Diagnostics, Inc.	159 Memorial Drive; Unit C	Shrewsbury, MA 01545	508-842-9020

Appendix K: Federal funding for academic, non-profit, commercial and health

NIH Funding for Companies and Institution in Worcester County

Companies/ Institutions	2007	2008	2009	2010	2011	2012	Total for each company/institution
ADVANCED CELL TECHNOLOGY		$199,532					199532
ASSUMPTION COLLEGE					$187,709		187709
BIOMEDICAL RESEARCH MODELS, INC.	$287,296	$767,501	$891,829	$1,202,180	$1,498,494	$754,629	$5,401,929
BIOPAL, INC	$795,036	$749,792		$487,625	$358,316	$629,423	$3,020,192
CLARK UNIVERSITY (WORCESTER, MA)	$1,007,567	$631,164	$690,953	$698,147	$755,791	$627,299	$4,410,921
COLLEGE OF THE HOLY CROSS	$304,261	$359,114			$341,672		$1,005,047
ECI BIOTECH	$358,311	$787,863	$511,472			$298,291	$1,955,937
GLSYNTHESIS, INC.	$3,126,530	$2,335,245	$2,167,087	$1,699,710	$935,484	$1,715,514	$11,979,570
GROVE INSTRUMENTS, LLC	$100,000	$953,153	$1,189,186	$1,106,749	$631,627	$450,297	$4,431,012
INSIGHT NEUROIMAGING SYSTEMS, INC.	$99,510						$99,510
JEFFREY D. MANCEVICE, INC.	$8,870						$8,870
JOHN WARE RESEARCH GROUP, INC.				$1,381,852	$869,521		$2,251,373
MICROBIOTIX, INC	$4,792,920	$6,063,209	$6,493,444	$5,469,578	$4,054,356	$8,080,924	$34,954,431
OXUS MEDICAL, INC.					$188,628		$188,628
RXI PHARMACEU				$298,544	$876,927	$292,272	$1,467,743

TICALS CORPORATION							
SIGNABLOK, INC.						$443,567	$443,567
UNIV OF MASSACHUSETTS MED SCH WORCESTER	$118,856,210	$122,800,391	135,430,351	$153,380,893	$153,534,616	$134,169,972	$818,172,433
VERAX BIOMEDICAL, INC.	$713,042						$713,042
WORCESTER POLYTECHNIC INSTITUTE	$672,885	$463,678	$1,551,124	$1,581,265	$621,287	$335,971	$5,226,210
WORCESTER STATE COLLEGE				$206,302			$206,302
Total	131122438	$136,110,642	148925446	167512845	164854428	147798159	**896323958**

Appendix L: Capital and Human Resources

NSF Survey of Science and Engineering Research Facilities - Worcester County			
Total Net Assignable Square Feet			
2003	University of Massachusetts Worcester	Biological Sciences	297449
2003	University of Massachusetts Worcester	Computer Sciences	0
2003	University of Massachusetts Worcester	Engineering (FY 2003,2005)	0
2003	University of Massachusetts Worcester	Mathematical Sciences	0
2003	University of Massachusetts Worcester	Medical Sciences	279839
2003	University of Massachusetts Worcester	Physical Sciences	0
2003	University of Massachusetts Worcester	Other Science and Engineering Fields	0
2003	Worcester Polytechnic Institute	Biological Sciences	11534
2003	Worcester Polytechnic Institute	Computer Sciences	5631
2003	Worcester Polytechnic Institute	Engineering (FY 2003,2005)	68211
2003	Worcester Polytechnic Institute	Mathematical Sciences	2224
2003	Worcester Polytechnic Institute	Medical Sciences	0
2003	Worcester Polytechnic Institute	Physical Sciences	18105
2003	Worcester Polytechnic Institute	Other Science and Engineering Fields	0
2005	Clark University	Biological Sciences	30000
2005	Clark University	Computer Sciences	10000
2005	Clark University	Earth, Atmospheric, and Ocean Sciences	0
2005	Clark University	Engineering (FY 2003,2005)	0
2005	Clark University	Mathematical Sciences	10000
2005	Clark University	Medical Sciences	0
2005	Clark University	Physical Sciences	30000
2005	Clark University	Other Science and Engineering Fields	0
2005	University of Massachusetts Worcester	Biological Sciences	222301
2005	University of Massachusetts Worcester	Computer Sciences	0
2005	University of Massachusetts Worcester	Engineering (FY 2003,2005)	0
2005	University of Massachusetts Worcester	Mathematical Sciences	0
2005	University of Massachusetts Worcester	Medical Sciences	145516
2005	University of Massachusetts Worcester	Physical Sciences	0
2005	University of Massachusetts Worcester	Other Science and Engineering Fields	0
2005	Worcester Polytechnic Institute	Biological Sciences	13422
2005	Worcester Polytechnic Institute	Computer Sciences	399
2005	Worcester Polytechnic Institute	Engineering (FY 2003,2005)	46514
2005	Worcester Polytechnic Institute	Mathematical Sciences	0
2005	Worcester Polytechnic Institute	Medical Sciences	0
2005	Worcester Polytechnic Institute	Physical Sciences	16332
2005	Worcester Polytechnic Institute	Other Science and Engineering Fields	0

Market Snapshot of Lab Space in Boston, Cambridge, and the Suburbs (including Worcester) – Q3 2012 Statistics

MARKET	SQUARE FEET (SF) SUPPLY	DIRECT SF AVAILABLE	SUBLEASE SF AVAILABLE	VACANCY*	Q3 2012 ABSORPTION	YTD ABSORPTION
BOSTON	60,869,797	7,928,481	637,408	14.1%	204,843	893,488
Back Bay	11,981,716	946,812	136,320	9.0%	(370,713)	(340,940)
Financial District	33,691,611	5,219,194	355,357	16.5%	586,199	956,032
Charlestown	2,886,860	344,780	26,825	12.9%	(93,828)	(142,142)
Crosstown	1,025,000	44,400	2,300	4.6%	(2,300)	11,700
Fenway/Kenmore	1,826,057	148,795	1,950	8.3%	15,662	98,428
North Station	1,881,789	234,307	13,476	13.2%	30,553	24,626
Seaport	6,392,747	802,555	86,391	13.9%	39,198	208,973
South Station	1,184,017	187,638	14,789	17.1%	72	76,811
CAMBRIDGE	19,732,414	1,727,570	310,657	10.3%	156,823	386,046
Alewife Station/Route 2	2,756,411	244,751	49,175	10.7%	67,135	86,748
East Cambridge	15,049,857	1,387,075	253,082	10.9%	102,331	274,199
Harvard Square/Mass Ave	1,926,146	95,744	8,400	5.4%	(12,643)	25,099
SUBURBS	131,411,475	22,775,259	2,736,940	19.4%	(493,612)	1,110,549
Inner Suburbs	5,905,228	765,754	53,769	13.9%	6,039	128,946
Route 128 North	8,309,485	1,259,885	51,983	15.8%	11,384	106,579
Route 128 Northwest	22,604,952	2,864,519	467,162	14.7%	209,836	667,120
Route 128 Mass Pike	28,592,670	4,055,581	743,638	16.8%	(457,895)	(137,023)
Route 128 South	15,709,411	3,128,539	193,812	21.1%	46,040	(183,641)
Route 495 North	25,799,262	5,138,116	516,380	21.9%	(160,401)	151,961
Route 495 West	18,137,308	4,147,905	658,561	26.5%	(61,915)	554,303
Route 495 South	4,539,492	1,045,547	51,635	24.2%	(41,868)	(106,757)
Worcester	1,813,667	369,413	0	20.4%	(44,832)	(70,939)
TOTAL	212,013,686	32,431,310	3,685,005	17.0%	(131,946)	2,390,083

**Including sublease space*

Appendix M: Workforce Education Level

2000 Educational Attainment of Employed in Central Massachusetts	Less than High School	High School	Some College	Associate's Degree	Total Less than Bachelor's Degree	Total Less than Bachelor's Degree	Bachelor's Degree	Master's Degree or more	Bachelor's Degree or more	Bachelor's Degree or more
Architecture & Engineering	89	708	1,195	749	2,741	2,741	2,367	1,226	3,593	3,593
Life, Physical, & Social Sciences	36	278	198	89	601	601	933	1,420	2,353	2,353
Computer & Mathematical	57	277	1,128	443	1,905	1,905	2,733	1,197	3,930	3,930
Healthcare Practitioners & Technical Services	158	1,033	2,906	3,126	7,223	7,223	4,896	4,680	9,576	9,576
Healthcare Support	955	2,507	2,148	851	6,461	6,461	487	226	713	713
Personal Care & Service	1,226	2,597	1,827	638	6,288	6,288	756	314	1,070	1,070
Production	7,255	12,722	4,849	1,200	26,026	26,026	1,202	283	1,485	1,485

2008-2010 Educational Attainment of Employed in Central Massachusetts	Less than High School	High School	Some College	Associate's Degree	Total Less than Bachelor's Degree	Total Less than Bachelor's Degree	Bachelor's Degree	Master's Degree or more	Bachelor's Degree or more	Bachelor's Degree or more
Architecture & Engineering	37	595	739	638	2,009	2,009	2,885	981	3,866	3,866
Life, Physical, & Social Sciences	21	109	184	108	422	422	1,131	2,307	3,438	3,438
Computer & Mathematical	-	365	975	607	1,947	1,947	3,477	1,848	5,325	5,325
Healthcare Practitioners & Technical Services	16	1,276	2,461	4,128	7,881	7,881	6,505	5,928	12,433	12,433
Healthcare Support	1,018	2,977	4,006	1,310	9,311	9,311	988	227	1,215	1,215
Personal Care & Service	1,255	3,490	2,971	953	8,669	8,669	1,625	335	1,960	1,960
Production	4,131	9,795	3,999	1,033	18,958	18,958	1,112	336	1,448	1,448

	2000		2008-2010		Net Change	
Workforce Education Levels in Central Massachusetts	Less than Bachelor's Degree	Bachelor's Degree or more	Less than Bachelor's Degree	Bachelor's Degree or more	Less than Bachelor's Degree	Bachelor's Degree or more
Architecture & Engineering	2,741	3,593	2,009	3,866	-732	273
Life, Physical, & Social Sciences	601	2,353	422	3,438	-179	1,085
Computer & Mathematical	1,905	3,930	1,947	5,325	42	1,395
Healthcare Practitioners & Technical Services	7,223	9,576	7,881	12,433	658	2,857
Healthcare Support	6,461	713	9,311	1,215	2850	502
Personal Care & Service	6,288	1,070	8,669	1,960	2381	890
Production	26,026	1,485	18,958	1,448	-7068	-37
Total Degrees in Workforce	51,245	22,720	49,197	29,685	-2048	6,965

2008-2010 Educational Attainment of Employed in Central Massachusetts	Total Less than Bachelor's Degree	Bachelor's Degree or more
Architecture & Engineering	2,009	3,866
Life, Physical, & Social Sciences	422	3,438
Computer & Mathematical	1,947	5,325
Healthcare Practitioners & Technical Services	7,881	12,433
Healthcare Support	9,311	1,215
Personal Care & Service	8,669	1,960
Production	18,958	1,448
Total Degrees in Workforce	49,197	29,685

Appendix N: STEM Degrees Awarded

Worcester County Colleges							Massachusetts Colleges				
Degree: Doctorate							Degree: Doctorate				
Year	2006	2007	2008	2009	2010		Year	2006	2007	2008	2009	2010
Degrees Granted	58	61	60	74	92		Degrees Granted	1238	1403	1372	1387	1374
Degree: Masters							Degree: Masters				
Year	2006	2007	2008	2009	2010		Year	2006	2007	2008	2009	2010
Degrees Granted	253	304	298	335	353		Degrees Granted	3119	3213	3373	3450	3620
Degree: Bachelors							Degree: Bachelors				
Year	2006	2007	2008	2009	2010		Year	2006	2007	2008	2009	2010
Degrees Granted	947	896	1015	970	1013		Degrees Granted	7228	7164	7662	7701	8118