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PLANNING FOR A BIOSCIENCES BASED ECONOMY:
EXPLORING THE POTENTIALITY IN THE EAST CENTRAL
MICHIGAN PLANNING AND DEVELOPMENT REGION

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ABSTRACT

PLANNING FOR A BIOSCIENCES BASED ECONOMY:
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PLANNING AND DEVELOPMENT REGION

By

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There has been minimal planning research completed on the benefits of the biotechnology and the broader bioscience industry to specific regions as a technology based economic development engine. Part of the lack of current literature on benefits and the measurability in bioscience based economic development is associated with the recent emergence and "newness" of the industry. In addition, policymakers have placed importance on spending state and federal monies on innovation and technology based industries to fuel regional and national economic growth. With the heightened interest on the spending of public funds, and with the hype and fad behavior surrounding the biosciences as being "the next big thing" for economic development, it is necessary to evaluate these new policies through a planning framework that tests the feasibility of bioscience based economic development. *Specifically in Michigan, are the biosciences likely to benefit regions external to the large metropolitan cities and the Life Sciences Corridor, which have an existing built up mass of bioscience firms?* The thesis research explores these issues within the geographic context of the State of Michigan and the East Central Michigan Planning and Development Region.

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CHAPTER 1.0
OVERVIEW OF THE RESEARCH

1.1 Origin of the research

The genesis of this research was inspired from the work completed by Cortwright & Mayer (2002), who analyze the biotechnology industry across the fifty-one largest metropolitan regions in the United States. The findings of their research revealed that only a few core group of cities have the critical mass in the biotechnology industry to be considered clusters, and that these cities benefit from the positive economic spillovers generated through the industry. Furthermore, the research revealed that the biotechnology industry is an emerging technology based industry, with a complex and specialized development process, limiting the understanding, benefits and the consequent implementation of economic development policies created to harness this industry as an engine for economic growth.

There has been minimal planning research completed on the benefits of the biotechnology and the broader bioscience industry to specific regions as a technology based economic development engine. Specifically, implementation of biosciences based economic development have yet to be understood in an urban and regional planning context, as well as the understanding of the potential economic benefits in regions external to key metropolitan cities. Part of the lack of current literature on benefits and the measurability in bioscience based economic development is associated with the recent emergence and "newness" of the industry. In addition, policymakers have placed importance on spending state and federal monies on innovation and technology based industries to fuel regional and national economic growth. With the heightened interest on the spending of public funds, and with the hype and fad behavior surrounding the biosciences as being "the next big thing" for economic development, it is necessary to evaluate these new policies through a planning framework that tests the feasibility of bioscience based economic development. *Specifically in Michigan, are the biosciences likely to benefit regions external to the large metropolitan cities and the Life Sciences Corridor, which have an existing built up mass of bioscience firms?*

The planning research undertaken here helps to explain the benefits of the bioscience industries as a contributor towards economic development. Understanding the contemporary nature of the bioscience industry, the planning research focuses on creating a model framework ultimately to test the feasibility of bioscience based economic development in Michigan's regions external to large metropolitan areas. Since the emergence of this industry is quite recent, planning practitioners will be informed through a planning process model on the potentialities the biosciences may offer for planned economic development in their region.

The uniqueness of the bioscience industry, in terms of the spatial scale (i.e. the concentration in few large metropolitan regions), and the specialized development issues associated with the industry will be explored through the research. Furthermore, there has been recent interest among states and sub-state regions, promising economic growth through technology based industries, such as the biosciences, as a silver bullet to solving a declining or slow local economy. The legislative and policy interests to boost economic growth through the bioscience industries has created programs investing significant public funds towards developing, attracting and retaining these industries. The research explores the question of the biotechnology and the *broader bioscience industry* as being a panacea to solving the problems of slower economic growth. Furthermore, the research here measures the feasibility of development and the consequent spread of economic benefits of this specialized industry to regions outside the large metropolitan cities.

The State of Michigan has historic and core strengths in the manufacturing and manufacturing process based industries, with established manufacturing regions across the state. With significant public funds being utilized through the Michigan Life Sciences Corridor (MLSC) initiative, towards developing, attracting and retaining bioscience and biotechnology firms, can Michigan's strength in manufacturing be harnessed to promote the bioscience industries to regions beyond the large metro cities? The research explores this question, by testing the feasibility of the spread of the bioscience industry beyond the key metro cities by utilizing a planning scenario approach, and by adopting the East Central Michigan Planning Region (ECMPDR) as the specific case.

The feasibility of planning for economic development through bioscience based industry development in the ECMPDR, is explicated by adopting the Program Planning Model, as the principal organizing planning framework which is proposed for this research project.

1.2 Research background

Through technological advancements made in the biosciences industries in DNA and biotechnology research and development (R&D), the bioscience industry has grown as an integral part of technology based industries. Technology-based industries are on the forefront of innovation, driving economic growth, stimulating investments, creating high-wage jobs and enhancing the overall economic climate in some of the largest city regions. States looking to capitalize on the promise of a high-skilled and high-wage workforce have mandated the creation, attraction, retention and integration of technology-based businesses into their economic development policies, including the biosciences.

In a report titled "Signs of Life: The Growth of Biotechnology Centers in the U.S.," as completed in 2002 by The Brookings Institution, the report's authors state that there are only a select group of metropolitan areas in the United States that have a critical economic cluster of biotechnology businesses (Cortwright and Mayer, 2002). These metropolitan areas have benefited from key economic development initiatives, and through collaborative university-industry partnerships that have enabled successful outcomes in biotechnology based economic development.

In an attempt to replicate this growth and stimulate economic development through the bioscience industries, the State of Michigan utilized a portion of the monies received from a national tobacco settlement towards implementing a corridor strategy focused on life sciences R&D. The R&D efforts took shape in the form a Life Sciences corridor, spanning the lower half of the lower peninsula in Michigan, and through an initial collaborative effort between four pillar research institutions, including Wayne State University, The University of Michigan, Michigan State University and the Van Andel Research Institute.

The overarching planning research goal here is to explore the feasibility and the economic development planning potential of the bioscience industries in Michigan through the existing Life Sciences Corridor initiative, and the regions in Michigan that are external to the corridor. In addition, the research is intended to provide a stimulus for the planning practice, and aims to inform local and regional planning practitioners on the potential of planned bioscience based economic development.

1.3 Research Goal

The specific goals of conducting the research are as follows:

- Explain the importance of bioscience industries as an engine of economic growth in Michigan, particularly in light of advances made in the bioscience industries through research and development;

- Highlight and document Michigan's bioscience industries, explaining the current state level initiatives, corporate landscape, and the role of higher educational and research institutions in promoting and facilitating growth in these industries;

- Incorporate a theoretical framework that enables a succinct understanding of technology based economic development, of which the biosciences are an integral part; and

- Provide guidelines and recommend actionable strategies that local and regional economic development planning practitioners can consider for incorporation into to their planning, especially for creating an environment to create and attract technology based industries, such as the biosciences.

1.4 Organizational Framework for the Planning Research

To place the research topic within the context of a planning and development model, which considers new and emerging sectors of planning interest, and provides a guiding framework to evaluate program and planning objectives, the research here employs the Program Planning Model (Van de Ven and Koenig, 1976). The model helps in organizing the research focus of bioscience industry based economic development, and aids in the execution of policy planning research and implementation. In addition, the model incorporates explicit policy evaluation stages, which helps test the overarching research question, i.e., ***the feasibility of biosciences based development in a region external to large metropolitan areas in Michigan***, specifically the case of the East Central Michigan Planning & Development region (ECMPDR).

The Program Planning Model includes the following stages:

Stage 1: Planning Mandate

Stage 2: Problem Exploration

Stage 3: Knowledge Exploration

Stage 4: Program Design

Stage 5: Program Activation

Stage 6: Program Operation and Diffusion

Stage 7: Program Evaluation (parallels stages 4 – 6)

The Program Planning Model (PPM) seeks to provide an organized process for undertaking innovative planning by outlining a workable sequence of activities at the appropriate stages of planning (Van de Ven and Koenig, 1976). The PPM functions and enables effective planning organization and progress, because each stage is led by particular actors who perform specific roles by the relevant stage, allowing for systemic and collaborative development in the planning process, as well as the ability to successfully complete all stages.

The overarching "objective of the PPM is to maintain a balanced concern for obtaining information necessary for solving technical problems and for structuring the participation of affected interest groups to enhance the social and political acceptability of the planning efforts (Van de Ven and Koenig, 1976)." Thus, the importance of a collaborative effort that leverages the collective strength of the relationships among a region's actors is necessary to enable the successful completion of all the stages and ultimately see the program's success. The planning scenario approach utilizes the ECMPDR as a geographic entity to test the feasibility of biosciences based economic development, in a Michigan region that is outside the largest metropolitan areas, while following the PPM stages.

1.4.1 Brief overview of the ECMPDR

The East Central Michigan Planning and Development Region began as the East Central Michigan Economic Development District (ECMEDD) in March of 1968, located north of the Southeast Michigan region. Major cities in the region include (but are not limited to) Saginaw, Bay City and Midland. The operations of the ECMEDD began with the receipt of a grant from the U.S. Department of Commerce, Economic Development Administration. The ECMEDD originally operated as a Economic Development District until January of 1973, and became a regional planning agency, the East Central Michigan Planning and Development Regional Commission (ECMPDRC).

The ECMEDD was originally drawn together for the purpose of creating a voluntary organization of county representatives as a common network seeking to solve county and regional level issues. The purpose of ECMPDRC encompasses the original purpose of the ECMEDD, and, it's primary goal is to promote intergovernmental cooperation, and to protect local government through assistance so they may better govern themselves.

Some of the ECMPDR's activities include regional and local planning studies that help to provide a vision for the region's future. In addition, the ECMPDR works with local member communities on a range of planning activities, and, in accordance to their needs. ECMPDR provides data and comprehensive planning and consultation services to many public and private sector organizations. The ECMPDR is supported financially through funding provided by from Federal, state, and from local member units of government.

Today the ECMPDR is governed by a 48 member full commission board that establishes regional policy, defines committee duties, and adopts the annual work program. A 23 member executive committee oversees general operations and fiscal matters. A 15 member committee comprises the RED Team (Regional Economic Development) which deals specifically with economic development within the region. The purpose of the organization remains true to its original intent - to promote intergovernmental cooperation and to retain local governmental control - despite many new issues facing the region today. Issues such as utility deregulation, telecommunications and technology issues, urban sprawl, environmental concerns and regulations; all of these issues, and many more, reinforce the need and stress the importance of this organization for the future of the region (http://www.ecmpdr.org , last accessed April 29, 2004).

Geographically, the ECMPDR comprises the counties of Arenac, Bay, Clare, Gladwin, Gratiot, Huron, Iosco, Isabella, Midland, Ogemaw, Roscommon, Saginaw Sanilac and Tuscola. Also included in the ECMPDR is the tribe of the Saginaw Chippewa Indians.

CHAPTER 2.0
INTRODUCTION TO THE BIOSCIENCES

2.1 Why biosciences?

The biosciences are a vital part of technology-based industries that are on the forefront of innovation. They are driving economic growth, stimulating investments, creating high-wage jobs and enhancing the overall economic climate in some of the largest cities and regions. States looking to capitalize on the promise of this economic engine have initiated and legislated the creation, attraction, retention and integration of technology-based industries into their economic development policies[1]. As of 2001, the biotechnology industry (an integral part of the biosciences) in the U.S. employed 191,000 people and the companies within the industry had revenues of approximately $28.5 billion[2].

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[1] For example, the state of Florida and Palm Beach County are spending $510 million to attract the San Diego based Scripps Research Institute, in an effort to build a bioscience cluster in the state. Arizona has placed $120 million in public-private funds to entice the International Genomics Consortium, and an additional $400 million is being spent in bioscience R&D at the state universities. Washington's Governor Locke, has urged legislators to create policy that would enable the state to invest $250 million in biotech R&D. And in Kansas, lawmakers have considered placing $500 million over the span of 10 years to fund bioscience R&D at state universities, as well as commercialization of that research (Governing March 04).

[2] See Biotechnology Industry Organization's Editor's and Reporter's Guide for 2003 – 2004 (BIO, 2003: 3-4).

Similarly, within the state of Michigan in 2001, 31,778 people were employed within the biosciences, with bioscience industry occupations paying on an average $15,900 more in comparison with the U.S. mean annual wage (AEG, 2004).

Not only are the bioscience industries important to driving economic growth, they are providing tangible health products to improve the quality and life of people. The improvements have amounted to the development of innovative health products, such as life saving drug treatments, early detection cancer systems, and to the utilization of less intrusive medical devices and instruments in surgical procedures. The improvements are evidenced by the fact that more than 325 million people worldwide have been helped by the 155 medicinal drugs and vaccines approved by the U.S. Food and Drug Administration[3]. Furthermore, there are more than 295 drug products and vaccines undergoing human clinical trials, with the medicines being designed to treat diseases like AIDS, multiple sclerosis, obesity, heart disease and different types of cancers (Oliver, 2000).

2.2 A brief history of the Biosciences

Biosciences involve the use of biological products and related technologies. Some of the scientific methods that produced these products and technologies have been around for centuries. In the time period circa 4000-2000 B.C., biological processes using yeast were first experimented with in Egypt to leaven bread and ferment beer. The twentieth century marked an important transformation from the beginnings of biosciences. In 1928, Alexander Fleming

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[3] Biotechnology Industry Organization's Editor's and Reporter's Guide for 2003 – 2004 (BIO, 2003: 3-4).

discovered the life saving drug Penicillin, and in the same year experimentations were conducted in France that led to the eventual commercial production of Bacillus thuringiensis (Bt), a bio-pesticide used to control a corn borer in Europe. In 1953, James Watson and Francis Crick published an article in the scientific journal Nature, which described the double helical structure of DNA, ushering in an era of modern genetics and biotechnology research. Following the initial research on the DNA structure, Stanley Cohen and Herbert Boyer perfected the techniques for creating recombinant DNA which was a breakthrough for modern medicine development and production (BIO, 2003). And in 2002, the draft version of the complete map of the human genome is published, and the first part of the Human Genome Project comes to an end ahead of schedule and under budget.

In the last few decades, improvements in information and communication technologies (ICT), as well as improved research and development (R&D) in the biosciences, has ushered in the use of enhanced technological processes in the biosciences, or biotechnologies. The continual improvement in ICTs and the advances made in R&D in the biosciences will help drive the commercial growth of these industries, well into the next century.

2.3 Towards defining the Biosciences

Biosciences research and development and the organizations working in conjunction with this industry are advancing knowledge, creating innovative technologies, and developing products that are improving the health and the quality of human lives. Historically, the industry had been focused primarily in the field of medicine, organized around pharmaceutical, medical equipment and supply, medical diagnostics companies and key medical research institutions (MEDC, 2003). With improvements in technology in the 1960s and 1970s, and the ability to technologically manipulate biological microorganisms, advancements were made in the field of biotechnology (BIO, 2003).

The improvements in biotechnology have allowed for further growth in sub-biotechnology sector companies. This growth has increased the number of complementary service firms in biotechnology (and generally in the biosciences) such as contract research organizations, research and higher educational institutes and ancillary industries that work with both biotechnology and the bioscience industry sectors. Oliver (2000), illustrates that the biotechnology (or as he refers to it as "bioterials") industry is helping to provide a diverse range of products – from home consumer goods, to chemicals used by manufacturers to enhance production processes. He cites the use of home pregnancy test kits that are based on biotechnology diagnostic products, as well as the business transformation of large chemical firms such as Monsanto, DuPont and Novartis to emerge as biotechnology based businesses (Oliver, 2000).

The technological improvements and commercialization of biotechnology has enabled advances in the biosciences, including in the medical and agricultural biology based businesses, as well as in the information sciences. These advances have allowed for better healthcare for individuals through genetic research, helped in increasing the yield for agricultural crops and have even helped spur other information-based industries such as bioinformatics[4].

The biosciences industry collaborates closely with a broad pool of other traditional science based industries, including genetics, immunology, biochemistry and molecular biology among others. In addition, the bioscience industry, which is driven by innovations through the process of constant research and development, is deeply integrated with research institutions and universities. The close alignment of biotechnology with the biosciences, and the proliferation of the biosciences (as well as biotechnology) into a diverse range of industries outside of the traditional pharmaceutical and medical based sector demands a broader definition of the industry.

2.4 Defining the Biosciences[5]

In a report commissioned by the Michigan Life Sciences Core Technology Alliance, the Anderson Economic Group (AEG) conducted a study titled "The Life Sciences Industry in Michigan: Employment, Economic and Fiscal contribution to the State's economy[6]." The study utilized a succinct definition of the life science industry, which involves biological R&D, the production of products required for innovative scientific and medical procedures, and the practice of advanced medical treatments (AEG, 2004). The study involved conducting a review of past industry

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[4] Bioinformatics has improved DNA testing – as witnessed in the popular media through the Monica Lewinsky and O.J. Simpson court cases – improving the criminal investigation and forensic medicine processes (Oliver, 2000).

[5] The term bioscience is used in the thesis interchangeably with the term life sciences.

[6] The Michigan Life Sciences Core Technology Alliance (CTA) is an association of key institutions of higher education in Michigan, including, Wayne State University in Detroit, The University of Michigan in Ann Arbor, Michigan State University in East Lansing and the Van Andel Research Institute in Grand Rapids.

reports, overviewed industrial sectors aligned with the biosciences, as well as interviewed key stakeholders in Michigan's life science economy to arrive at the following definition for the bioscience industry[7]:

> "businesses whose work helps to improve the quality of human life through the research, development, and application of biological processes, tools, and advanced medical treatments (AEG, 2004)."

The Anderson Economic Group study also defined the biosciences industry utilizing the North American Industrial Classification System (NAICS) codes, which helped to inform the overall economic contributions of the industry to Michigan's economy. Their definition of the industrial sectors included in the biosciences was based upon a review of past industry reports, a detailed evaluation of the NAICS industrial sectors aligned with the biosciences, as well as a NAICS based survey of key stakeholders in Michigan's life science economy who identified core industrial sectors that are part of the biosciences.

> "The resulting definition presents both a conservative and reliable overview of the Life Sciences industry, including firms from the manufacturing, service, and research sectors. This definition captures not only the biotechnology sector, but

[7] Stakeholders in Michigan's Life Sciences Economy include university research & development officers, venture capitalists, scientists at research institutes, and economic development executives involved in advancing the life sciences in Michigan.

also those sectors working to apply biotech research through advanced medical care, as well as the industries that develop products used in biological research and advanced medical care. (AEG, 2004)"

The table below identifies the core NAICS based sectors involved in Michigan's bioscience economy.

Table 1: Definition of the Bioscience Industry by NAICS

NAICS Code	NAICS Description
325188	Inorganic Chemical Manufacturing (20% included)
325199	Organic Chemical Manufacturing (80% included)[8]
325411	Medicinal & Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-vitro Diagnostic Substance Manufacturing
325414	Biological Product(except diagnostic) Manufacturing
334510	Electromedical & Electrotherapeutic Apparatus Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334517	Irradiation Apparatus Manufacturing
339112	Surgical & Medical Instrument Manufacturing
339113	Surgical Appliance & Supplies Manufacturing
541710	R&D in the Physical, Engineering & Life Sciences
621111	Offices of Physicians (1.5% included)[9]
621511	Medical Laboratories
621512	Diagnostic Imaging Centers
621991	Blood & Organ Banks
622310	Specialty Hospitals

Source: Anderson Economic Group 2004

2.5 Role of Biosciences in the U.S. Economy

As advancements in technology and R&D in the biosciences are accrued, this sector will be a source for growth in the U.S. economy by providing

[8] To determine the portion of the chemical manufacturing sectors, AEG provided a detailed list of chemical names that fall under each category to a scientist at Van Andel Institute in Grand Rapids. This was done as the chemical industry itself is very large, and only certain sub-industry sectors are involved in the biosciences. From this it was estimated that 25 - 33% of the manufacturers of inorganic chemicals were primarily involved in the Life Sciences, and 90 - 95% of organic chemical manufacturers were primarily involved. The AEG study used a more conservative estimate of 20% and 80% for each respective industry (AEG, 2004).

[9] The data for the "physician office" subsector is inclusive of both general and specialty physicians, AEG used 1.5% of total physician office employment. This figure was arrived at by assuming that the ratio of employment in specialty physician offices to total physician office employment is similar to the ratio of employment in specialty hospitals (2,690 in 2001) to total hospital employment (182,782 in 2001) (AEG, 2004).

improved services to people, and or create new companies and sub-industries that generate employment opportunities. The biosciences pervade a diverse range of industries, including the chemical, agricultural, and information and biotechnology based sectors. Considering the importance of the biosciences to improving human health, and the consequent demand for bioscience products, the industry will play an important role in the economy. For example, the biotechnology industry (an integral part of the biosciences) employs 191,000 people nationwide, and has seen an immense growth in revenues from $8 billion in 1992 to $28.5 billion in 2001[10]. In 2001, the five largest biotech firms spent $133,600 per employee in R&D. Furthermore, publicly traded biotechnology firms in the U.S., and had a market capitalization of $206 billion as of mid-April 2003[11].

2.6 Importance of the Biosciences to Michigan's Economy

The diversification of Michigan's industries to include the biosciences will help secure a stable financial future for the state, creating employment and business opportunities for the State's residents. In Michigan, the automotive and related manufacturing based industries are considered as core industrial sectors and a strong base for economic growth. Over-reliance on a single industry (i.e. the automotive sectors) could place Michigan at unwarranted risk of the consequences of economic cycles and national and global competition. Development of other industries, such as the biosciences will help stabilize and secure Michigan's economic future for the following reasons:

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[10] See Biotechnology Industry Organization's Editor's and Reporter's Guide for 2003 – 2004 (BIO, 2003: 4).
[11] Biotechnology Industry Organization's Editor's and Reporter's Guide for 2003 – 2004 (BIO, 2003: 5-6).

- The changing demographic structure, in particular the rapid aging of the US population increases the demand for more and improved therapeutics, diagnostics, medical devices and health based services. This demographic change, signals the potential growth of bioscience based industries, and Michigan can take advantage of this national economic growth trend, while providing quality care products and services for the aging adult population.
- Growth in the biosciences industry is predicated on advances made in knowledge and information and communication technologies rather than a reliance on physical resources (i.e. timber, oil etc.). Michigan is poised at a strategic advantage (in the biosciences) because of the presence of an advanced knowledge base at the state level institutions of higher education. The existing research universities and institutes can help advance bioscience based industries within the state, creating jobs and helping to diversify the economic base.
- The bioscience industries are an array of different industrial sectors, collaborating to advance research and development and commercialization technologies. Michigan, has a historical presence of large bioscience firms such as Pfizer – pharmaceuticals, Dow Chemical Corporation – chemicals, and Stryker Corporation – medical instruments manufacturing, among other companies. Michigan can build upon this pre-existence of bioscience firms, and can further strengthen the bioscience industry cluster within the state.
- The jobs created are "gold collar" jobs, with salaries averaging $80,000 per year. (MEDC, 2003) These high-wage jobs help increase per-capita personal income

(an indicator of affluence), as well as generate additional tax revenues for the state, raising the standards of living and improve the socio-economic well being of residents on the State[12].

- Employment within the life science sectors in Michigan grew by 12.5% between 1998-2001, and in comparison, total employment within the State grew by only 2.3% during the same time period (AEG, 2004). The total employment within the life-sciences sectors are forecasted to grow to about 41,555 by 2005, an increase by 30.7% from the 2001 employment level of 31,778 persons (AEG, 2004).
- The direct economic contributions of the life-science sectors to the Michigan economy was $1.64 billion in 2001, an increase from $1.35 billion in 1998, and the indirect contributions of the life-sciences to Michigan's economy $1.36 billion in 2001 (AEG, 2004)[13].
- The bioscience industries contribute to the State's revenues by paying a considerable sum in taxes. The direct economic activity of life science firms and their employees, contribute approximately $360 million in state and local taxes annually – which include single business, sales, transportation, property and individual income taxes (AEG, 2004). Including the activity of indirect businesses linked to the life science firms, the annual total taxes collected by state and local governments, amount to $658 million (AEG, 2004).

[12]See Michigan Economic Development Corporation. "Ready for the Next Leap Forward: A competitive assessment
and strategic plan to develop Michigan's life sciences industry." MEDC, http://medc.michigan.org; accessed [April 20th, 2004].

[13] Anderson Economic Group includes as direct economic contributions only the actual payroll from Life Sciences employers. Indirect contributions include only payroll resulting from purchases made from non-Life Sciences employers for Life Sciences purposes (AEG, 2004).

The biosciences industry employs not only the traditional "white coat" research and laboratory scientists, but persons working under a diverse range of occupations, including administrative and clerical professionals, exhibiting occupational diversity while providing higher-paying jobs, and thereby potentially a new economic engine.

In Michigan, nearly one-quarter or 25% of the direct occupations in the biosciences include healthcare practitioners and technical personnel, 26% include office and administrative occupations, and about 4% of the total industry employment can be classified as life, physical or social scientists. Given the fact that only a small percentage of persons employed within the biosciences in Michigan are occupied in knowledge intensive jobs (requiring advance training), the industry could support the employment of workers with lower education levels. This could enable residents from distressed areas and those with lower levels of knowledge expertise to be employed within the biosciences, albeit in smaller numbers. The information below (table 3) outlines the diversity of occupational categories included within the bioscience sectors (AEG 2004), and was obtained through the Bureau of Labor Statistics, which maintains occupation level data[14].

[14] For a detailed review of the job types within each occupation, see the Bureau of Labor Statistics (BLS) website at www.bls.gov .

Table 2. Occupational Diversity within the Bioscience Industry Sectors

Occupation	Portion of Total Bioscience Industry Employment[15]
Architecture and Engineering	5%
Arts, Design, and media	< 0.5%
Building and Grounds maintenance	1%
Business and Financial	3%
Community and Social services	1%
Computer and Mathematical Sciences	3%
Construction and Extraction	<0.5%
Education and Training	<0.5%
Farming, Fishing, Forestry	<0.5%
Food Preparations and serving	<0.5%
Healthcare Practitioners and Technical	25%
Healthcare Support	9%
Installation, Maintenance, and Repair	2%
Legal	<0.5%
Life, Physical, and Social Scientist	4%
Management	6%
Office and Administrative	26%
Personal Care and Service	<0.5%
Production Occupations	11%
Protective Service	<0.5%
Sales and Related	1%
Transportation	1%

Source: Anderson Economic Group 2004

The Bureau of Labor Statistics also provides wage level data by occupational type (shown above in table 3). The Anderson Economic Group study (2004) captured this information on a national level revealing some interesting

[15] Anderson Economic Group has rounded up the figures, and therefore total employment may not total to a 100%.

information on wages by occupation type (see table 4 below). Nationally, the bioscience industries paid 44.75% higher wages in comparison to the U.S. mean annual wage. Healthcare practitioners earned 48% more than the U.S. annual wage for all industries, while legal and sales related occupations within the biosciences earned 37% and 87% respectively higher than the U.S. annual wage for all industries.

Table 3. 2001 Mean Annual Wage by Occupation Type: Biosciences and U.S. Industry

Occupation	Annual Mean Wage: Biosciences Industry	Annual Mean Wage: U.S. Industry Average	Difference	Difference in %
Architecture and Engineering	$65,168.41	$58,020.00	$7,148.41	12.32%
Arts, Design, and media	$51,522.76	$41,660.00	$9,862.76	23.67%
Building and Grounds maint.	$22,136.92	$20,850.00	$1,286.92	6.17%
Business and Financial	$56,743.23	$53,350.00	$3,393.23	6.36%
Community and Social services	$35,809.88	$34,630.00	$1,179.88	3.41%
Computer and Mathematical Sciences	$68,702.21	$61,630.00	$7,072.21	11.48%
Construction and Extraction	$43,381.42	$36,340.00	$7,041.42	19.38%
Education and Training	$39,501.58	$40,160.00	**($658.42)**	**-1.64%**
Farming, Fishing, Forestry	$22,366.00	$20,220.00	$2,146.00	10.61%
Food Preparations and serving	$21,083.32	$17,180.00	$3,903.32	22.72%
Healthcare Practitioners and Technical	$79,902.56	$53,990.00	$25,912.56	48.00%
Healthcare Support	$25,311.62	$22,410.00	$2,901.62	12.95%
Installation, Maintenance, and Repair	$41,865.84	$35,780.00	$6,085.84	17.01%
Legal	$106,107.89	$77,330.00	$28,777.89	37.21%
Life, Physical, and Social Scientists	$57,529.39	$52,380.00	$5,149.39	9.83%
Management	$93,597.24	$78,870.00	$14,727.24	18.67%
Office and Administrative	$27,666.54	$27,910.00	**($243.46)**	**-0.87%**
Personal Care and Service	$22,928.95	$21,370.00	$1,558.95	7.30%
Production Occupations	$31,727.78	$28,190.00	$3,537.78	12.55%
Protective Service	$34,575.01	$33,330.00	$1,245.01	3.74%
Sales and Related	$57,348.85	$30,610.00	$26,738.85	87.35%
Transportation	$28,152.27	$27,220.00	$932.27	3.42%
Industry Total	$51,473.48	$35,560.00	$15,913.48	44.75%

Source: Anderson Economic Group 2004

The biosciences are not only a growing industry sector, but provide immeasurable benefits to improving healthcare and medical diagnostic technologies. As improvements in technology and R&D in the biosciences are accrued, this sector will be a source for growth in the U.S, as well as Michigan's economy, providing improved services to consumers, while creating new companies and sub-industries that generate employment opportunities and provide an above average income to the employees.

2.7 Understanding Michigan's efforts to create a bioscience economy: An overview of the of the Michigan Life Sciences Corridor initiative[16]

The Michigan Life Sciences Corridor (MLSC) was conceived in 1999 by leadership at the State of Michigan, the University of Michigan (UM), Wayne State University (WSU), Michigan State University (MSU), and the Van Andel Research Institute (VARI) to build upon their collective strengths in biotechnology and medical research. The MLSC has since evolved into a unique private-state-university community initiative including other universities, state and local government initiatives, and small and large life sciences corporations stretching from Detroit to Grand Rapids and other regions of the state.

The life sciences research initiative was established to develop world-class research and exemplary life science commercial ventures *within the state of Michigan*, while promoting economic development and creating high-wage jobs. The initiative was spawned through the monies received by Michigan in a national tobacco lawsuit settlement, committing $1 billion over the span of twenty years.

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[16] Information and data utilized in this section was obtained from the State of Michigan Legislature and through the Michigan Economic Development Corporation (MEDC), with regards to understanding and outlining the program and legislative agenda of the MLSC initiative (MLSC, 2002; State of Michigan Senate, 1999).

The Michigan Public Act 120 of 1999 created and provided funding appropriation for the "Michigan Health and Aging Research and Development Initiative," allocating $50,000,000 for research and development in the life sciences. Public Act 80 of 2001 regarding the appropriation for the "Life Sciences Corridor Fund" (Section 410 of this Act) can be found in Appendix C[17].

The current life sciences corridor steering committee (health and aging committee) is aware of the importance of the collaborative effort needed between higher education institutions and private industry, to develop Michigan as a research and development based life sciences cluster. The committee also is cognizant of the fact that research completed in one state, does not necessitate the development of the research (product and outcomes) in the same state, and the committee is steadfast on utilization of all public monies to benefit Michigan based organizations and institutions. This can be observed through the specific mission and goals of the MLSC as outlined below in the next section.

2.7.1 Program mission and purpose

The MLSC program mission states that the initiative aims to develop the best academic science at institutions of higher education, create a robust private sector and an entrepreneurial environment leading to growth in established and new life science firms. These developments are intended to lead to the subsequent

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[17] Public Act 169 of 2003 has introduced new legislation which appropriated $25 million towards projects in two other disciplines besides the life sciences, and the initiative has been renamed the "Tri-Technology Corridor". The three disciplines slated to receive funding under the current act are (1) the life sciences, (2) homeland security and (3) advanced automotive technologies. Although the tri-technology corridor is not part of this research study, extensive written literature can be obtained from the MEDC. The life sciences steering committee and programmatic initiatives continue to remain unchanged, except for the smaller amounts of funding that is available for stand-alone life science based projects. MEDC, www.medc.michigan.org; accessed [April 25th, 2004]

enhancement of economic opportunities and the health and quality of life for Michigan's residents.

Program Goals

Consistent with this legislation and mission, the primary goals of the Life Sciences Corridor are:

- To support and enhance world-class science and support and develop world-class scientists in Michigan's universities and research institutions;
- To establish a culture and practice of inter-institutional and industrial collaboration among Michigan's universities, research institutions, and firms to the benefit of Michigan citizens and Michigan-based companies;
- To foster a network of entrepreneurial, fast-growing life science firms working in partnership with Michigan's universities and research institutions; and
- To preserve and enhance the health and quality of life for the people of Michigan, the U.S., and the world (MLSC, 2002).

Objectives

Objectives for the Life Sciences Corridor include:

- To position the State of Michigan to be a major global center for both life sciences research and development and its resultant commercial use and applications;
- To support the generation of life sciences research results that are significant in both human and scientific terms;

- To use funds in ways that improve and enhance scientific stature and research reputation of the State's higher education and private and public research organizations;
- To use funds in ways that improve and enhance the State's technological capabilities, infrastructure for research discoveries, and technology transfer and commercialization capabilities and impacts;
- To support the expansion of the well-educated life sciences workforce in the State; and
- To leverage strategically the State's investment through the Life Sciences Corridor in ways that attract additional private, federal, and philanthropic resources to address life sciences research, development, and deployment (MLSC, 2002).

Thereby, the specific program goals and objectives target the disbursement of funding to Michigan specific non-profit, for profit and higher educational and research institutions. The program goals are designed to lead to the accrual of benefits, both economic and in terms of the improvement of health, first for Michigan's residents and subsequently citizens nationwide.

2.7.2 Understanding the type of grants that can be funded under the MLSC initiative

Given the dynamic nature of life science research and development, and the linkage of research with the potentialities of commercial development, the MLSC funding is appropriated in three categories with an emphasis on health and aging research. The categories described are not considered as definitive and constricted funding brackets, but as a continuum from basic research, to applied research and to the eventual commercialization of life sciences research in the form of companies and or products. The following three categories help describe the types of funding available and are consistent with the constantly evolving demands of life sciences research and commercial development potentialities.

Types of funding

Basic Research Fund (Category I)

These are to be distributed on a competitive basis to Michigan universities and non-profit research organizations for basic research in health-related areas, with an emphasis on aging.

Collaborative Research Fund (Category II)

These are allocated for a collaborative research fund to support peer-reviewed collaborative grants among Michigan universities and/or private or non-profit research facilities (including private life sciences companies), with an emphasis on testing or developing emerging discoveries.

Commercial Development Fund (Category III)

These are allocated to support a commercial development fund to support commercialization opportunities for life science research in Michigan (MLSC, 2002).

Funding from the MLSC "health and aging" initiative is closely aligned to benefiting Michigan organizations and institutions. In fact, the three categories target Michigan based institutions from basic research to the eventual commercialization stage of life sciences development. The eligibility criteria for the eventual disbursements of the awards set stringent rules that benefit life science research in Michigan, and increase the economic opportunities and health services for residents within the state. This is illustrative within the specific eligibility criteria set for the potential receipt of the award monies.

Eligibility for funding by category

Category I (Basic Research Fund)

These awards can be made only to Michigan universities and Michigan non-profit research institutes. Additionally, collaboration between Michigan higher education institutions and non-profit research institutes is encouraged in the use of these funds.

Category II (Collaborative Research Fund)

These awards can be made to Michigan higher education institutions and Michigan-based private research facilities, including private for profit and non-profit organizations. If a non-profit research organization applies for funding under this category, collaboration with the private sector is required. In extraordinary circumstances, private for profit applicants may apply individually, but collaboration with Michigan universities and non-profit research organizations is encouraged.

Category III (Commercial Development Fund)

These awards can be made to Michigan-based higher education institutions, public and private non-profit organizations, and private for profit firms (MLSC, 2002).

The type of life science research that is proposed is to be reviewed with a broad perspective of research and development activities that can be carried out in advancing world-class research and commercial ventures in Michigan. Reviewers of the MLSC grant proposals will identify the specific innovation potentials and the benefits that can be captured by Michigan based industries. This review is consistent with the legislative language of the MLSC initiative, advancing the research and commercial development of life sciences within the state.

The proposals also will be assessed on the basis of the downstream economic impact of life sciences research funded in category I and II. The economic impact and benefit to Michigan through the commercialization phase in category III will be closely reviewed, particularly reviewing and favoring the proposals that promote the inter-institutional collaboration with Michigan institutions, as well as those coordinating with existing state sponsored programs.

Furthermore, the proposals must have a cogent transfer of technology plan from basic to applied research and eventually to commercialization, which is to include a substantive involvement of private firms (Michigan based) in the life sciences. If a proposal does not have Michigan industry involvement, it must have a succinct plan for how the applicant plans to seek and secure such Michigan involvement and interest. For multi- year projects, future year funding should be predicated on continued and sustained industry support and involvement.

2.7.3 MLSCs commitment to securing the intellectual property generated through life science research

Research and development in the life sciences at institutions of higher education or research organizations generally result in the creation of intellectual property[18]. The MLSC initiative assumes that issues of potential and existing intellectual property will be present in the proposals and as an outcome of the life sciences research and development.

Given that the Life Sciences Corridor is an investment program of the State of Michigan, certain stringent principles are outlined in the MLSC program language regarding intellectual property. These principles and issues include:

- developing intellectual property that stimulate new or enhance existing Michigan based businesses;
- articulating a strategy and plan for allocating interests, protecting and commercializing intellectual property;
- development of high quality and commercially useful patents;
- providing evidence for seamless, industry- friendly, and flexible policies and practices regarding intellectual property;
- dedicating needed project resources and tasks for this purpose; and
- making significant attempts to first license resulting intellectual property to a Michigan firm or to a firm with a Michigan-based facility that will directly benefit

[18] Intellectual property can be characterized as new and developed knowledge accrued through the process of research. This type of "property" usually is derived from intensive research and development projects and generally originates in research departments of universities and is administered through an office of intellectual property or technology transfer department. Intellectual property provides the basis to commercialize the research, generating revenues for the university or organization where the research originated.

from the licensing efforts with out-of-state entities (MLSC, 2002).

The MLSC steering committee may include a provision on the proposal and award contracts that would reserve the right to demand repayment of the grant monies. Such a provision will be effective if the intellectual property is used to develop life science products and industries (and resulting in little or no economic benefit to the state) outside of Michigan. Thus, we can note that the legislative and programmatic language towards the disbursement of MLSC funds adheres to the principles of retaining and developing world-class research and commercial development ventures within the state of Michigan.

2.7.4 The MLSC program evaluation criteria

In order to measure the success of the MLSC initiative, particularly towards capturing benefits from public investments in the life sciences, the steering committee has included descriptive evaluation criteria. These criteria are provided on the basis of the scientific contribution, economic development benefits and the commercialization potential of the MLSC funded projects to the state. The MLSC steering committee has provided suggested guidelines that encourage the monitoring and an evaluative review of the aforementioned criteria, providing a basis to measure the programmatic success. The specific outcomes of each criteria would be measured through reporting the following:

<u>Scientific achievements</u>

- Publications in scientific journals
- Citation, as reported in major indices
- Subsequent federal, industry, or foundation research funding

- Enhancement of scientific stature of Michigan's research programs, as reported by rankings
- Enhancement of Michigan's research and development capability and capacity

<u>Economic development benefits</u>

- Industry partnerships and funding
- Start-up companies built on MLSC-supported technologies
- Growth in life sciences commercialization capabilities and infrastructure
- Investment in Michigan-based companies
- Enhancement of the valuation of Michigan-based companies
- New jobs and wages associated with new jobs
- New products introduced
- Graduates in Life Sciences Corridor supported programs (new degrees, upgrading, retraining)
- Retention rate of graduates in Michigan five years after graduation

<u>Commercialization achievements</u>

- Patents generated from life science research
- Licenses issued to life science research outcomes
- Status and results of clinical trials and attainment of other product development milestones
- Sales revenues from life science based organizations

- Royalty income from licenses and patents accrued for Michigan based organizations (MLSC, 2002).

The reporting of the three criteria categories are suggested as a guideline to be followed, and are to be completed by the MEDC in an annual report. In addition, the steering committee has suggested that a third-party (external) review of the program criteria be conducted, to assess and measure the MLSC initiative's success. The program evaluation will provide benchmarks to base future analyses, as well as create positive support for similar initiatives to generate economic growth and create better services for Michigan's residents.

What follows is a summary of the importance of public funding in the biosciences, and a preliminary empirical review of the MLSC initiatives programmatic successes, as reported by the MEDC and the Governor's office in Michigan.

2.8 Assessing the benefits of the public funding towards developing the Life Sciences in Michigan

2.8.1 Importance of public funding towards developing the Biosciences

Government funding is important particularly in the biosciences industry, as it funds advanced research and development, and the subsequent development of life saving drugs and therapeutics. The nature of development in the bioscience industry, with the required long period of gestation and the sustaining financing for research and development, clinical trials, and ultimate approval from the U.S. Food and Drug Administration can take several decades, if at all successful (Cortwright and Mayer, 2002; MEDC, 2003). Investors are usually risk averse to such product development processes with uncertain outcomes, and therefore venture capitalists and traditional investors (i.e., banks) are disinclined to place their money in bioscience-based firms.

Much of the research supported by government funding culminates in discoveries that can be classified as "public goods," with positive spillover effects (creating novel discoveries and technologies that benefit people). An example of such an effort is "Project BioShield," although stalled in the U.S. Congress, part of the $6 billion in Federal R&D funds are being channeled to university and government laboratories for biodefense[19] research (Economist, April 24, 2004).

Public goods are those whose consumption is nonrival and nonexcludable. For example, once findings of a research project are published, one person's use of the findings (consumption) does not negatively impact another person's ability also use the findings (nonrival). Additionally, once the research is published it is possible for anyone to obtain the results (nonexcludable).

Non-excludability gives rise to the free-rider problem, whereby firms knowing that they can get the goods (research) at no cost are left with no incentive to conduct the research on their own. In addition, if the research has positive spillover effects, whereby benefits accrue to people other than those paying for the research, there is marginal or no incentive to conduct the initial research. As a result, research and development in the sciences, national defense, and other similar areas are often publicly funded.

[19] In an effort to curtail the effects of a biologically based terrorist attack, much feared since September 11, 2001, research projects on early detection systems, immunization vaccinations and prevention drugs are being researched and developed through Federal efforts under the Department of Homeland Security.

The use of public funds to help develop Michigan's Life Sciences economy and the specificity of the award criteria help alleviate much of the fear of "losing" the invested public funds to nationally and or globally competitive state's and regions. Furthermore, Zucker, Darby and Armstrong (2001) contend that because of the steep learning curve involved with biotechnology research, certain types of research information can be excluded. This exclusion arises from the complexity of biotechnology research and the tacit knowledge sharing that is needed among scientist to advance life sciences based research. These scientists hold key knowledge information, which is not easily disseminated, and can create a competitive advantage for institutions, as well as the regions where the institutions are located. Thus, not only is the MLSC program initiative aimed at securing its investment dollars to benefit Michigan, but the complicated research processes in the life sciences itself lend themselves to region specific benefits, such as advancing life sciences research, generating economic growth and improving the quality of health services for residents.

2.8.2 Outcomes from Michigan's MLSC initiative

The programmatic initiatives of the MLSC have a succinct and stringent mission and goals that are outlined above, specifically channeling the economic outcomes of public funding towards benefiting Michigan and its residents. The program goals and objectives, overtly state the inclusion of Michigan based institutions to be beneficiaries of the MLSC award monies, as well as developing world-class research and commercial opportunities in the life sciences in Michigan. In addition, the award eligibility criteria mandate the utilization of the funds to benefit Michigan based organizations, from the basic research to the eventual commercial venture stage (including the protection of intellectual property generated in Michigan) of life sciences research and development.

At the outset, the program goals, eligibility criteria and the program evaluation, are intended to advance excellence in research and development in the life sciences within Michigan, which is evident in some of the outcomes. In 2003, more than $3.4 million of the MLSC funds in basic research were awarded to Wayne State University, to integrate bioengineering and biocomputing for the advancement of computer aided surgery research (Governor, 2003). Other funded proposals included research awards towards early detection cancer systems, and the creation of a center specializing in new molecular diagnostic techniques for pancreatic cancer (Governor, 2003). In terms of commercialization of the research efforts, more than 50 new life science firms were founded in Michigan since the program began funding research and development in 2000. In 2003, the MLSC awarded $1.5 million to Birmingham, Michigan based Seneca Health Partners, which promised to leverage an additional $30 million towards the creation of a life sciences venture capital fund. Venture capital helps early stage and start-up companies convert their ideas and research to commercial and profitable opportunities, and since its inception, the MLSC awards have helped Michigan firms' leverage more than $60 million in venture capital (Governor, 2003). Michigan's life science industry currently comprises 500 firms employing more than 31,000 people and has a record $4.8 billion in annual sales (Governor, 2003).

2.8.3 The MLSC awards by type of category

The MLSC program monies are disbursed according to the aforementioned criteria, i.e. Category I – Basic Research, Category II – Collaborative Research and Category III – Commercial Development. The following tables and figures help illustrate the type of funding disbursement by category and outline the major institution (public and or private receiving the monies). This provides pertinent information about the type of life sciences based advancement occurring at an institutional level, as well as economic development opportunities within communities where the institutions are located.

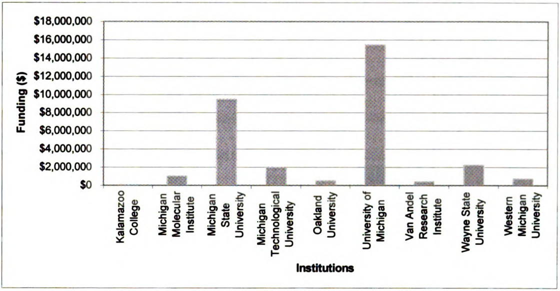
Basic Research Funding

In 2000-2001, The University of Michigan in Ann Arbor received the highest award funding from the available MLSC award monies, with over $15 million. Michigan State University in East Lansing, received over $9 million, and Wayne State University in Detroit and Michigan Technological University in Houghton, each received just over $2 million. Table 5 and figure 1 below depict the research award disbursements.

Table 4. Basic Research Funding awards by the MLSC 2000 – 2001

Institution	2000- 01 Funding
Kalamazoo College	$84,975
Michigan Molecular Institute	$1,024,996
Michigan State University	$9,492,132
Michigan Technological University	$2,013,729
Oakland University	$528,802
University of Michigan	$15,479,033
Van Andel Research Institute	$427,005
Wayne State University	$2,246,935
Western Michigan University	$750,000
	Source: MEDC

Figure 1: Basic Research Funding awards by the MLSC 2000 – 2001



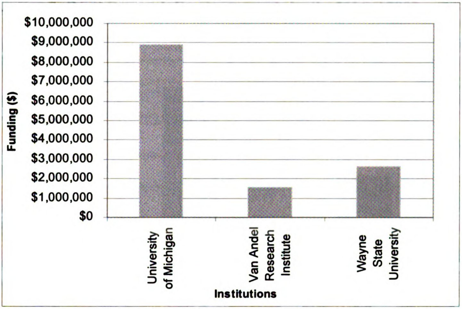
Source: MEDC

In 2002 only three institutions received basic research funding awards. The University of Michigan – Ann Arbor, received the highest with nearly $9 million in MLSC award monies. Table 6 and figure 2 below illustrate the award MLSC disbursements.

Table 5. Basic Research Funding awards by the MLSC 2002

Institute	2002 Funding
University of Michigan	$8,918,013
Van Andel Research Institute	$1,549,382
Wayne State University	$2,651,826
	Source: MEDC

Figure 2: Basic Research Funding awards by the MLSC 2002



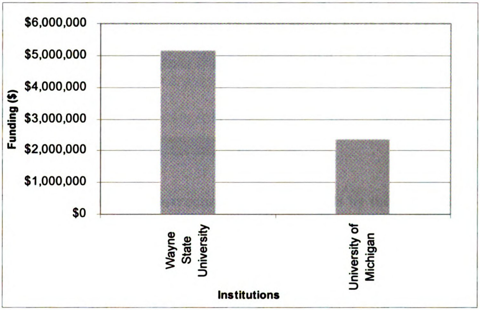
Source: MEDC

In 2003 (the most current data available at the time of conducting this research), only two institutions received money from the MLSC awards. Wayne State University in Detroit received over $5 million and The University of Michigan – Ann Arbor received just over $2 million. Table 7 and figure 3 below illustrate the award monies.

Table 6. Basic Research Funding awards by the MLSC 2003

Institution	2003 Funding
Wayne State University	$5,140,007
University of Michigan	$2,360,216
	Source: MEDC

Figure 3: Basic Research Funding awards by the MLSC 2003



Source: MEDC

<u>Research Infrastructure Funding</u>

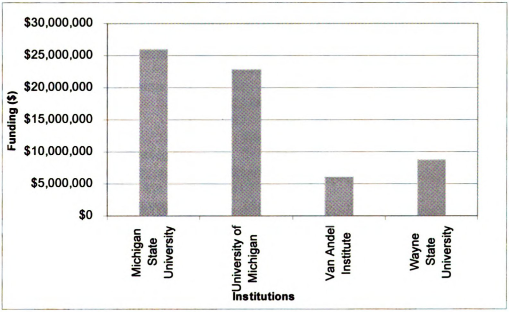
In order to stimulate and facilitate R&D in the biosciences within the State, the MLSC also funded basic research infrastructure grants needed to support ongoing research. Such grants have amounted to the purchasing of new equipment, established research centers of excellence, and enhance the overall biosciences economic climate of the State.

The 2000-2001 years of the MLSC award funding saw the largest disbursement of funds towards research infrastructure. The MLSC initiative was in a burgeoning stage, and early stage infrastructure monies were needed to jumpstart several R&D programs. Michigan State University in East Lansing received the highest amount, with over $26 million, while the University of Michigan-Ann Arbor received nearly $23 million. Table 8 and figure 4 outline the monies received by each institution in the 2000-2001 award years.

Table 7. Research Infrastructure Funding awards by the MLSC 2000-2001

Institutions	2000-01 Funding
Michigan State University	$26,010,009
University of Michigan	$22,861,758
Van Andel Institute	$6,128,128
Wayne State University	$8,679,129
	Source: MEDC

Figure 4. Research Infrastructure Funding awards by the MLSC 2000-2001



In 2002 only Wayne State University in Detroit received about $3.5 million in research infrastructure grants, and in 2003 only the Van Andel Research Institute in Grand Rapids received $250,000 (MEDC).

Commercialization Funding – Company Investments

In order to spur the commercialization of biosciences R&D, category III – commercialization funds are being used by the MLSC to advance the R&D in the state by investing in companies, as well as commercial ventures at state level universities and institutions. These organizations are integral to the development of communities and regions in which they are located, creating advanced bioscience based products and generating employment opportunities. Tables 9-11 show the funding awards to private commercialization ventures.

Table 8. Company/Institution Investment Funding awards by the MLSC 2000-2001

Company/Institutions	2000-01 Funding
Accumed Systems Inc.,	$1,291,218
Integrated Sensing Systems	$2,750,000
Nephros Therapeutics	$1,061,696
Thromgen, Inc.	$1,172,784
NanoBio	$900,007
Advanced Sensor Technologies	$779,867
Rubicon Genomics	$1,891,242
Molecular Therapeutics, Inc.	$1,613,179
Advanced Sensor Technologies	$498,335
ApoLife, Inc.	$792,000
AvTech Laboratories	$1,515,000
	Source: MEDC

In the 2000-2001 MLSC award years, eleven companies received direct commercialization award monies, with approximately $14.2 million in investment by the State.

Table 9. Company/Institution Investment Funding awards by the MLSC 2002

Company/Institutions	2002 Funding
ApoLife, Inc.	$900,000
Osteomics, Inc.	$3,310,777
DNA Software, Inc.	$932,849
	Source: MEDC

In 2002, only three companies received MLSC awards, amounting to approximately $5.1 million in investment by the State.

Table 10. Company/Institution Investment Funding awards by the MLSC 2003

Company/Institution	2003 Funding
University of Michigan	$1,432,230
Michigan State University	$1,137,449
University of Michigan	$3,495,977
Wayne State University	$2,354,979
DNA Software, Inc.	$364,000
GeneGo, Inc.	$1,653,964
AmphiBiotics, LLC	$200,000
Kalexsyn	$192,200
Jasper Clinical R&D	$175,000
Proteos	$200,000
SpecStar	$200,000
ADMETRx	$200,000
CeeTox	$200,000
AureoGen Pharma	$200,000
Trilithon Pharma,	$200,000
dKb Technologies	$56,000
Molecular Imaging	$200,000
	Source: MEDC

In 2003 18 companies/institutions received commercialization investments, including ventures at the University of Michigan – Ann Arbor, Wayne State University – Detroit, and Michigan State University – East Lansing. These investments amounted to State level awards through the MLSC in the amount of

$12.4 million dollars.

Commercialization Funding – Entrepreneurship Infrastructure Funds

In order to stimulate entrepreneurial ventures within the State of Michigan, the MLSC awards monies to organizations involved in advancing bioscience based entrepreneurship activities. The intent of this funding is to generate new life science based firms and opportunities for employment and economic development within Michigan. Tables 12 – 13 illustrate the award monies disbursed to organizations for entrepreneurship infrastructure between 2000 and 2002.

Table 11. Organization level entrepreneurship infrastructure awards by the MLSC 2000-2001

Organization	2000-01 Funding
BBC Ventures, LLC	$1,889,318
Wayne State University	$359,007
Sloan Enterprises, LLC	$842,992
Michigan State University	$4,738,795
	Source: MEDC

In 2000-2001, the MLSC awarded $7.8 million to four organizations advancing entrepreneurship in the life sciences. Michigan State University – East Lansing, received the highest amount, approximately $4.7 million.

Table 12. Organization level entrepreneurship infrastructure awards by the MLSC 2002

Organization	2002 Funding
Michigan Biosciences Industry Association	$1,816,862
University of Michigan	$959,706
	Source: MEDC

In 2002, the Michigan Biosciences Industry Association (MichBIO), Michigan's biotechnology and life sciences trade organization received approximately $1.8 million in entrepreneurial infrastructure monies. The overall funding for the 2002 year was about $2.7 million towards entrepreneurial initiatives in the State. In 2003, Michigan State University was the only organization to receive the entrepreneurial infrastructure grants, with approximately $1.2 million (MEDC).

Commercialization Funding – Venture Capital Funds

In 2002 – 2003, the MLSC also awarded monies to private venture capital firms. Venture capital plays an important role in developing and commercializing technologies, including for bioscience R&D firms. In addition, venture capital firms are able to leverage State invested monies to attract additional funding and private capital, advancing bioscience based R&D in the state and creating employment opportunities. Venture capital firms generally operate by pooling in monies (and creating a fund) to then subsequently invest these monies in companies and organizations that provide the investors an attractive profit return. The larger the contribution in an existing fund, the potentiality of attracting and leveraging funds from investors increases. Thus forming a bioscience industry development fund, or to receive monies by the state towards the creation of such a fund, stimulates investments in the bioscience industry and the subsequent growth firms and the industry itself. Table 14 below outlines the MLSC award funding disbursed to venture capital firms in Michigan.

Table 13: Venture Capital Funding by the MLSC 2002 – 2003

Venture Capital Firm	2002 - 2003 Funding
TGap Ventures	$1,550,000
Arboretum Ventures	$1,550,000
Apjohn Group LLC	$1,529,441
Seneca Partners GP, LLC	$1,500,000
	Source: MEDC

In 2002 – 2003, the MLSC funded approximately $6.1 million in venture capital investments to four different Michigan based firms. It is intended that this funding will enable further investments in Michigan's bioscience industries, as well as attract new and additional capital.

The MLSC program's initiatives have helped in the utilization of the public funds towards improving life sciences research and development, as well as health services for Michigan's residents. The aforementioned empirical information illustrates a few of the research and commercial ventures that have been spawned from the award monies, leading to the creation of companies, generating jobs and advancing life sciences based research. However, as the MLSC initiative evolves and matures, continuous evaluation is needed (as suggested by the steering committee through an intense external review) to assess the economic, social and health benefits that have been accrued to Michigan's residents. In addition, evidential information and debate about the spending of the MLSC funds should be conducted periodically on a public stage, since it is public funding that is being used to advance the public purpose of creating jobs and impelling economic development in the state.

2.9 Importance of Michigan's Bioscience economy's realities for local and regional planning organizations

Planning organizations in charge of stimulating economic development through technology industries such as the biosciences, will find the empirical information (in chapters 2.0 and 3.0) useful for strategizing policies and optimizing policy choices. Planning organizations and local planners can utilize such empirical information to inform planning decisions, while channeling their resources towards economic development efforts that will benefit their region.

For the purposes of the thesis research, the researcher adopts the program planning model (outlined in section 1.4, and is explicated in detail through chapters 3.0 – 8.0). The model helps to understand the empirical realities for a specific planning region, such as the ECMPDR, while providing a realistic approach for planning towards a bioscience based economy within the region. In addition, the model attempts to show how the ECMPDR can seek to capture the value added investments and empirical realities of the bioscience based economy currently present in the region, while leveraging regional, state and national economic strengths in the biosciences industry.

The two basic tenets within the model would ensure firstly, that the planning mandate was charged and implemented successfully (at a local or regional level) with the requisite support from the participating stakeholders. Second, the model also captures the empirical realities of the region (as conducted in chapter 3.0), while understanding the successes and program implementation practices from other regions and localities. This provides the planning organization with the necessary base to conduct further analysis or programmatic initiatives.

Ultimately, the model helps to propose a realistic strategy for the ECMPDR, that takes into account the planning mandate, and the local realities and resources available for planning a biosciences economy. The strategy is operationalized through reviewing exemplary programs and initiatives completed by other regions, and specifically gleaning those practices that can be executed in the region to meet the planning mandate. Lastly, throughout the strategic planning and implementation, the model proposes constant monitoring and evaluation that helps to achieve an effective and balanced approach towards following the charge of the planning mandate.

CHAPTER 3.0
THE PLANNING MANDATE FOR BIOSCIENCE INDUSTRY BASED EOCNOMIC DEVELOPMENT IN THE ECMPDR – STAGE 1

3.1 The planning mandate

The planning mandate stage helps to address the critical needs for bioscience-based development in a region outside the largest metropolitan cities in Michigan. The mandate outlines and drives the requisites for a planning intervention, identify the key executives or resource controllers, partner agencies, actors and stakeholders in the region who are to implement and or benefit from the economic development planning solution, and finally help to enlist the available and required resources (including external experts or actors) needed for program intervention. The model suggests that this stage requires two key ingredients, the first being a planning mandate which legitimizes the development of the program planning process, and the second is access to adequate financial and human resources to address the program needs (Van de Ven & Koenig).

At this stage, I hypothesize a planning mandate that will help address the key planning research question. For example, in this scenario, Sue Fortune, Executive Director of the ECMPDR is aware of the current MLSC initiative and wants to explore the potentiality of bioscience industries based economic development within her planning region. The planning mandate will help guide the formulation of a planning steering committee comprised of representatives of key stakeholder groups within the region, and provide the assured financial and human resources, as well as activate a dynamic and responsive approach to governance that is needed to test the feasibility of biosciences based planning and development.

3.2 The key stakeholders needed to implement the planning mandate and participate in regional economic development goals

For the purposes of achieving the planning mandate charge of creating a strong biosciences based economy in the ECMPDR, it is necessary to create an inclusive group of stakeholders committed to the planning process.

Stakeholders Involved

The key is that a group must be representative of the community/region for which it will advise on its strategic planning. The principal economic, social and cultural sectors and institutions of the community/region must be involved. These are the generally recommended categories of representation for an effective planning steering committee of stakeholders; it is from these categories of stakeholders that members for the planning steering committee should be selected:

- Business, including small and large enterprises and organized labor
- Public-sector actors such as representatives from levels of government, such as local, multi-jurisdictional, regional, including executive and elective office holders, e.g., Congressional representative(s)
- Nonprofit-sector and institutions, especially education representatives at the critical levels of tertiary (including community college), secondary, and primary/pre-school, plus area social welfare organizations, arts and other cultural groups

- Individuals who are opinion leaders and or persons who are influential (and or wealthy) and whose views and service to the community have attracted respect; e.g., developers, investors, media owners, etc.

Suggested Formulation and Operating Principles for the Planning Steering Committee of Stakeholders:

Ideally, the planning steering committee should be 9 to 15 persons in size and well staffed. The group should be diverse and multi-generational in nature, and a blend both younger and mature representatives are critical. The group needs the fresh and innovation-oriented perspectives of the younger participant and the practical and feasibility-oriented perspectives of the mature and experienced participant. In addition, the principal ethnic/racial, minority communities and distressed community residents of the area must be fully represented and involved, including Native American interests, where applicable.

Resource controllers must be at the table (or their trusted delegates); assuming a voluntary effort of cross-jurisdictional intergovernmental/interinstitutional, multi-corporate actors, there must be full involvement of representatives who can, and are likely to bring budgetary and/or grant funding and other resources (e.g., in-kind)
to invest in the strategic planning effort; in addition to government and corporate investors, community foundations and other statewide or national foundations based in Michigan are likely resource controllers who might have stakes and investment interest in this effort; their participation might be either direct or indirect in nature

Members of the planning steering committee must be able to significantly devote and commit to this effort, such that there is effective participation and representation of the constituencies who have important stakes in this strategic planning project.

Lastly, these guidelines and principles are general, but not exhaustive and comprehensive. They do represent initial directions that are intended to be helpful as the planners and leaders of the region grapple with taking action and begin to activate their planning mandates and programmatic initiatives.

CHAPTER 4.0
THE ECMPDR PROBLEM EXPLORATION – STAGE 2

The function of this stage of the PPM is to assess, document and provide empirical information about the biosciences industry within the region, as well as on the state level. The relevant stakeholders (an inclusive part of the planning steering committee) at this stage are the regional economic development actors, directors of regional agencies, local and regional business and non-profit groups, as well as citizens who can identify problems within the region and or help document/gather important data needed to address the program planning mandate. Specifically this stage, will provide pertinent information at the state and the regional/local level, of key empirical data on the following:

- *4.1 Industrial classification and definition of the Biosciences*

As stated above, the biosciences industry includes *"businesses whose work helps to improve the quality of human life through the research, development, and application of biological processes, tools, and advanced medical treatments (AEG, 2004)."*

This broad definition, along with the operational definition of industrial sectors involved in the bioscience industries by NAICS codes (see table 2) provides the basis for the majority of the empirical research undertaken in the thesis.

- *4.2 Firm level information on companies in Michigan and the ECMPDR involved in the Biosciences*[20]

Utilizing the NAICS codes (table 14) to identify industry sectors involved with the biosciences, research was conducted to extract specific firm level information, such as number of employees and sales revenues of bioscience companies[21]. Information such as this is pertinent to evaluating not only the economic contribution of bioscience firms in Michigan, but also in determining the spatial location of bioscience firms, which help towards planning for bioscience based economic development of sub-state regions, such as the ECMPDR. Understanding the economic landscape of the State, and specifically a sub-state region can help in developing policies that will benefit economic growth, creating employment and improving the quality of life for community residents. Appendix A of the thesis provides detailed information on the bioscience firms in Michigan, obtained through the Dun & Bradstreet database, including information such as city and county location, number of employees and

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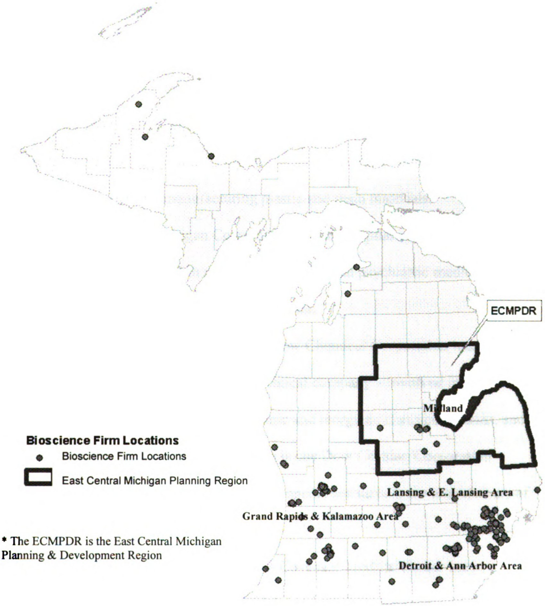
[20] A study was conducted by the MEDC titled "Ready for the Next Leap Forward: A competitive assessment and strategic plan to develop Michigan's life sciences industry," where specific firm level information was gathered and documented on a state and sub-state geographic scale. MEDC, http://medc.michigan.org

[21] NAICS codes identified in table 14 were utilized to obtain bioscience industry firm level data from Dun & Bradstreet's Million Dollar Database (D&B MDB). It should be noted that the D&B MDB allows selections based on NAICS categories, and these data may not reflect all bioscience firms in Michigan. Certain bioscience firms are in a developmental stage, and their corporate information has yet to be codified by commercial data providers, such as Dun & Bradstreet. Nonetheless, the data are revealing in terms of the geographic/spatial distribution of bioscience firms in the state.

firm level sales revenues. Figure 5 below (on page 56) illustrates the spatial distribution of bioscience firms in Michigan, and within the ECMPDR.

Figure 5. Bioscience Firm Locations in Michigan and the ECMPDR



Source: Dun & Bradstreet 2004

According to the Dun & Bradstreet data, there are approximately 195 firms in Michigan involved directly and indirectly in bioscience-based industries. These firms had sales revenues in the amount of $48.6 billion, and employed 62,305 people (D&B MDB 2004). As figure 5 shows, the largest cluster of bioscience firms occurs in the Detroit and Ann Arbor area, and a second strong cluster emerges in the Grand Rapids and Kalamazoo area. In the ECMPDR the Dun & Bradstreet data revealed the following information:

- There are two branch locations of Dow Corning Corporation in Auburn, Bay County – involved in manufacturing industrial and organic chemicals, product testing laboratories and manufacturing plastic and resin materials.
- There is one State of Michigan Community Health Hospital in Mt. Pleasant, Isabella County – involved in providing specialty and psychiatric medical intervention and is listed as a specialty hospital.
- In Midland, Midland County, there four Dow Chemical Corporation locations, including a headquarter for the Dow Chemical company – involved in manufacturing specialty chemicals, organic and inorganic chemicals, resins, and other plastic products. Furthermore, there is one Dow Corning Corporation location within the county, whose primary operations include the manufacture of silicone based products.
- In Saginaw, Saginaw County, there is the Covenant Medical Center Inc. – involved in medical testing and related laboratory testing. Furthermore, in St. Charles, Saginaw County, there is the Flents Products Company Inc. – producing manufactured hearing protection and related medical devices.

Table 15 (below) illustrated the Dun & Bradstreet data obtained utilizing the NAICS codes for bioscience based industries in the ECMPDR.

Table 15. Bioscience based industries in the ECMPDR

Company Name	City	County	Sales	Employees
Dow Chemical Company	Midland	MIDLAND	$18,900,000	106
Dow Chemical Company	Midland	MIDLAND	$24,800,000	150
Dow Chemical Company	Midland	MIDLAND	$27,609,000,000	3000
Dow Chemical Company	Midland	MIDLAND	$180,200,000	1000
Dow Corning Corporation	Midland	MIDLAND	$2,610,100,000	900
Community Health Michigan Dept	Mount Pleasant	ISABELLA	$18,500,000	585
Dow Corning Corporation	Auburn	BAY	$85,900,000	400
Dow Corning Corporation	Auburn	BAY	$63,700,000	300
Covenant Medical Center Inc	Saginaw	SAGINAW	$11,200,000	250
Flents Products Co., Inc.	Saint Charles	SAGINAW	$18,356,000	145
		Total:	$30,640,656,000	6,836

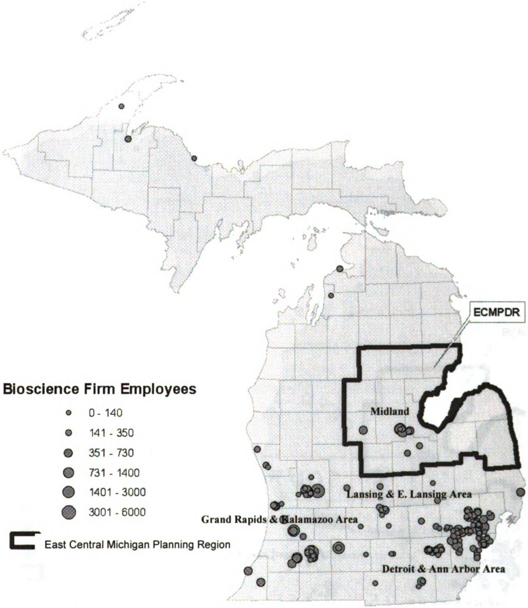
Source: D&B MDB

It should be noted that the aforementioned organizations and firms may not be wholly involved in the biosciences, but a portion of their business and employment could be attributable to bioscience industries. For example, Dow Chemical Corporation may manufacture specialty chemicals used in biological processes and utilized by biotechnology firms or other bioscience industries in R&D or production processes.

Figures 6 – 9 provide a detailed spatial overview of the Dun and Bradstreet data, as utilized to extract information about Michigan's bioscience industry. The Dun and Bradstreet data were geocoded using a geographic information system (GIS), providing local level data, as well as county level data (aggregated sales revenues and number of employees). This provides insight into corporate information, such as sales and employees at the corporate location, on both an aggregated and disaggregated scale, and should be used for empirical evidence in planning for a biosciences economy.

- Figure 6 provides point level locations of bioscience employees by firm in Michigan.
- Figure 7 provides point level locations of bioscience sales by firm in Michigan.
- Figure 8 outlines the data in an aggregated format, providing total bioscience employees by county in Michigan.
- Figure 9 outlines the data in an aggregated format, providing total bioscience sales by county in Michigan. At the time of data collection, a firm located in Charlevoix county did not provide any sales level data, and hence is not geographically referenced and mapped as showing sales.

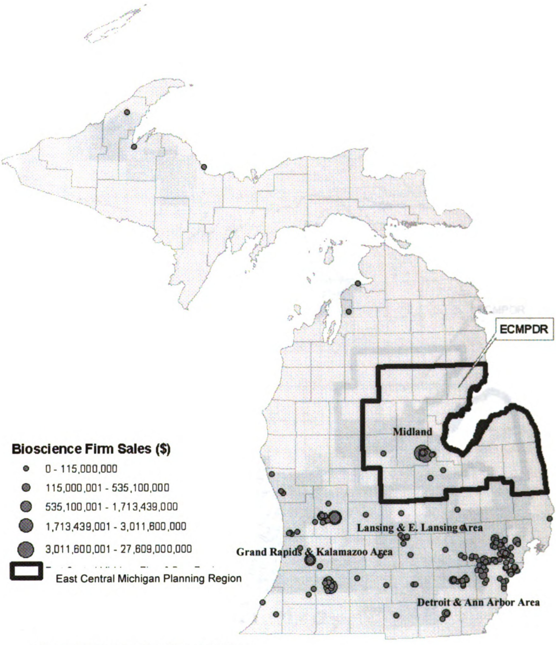
Figure 6: Bioscience Employees by firm location in Michigan



* The ECMPDR is the East Central Michigan Planning & Development Region

Source: Dun & Bradstreet 2004

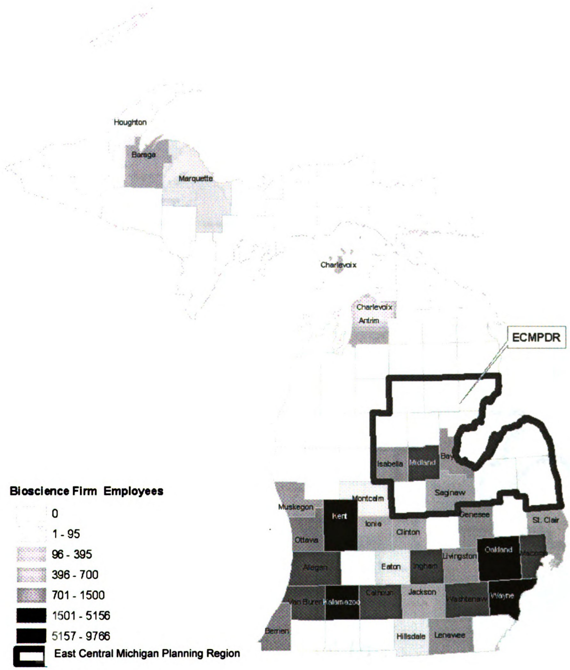
Figure 7: Bioscience Sales by firm location in Michigan



* The ECMPDR is the East Central Michigan Planning & Development Region

Source: Dun & Bradstreet 2004

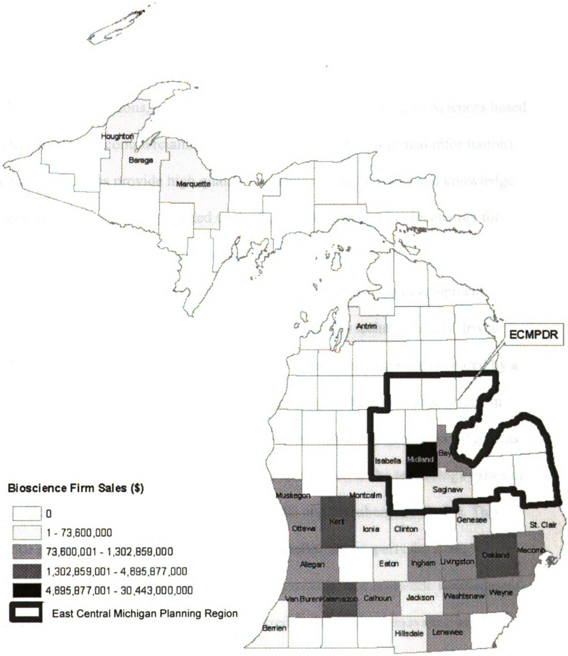
Figure 8: Bioscience Employees aggregated on a county scale in Michigan



* The ECMPDR is the East Central Michigan Planning & Development Region

Source: Dun & Bradstreet 2004

Figure 9: Bioscience Sales aggregated on a county scale in Michigan



* The ECMPDR is the East Central Michigan Planning & Development Region

Source: Dun & Bradstreet 2004

4.3 Location of research institutions and four-year colleges/universities in Michigan, and their focus in the Biosciences

In the contemporary global economy and network society, knowledge based functions and production processes are driving economic growth and regional development (Varga, 2000:140). In Michigan, research and higher educational institutions, can play an important role in advancing biosciences based R&D, as well as commercialization (see section 2.8.2 for empirical information). These institutions provide high quality academics in the sciences and knowledge based subjects, graduating skilled students, as well as becoming incubators for researching, developing and maturing ideas.

Technology and knowledge based industries undergo a development process which is important to understand. Traditionally technologically driven R&D occurs within a university laboratory or center, and is generally shared by a group of researchers working to advance knowledge. The knowledge results in publications, the training of skilled personnel, as well as the generation of patents and intellectual property, which can then be transferred to the technology office or an office of intellectual property (MEDC, 2003 and Sternberg, 2000: 89). This office generally sources out or licenses this intellectual property for a fee, generating revenues for the university. In commercial and economic development terms, the intellectual property can be utilized to develop an innovative product such as a cancer treatment vaccine etc., and if successful, the commercial organization experiences business profits, leading to new commercial opportunities and or business expansion. Thus in terms of biosciences based economic development, the planning process can generally begin at the university or research institution stage, where basic science research is conducted.

Therefore, universities play an integral role in technology based research and development, and subsequent economic development. This is evidenced by witnessing the rise of global high-technology centers such as Silicon Valley in California, or Boston, Massachusetts, where a significant growth factor is the research and development productivity of world-class research universities.

Understanding the location of universities, as well as the bioscience research strengths of universities and higher educational institutions in Michigan is key to planning for regionally based economic development. Varga notes that the local network of university and corporate scientists is the principal mode of transmission for technological information from academia to high-technology industries, e.g. in the biosciences (Varga, 2000: 141). Universities provide access to qualified graduate students and scientists, which are an important linkage in university-high technology industry partnerships. These graduates and future scientists are likely to stay close to the university for their first jobs, and become a source for localized knowledge transfer into commercial activities (Varga, 2000: 141). Therefore, measuring the research capacity in terms of graduate level degrees granted can function as a surrogate for strength in biosciences, as well as the potential commercial opportunities that emerge from a skilled bioscience workforce.

The data for locations of research universities in Michigan, as well as bioscience research capacity were obtained from the National Center on Education

Statistics (NCES), relying on the predefined biological sciences categories stated by NCES (see Appendix B for bioscience categories)[22]. The predefined academic categories not only help in obtaining data, but also help to identify potential bioscience strengths at research universities, and could be applicable to planning for bioscience based development. The bioscience research capacity in this section is measured by the number of master's and doctoral level degrees granted by research institutions in Michigan. Table 17 below outlines the bioscience research capacity in Michigan, by listing university locations and the number of doctoral and master level degrees granted for 2002[23].

[22] The researcher selected all categories involved within the biological sciences, after screening and review of the category descriptions.
[23] The 2002 data from the NCES was the most recent, at the time of this research. (www.nces.gov)

Table 16: Bioscience Research Capacity in Michigan – Bioscience degrees granted

Institution	Doctoral & Master's Degrees Granted 2002
ANDREWS UNIVERSITY - Berrien Springs	4
CENTRAL MICHIGAN UNIVERSITY - Mount Pleasant	18
EASTERN MICHIGAN UNIVERSITY - Ypsilanti	14
UNIVERSITY OF MICHIGAN-ANN ARBOR - Ann Arbor	355
MICHIGAN STATE UNIVERSITY - East Lansing	269
MICHIGAN TECHNOLOGICAL UNIVERSITY - Houghton	33
UNIVERSITY OF MICHIGAN-FLINT - Flint	3
NORTHERN MICHIGAN UNIVERSITY - Marquette	24
WAYNE STATE UNIVERSITY - Detroit	100
WESTERN MICHIGAN UNIVERSITY - Kalamazoo	18
Total:	838

Source: NCES and Analysis: Author

Table 16 shows that as of 2002, University of Michigan in Ann Arbor and Michigan State University in East Lansing have the highest number of graduates (master and doctorate level) in the biosciences, at 355 and 269 respectively. Central Michigan University (CMU), located in Mt. Pleasant, Isabella County is within the ECMPDR and had 18 graduates (master and doctorate level) in the biosciences. These graduates within the ECMPDR at CMU, represents a potential source of local knowledge transfer, especially if their academic R&D efforts can be effectively commercialized. Although a critical mass of graduates in the bioscience fields is a requisite for world-class research and development productivity, CMU has a strong base upon which to build from while planning for a biosciences based economy.

- *4.4 External research monies to promote technology industries through institutional research*

In technology based industries, such as the biosciences, external funding from federal and state sources are an important source of financial capital to conduct knowledge intensive research. As stated earlier, R&D initiatives in the biosciences generally leverage funds from a variety of sources, including Federal – National Institutes of Health (NIH) and National Science Foundation (NSF), State – "MLSC type" initiatives, as well as from venture capital firms and the traditional form of bank financing. In fact in Michigan, the MLSC favors R&D initiatives in the biosciences that leverage existing MLSC funding with federal sources, such as NIH and NSF, advancing health and science research and creating economic opportunities in the state[24].

This sub-section specifically analyzes the National Institutes of Health (NIH) funding allocated to Michigan Universities between two time periods, 1999-2001 and 2002-2004[25]. The NIH funds are disbursed to a variety of projects, in the bioscience fields, advancing knowledge and research, and creating innovative health products. This type of funding plays an important role in the early stage R&D process in universities and ultimately can lead to the potential commercialization of the research, advancing business development and

[24] See "Michigan Tri-Technology Corridor Fund Request for Proposals – Fiscal Year 2004 Competition," MEDC. Available at medc.Michigan.org [Accessed May 10, 2004].

[25] For the purposes of this thesis, NIH funding is used. However, it should be noted that other forms of Federal and State level funding also can provide appropriate research capacity measures for a region. Such funding sources could be from the National Science Foundation (NSF) and other government sources.

generating employment opportunities. Therefore, understanding and documenting the research capacity of the area using NIH funding becomes one indicator for potential commercial spin-offs of the R&D efforts in university laboratories. These commercial spin-offs can provide valuable economic development benefits to regions (specifically if their focus is on technology led development practices).

The data were obtained utilizing the NIH internet database search engine www.nih.gov, and entering in a Michigan specific geographic query that ferrets out information for the defined time period. The data then were compiled and geocoded using GIS to provide a spatial/geographic depiction of the NIH grants by university.

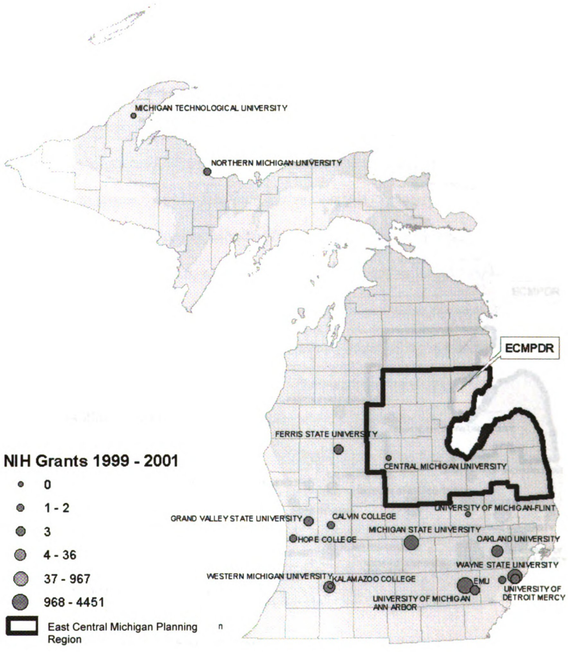
Between the 1999-2001 and 2002-2004 period, the number of NIH grants to Michigan universities declined from 6,081 to 4,524, or by approximately 25%. The largest share of the grants (for both time periods) was captured by the University of Michigan – Ann Arbor, Michigan State University – East Lansing and Wayne State University – Detroit (see table 17 below). In the ECMPDR, Central Michigan University in Mt. Pleasant, received three grants for the 2002-2004 time period, and none for the 1999-2001 period.

Figure 10 and 11, show the NIH grant funding received by Michigan universities, between 1999-2001 and 2002-2004 respectively.

Table 17: NIH Grants by Institutions in Michigan

Institution	City	Enrollment	NIH Grants 2002 - 2004	NIH Grants 1999-2001
CALVIN COLLEGE	Grand Rapids	4,324	3	2
CENTRAL MICHIGAN UNIVERSITY	Mt. Pleasant	27,919	3	0
EASTERN MICHIGAN UNIVERSITY	Ypsilanti	24,532	4	3
FERRIS STATE UNIVERSITY	Big Rapids	11,074	3	3
GRAND VALLEY STATE UNIVERSITY	Allendale	20,407	1	3
HOPE COLLEGE	Holland	3,035	2	1
KALAMAZOO COLLEGE	Kalamazoo	1,265	2	0
MICHIGAN STATE UNIVERSITY	East Lansing	44,937	405	591
MICHIGAN TECHNOLOGICAL UNIVERSITY	Houghton	6,619	3	0
NORTHERN MICHIGAN UNIVERSITY	Marquette	9,016	0	1
OAKLAND UNIVERSITY	Rochester Hills	16,059	28	36
UNIVERSITY OF DETROIT MERCY	Detroit	5,671	0	3
UNIVERSITY OF MICHIGAN-ANN ARBOR	Ann Arbor	38,972	3,336	4,451
UNIVERSITY OF MICHIGAN-DEARBORN	Dearborn	8,486	0	1
UNIVERSITY OF MICHIGAN-FLINT	Flint	6,434	1	0
WAYNE STATE UNIVERSITY	Detroit	31,167	711	967
WESTERN MICHIGAN UNIVERSITY	Kalamazoo	29,732	22	19
		Total:	4,524	6,081
NIH Grants 1999 - 2001			Source: NIH	

Figure 10: NIH Grants received by Michigan Universities, 1999-2001

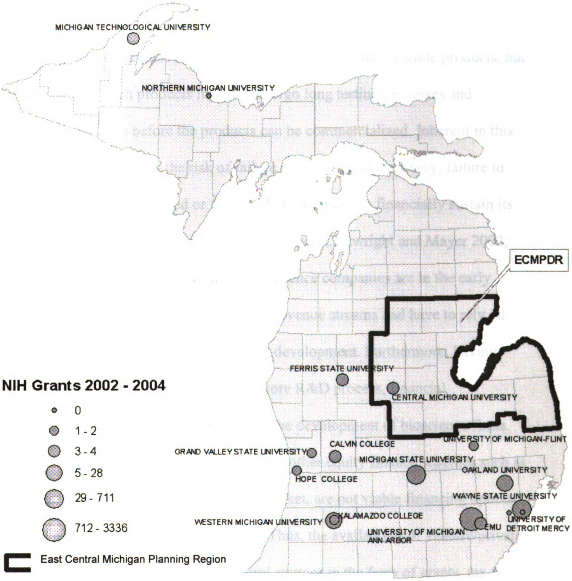


*University of Michigan - Dearborn is not labeled, but received 1 NIH grant during the time period.

* The ECMPDR is the East Central Michigan Planning & Development Region

Source: www.nih.gov

Figure 11: NIH Grants received by Michigan Universities, 2002-2004



*University of Michigan - Dearborn is not labeled, but received no NIH grants during the time period.

* The ECMPDR is the East Central Michigan Planning & Development Region

Source: www.nih.gov

- *4.5 Importance of Venture capital resources, and Michigan's Venture Capital Capacity*

The growth and development process in bioscience ventures can be expensive and risky. Not only do bioscience firms perform costly and time-consuming research to move their scientific discoveries into tangible products, but the resulting research products have to undergo long testing processes and regulatory approvals before the products can be commercialized. Inherent in this product growth process is the risk of failure of the original discovery, failure to meet regulatory standards and or failure of the company to financially sustain its growth during each stage due to a lack of funding (Cortwright and Mayer 2002; MEDC, 2003). In addition, since many bioscience companies are in the early stages of growth, they have marginal or no revenue streams and have to rely on external sources of funding for growth and development. Furthermore, having small staffs and scientists involved in the core R&D process, financial management takes a secondary role within the development of bioscience firms. For these reasons, traditional bank loans, and other equity finance schemes such as initial public offerings (IPO) in the stock market, are not viable financing options for most bioscience firms (MEDC, 2003). Thus, the availability of venture/private capital, and funding from state and Federal sources in the form of grants, tax abatements and or traditional capital plays an important role in the development of bioscience companies[26].

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[26] The role of venture capital executives, experienced with bioscience industries is critical to the success of many of the bioscience based R&D and commercialization ventures. These executives not only provide seed, start-up and late stage equity/capital, but also help to coach company managers and guide the bioscience firms into a profitable venture. This ensures the viability of the

Investing in bioscience R&D, as well as commercialization ventures helps to drive regional economic growth, and increases the competitiveness of Michigan's bioscience industries. Therefore, the availability of venture capital to advance R&D, as well as the consequent commercial development of firms, is critical to the state of Michigan and the sub-state regions.

To provide an understanding of Michigan's venture capital capacity, supporting data from PriceWaterhouseCoopers' Moneytree TM survey is used. The PriceWaterhouseCoopers (PWC)/ Thomson Venture Economics/National Venture Capital Association (NVCA) MoneyTreeTM Survey, is conducted nationally and is updated every quarter. This survey monitors equity investment in emerging U.S. companies by private and corporate venture capital firms. The thesis research relied on 2003 - quarter four release data, which was the most current at the time of research. The data provide an indication of venture capital availability, as well as an insight into the later stage commercial activity occurring in bioscience firms – as measured by the number of deals by venture capital firms in Michigan. Figure 12 below, provides detailed information on venture capital investments made in Michigan since 2000 in the biotechnology sector[27].

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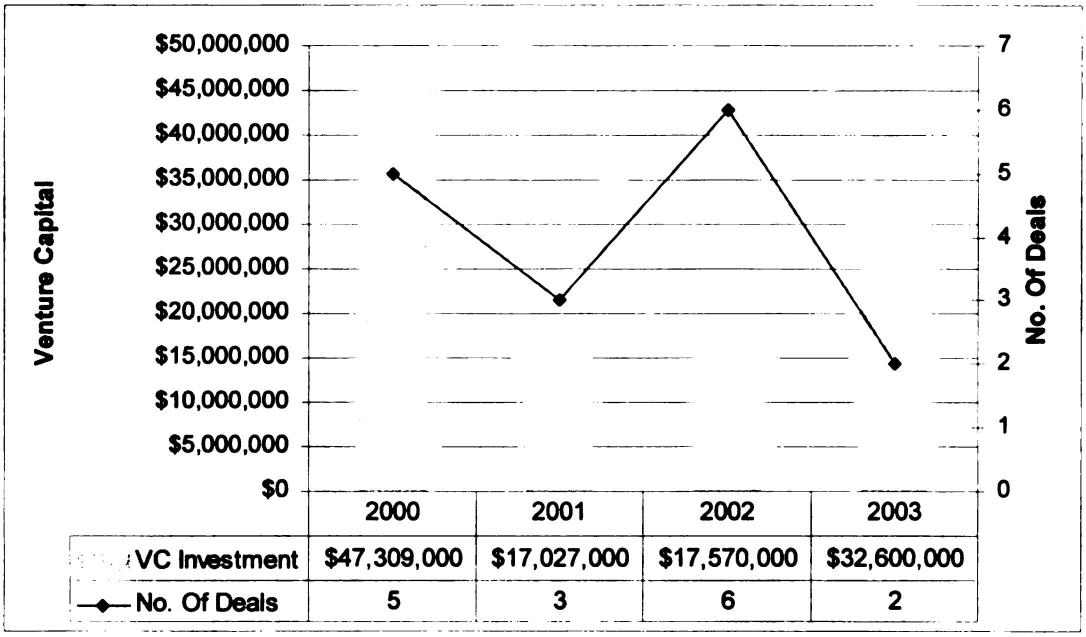
business (as firms are guided by seasoned professionals), the assurance of capital to continue R&D and innovation, as well as the consequent firm level financial profitability and overall economic development of the region where the firm is located.

[27] The PriceWaterhouseCoopers survey defines Biotechnology as - developers of technology promoting drug development, disease treatment, and a deeper understanding of living organisms. Includes human, animal, and industrial biotechnology products and services. Also included are biosensors, biotechnology equipment, and pharmaceuticals. While this definition may not be consistent with the thesis's definition of biosciences, it captures the basic essence of venture capital activity within the general biosciences sector in Michigan.

Figure 12: Venture Capital Investments in the Biotechnology sector in Michigan, 2000-2003

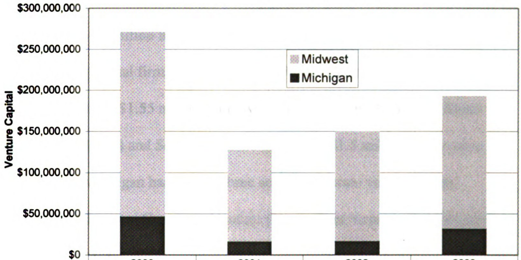


Source: PWC

Figure 11 shows that venture capital investments in the biotechnology sector was highest in 2000, with over $47 million being invested across five different deals (or ventures). In 2001 and 2002, the amount of venture capital invested dropped by about 64% to around $17 million per year, but there were three deals in 2001 and six deals in 2002. By 2003, the amount of venture capital invested in the biotechnology sector in Michigan increased to about $32 million and there were two ventures initiated by the end of the fourth quarter.

Figure 13 (below) shows Michigan's share of venture capital investments made in the biotechnology sector, in comparison with the rest of the Midwest states[28].

Figure 13: Venture Capital investments in the Biotechnology Sector in Michigan vs. Midwest, 2000 - 2003



	2000	2001	2002	2003
Midwest	$223,264,000	$109,795,000	$132,067,000	$159,667,000
Michigan	$47,309,000	$17,027,000	$17,570,000	$32,600,000

Source: PWC, Analysis: Author

In 2000, both the Midwest states and Michigan had the highest amount of investment in the biotechnology sector, with approximately $223 million and $47 million respectively. Michigan's share of the total venture capital investment made in the Midwest was about 21% in 2000. By 2003, biotechnology sector venture capital investments dropped both in the Midwest and Michigan, to $159 million

[28] The PriceWaterhouseCoopers survey defines the Midwest inclusive of the following states: Illinois, Missouri, Indiana, Kentucky, Ohio, Michigan, and western Pennsylvania.

and $32 million respectively, but Michigan's share of the investments hovered around approximately 20%.

According to the MEDC (2003), there are about nineteen private venture capital funds currently operating in Michigan, including eight established since 1999, and twelve with interest in the bio and life sciences. Arboretum Partners and Accelero Capital Partners each received a Michigan Capital Growth Fund (MCGF) award of $300,000 from the MEDC in 2002. These two firms are committed to investing about $45 million in the life sciences industry. The MLSC has funded four new venture capital firms including TGap Partners ($1.55 million), Arboretum Ventures ($1.55 million), the Apjohn Group ($1.53 million), Sloan Enterprises ($843,000) and Seneca Partners GP, LLC ($1.5 million), (see table 14). In addition, Michigan has at least three active corporate venture funds including Dow Chemical Corporate Venture Group, Ford Venture Capital Group, and XR Ventures L.L.C.

Given the requisite need of finances for growth and development of technology industries, such as the biosciences, venture capital begins to play a vital role in technological innovation and economic development (Smith and Florida, 2000). Silicon Valley in California, and the Boston, Massachusetts region can attribute much of their economic success and their regionally innovative economies to the presence and availability of venture capital. Despite the recent economic slowdown in the technology based industries sector, these regions stand out in comparison with the stagnation and decline facing traditional manufacturing based regions.

Technology based industries can act as catalysts for economic revitalization, boosting employment growth in a region, as well as opportunities for related industries to develop. "Venture capital has played a catalytic role in the formation of new technologies, and indeed entirely new industries (Smith and Florida, 2000: 205)." Smith and Florida (2000) note that without the infusion of venture capital, innovative ICT based firms such as Sun Microsystems, Apple, Intel or bioscience firm Genentech would not have got off the ground and would have been fledgling start-up's or failures.

Thus, venture capital can play an important role in biosciences based development strategies for regions such as the ECMPDR, and planners need to be aware of the availability of venture capital dollars, as well as the presence of venture capital firms.

- *4.6 Bioscience patents issued in Michigan's University Towns between 1996-2002*

Bioscience industries are well ingrained in the knowledge economy, where technology and education play a vital role in driving productivity and income growth, on a national, state and regional scale (Gottlieb, 2001). Understanding the innovative capacity of research based institutions as drivers of research and development and commercial technologies is imperative for sub-state biosciences based planning and development. Not only, is the spatial scale of innovative capacity (as measured by patents) illustrated, but also the specific bioscience based technologies being researched can be cross analyzed. This research can yield in the ultimate commercialization of patented technologies, leading to business expansion and economic development in the region. This section specifically looks at the bioscience knowledge capacity of Michigan, and the ECMPDR, by analyzing patent data issued by towns across the state[29], where there is a presence of large research based institutions.

[29] The author defines this geography, as towns having the presence of at least one "world-class" research institution. Although this is a self-defined category, it captures Michigan's major research based institutions, and is an appropriate geographic scale for this thesis research.

The following table (18) outlines the geographic scale of inquiry, used to retrieve the patent data.

Table 18: Cities in Michigan with a presence of large research based institutions

City	Research Institution*
Detroit	Wayne State University
Ann Arbor	The University of Michigan
East Lansing	Michigan State University
Grand Rapids	Grand Valley State University
Kalamazoo	Western Michigan University
Midland	Dow Chemical Corporation
Mt. Pleasant	Central Michigan University
Houghton	Michigan Technological University
Marquette	Northern Michigan University

*Institution by city is not an exhaustive list of all research institutions located in the city of inquiry

Source: Author

The U.S. Patent and Trademark Office (USPTO) publishes data on the number of patent approvals for over 250 technology categories. Oliver (2000), utilizes four basic patent categories that comprise of the principal components of biotechnology innovations (shown below in table 20), which will be utilized in this report. The biotechnology patents used are not encompassing of downstream or upstream bioscience industry linkages, as it is virtually impossible to isolate bioscience and biotechnology based patents across all industry sectors. For example, there are several categories pertaining to agriculture, chemicals, environmental processes, food additives, and medical equipment etc. that could be linked with the bioscience industries, but essentially impossible to capture the specific linkage with bioscience patents (through the USPTO database).

Nonetheless, this initial analysis provides a formative insight into the bioscience knowledge capacity of Michigan and the ECMPDR, by analyzing the patent categories listed in table 19.

Table 19: Bioscience Patent Categories

Patent Number	Patent Category
935	Recombinant DNA
800	Multicellular Organisms
435	Molecular Biology and Microbiology
424	Drugs, bio-effecting, and body-treating compositions

Source: (Oliver, 2000: 56)

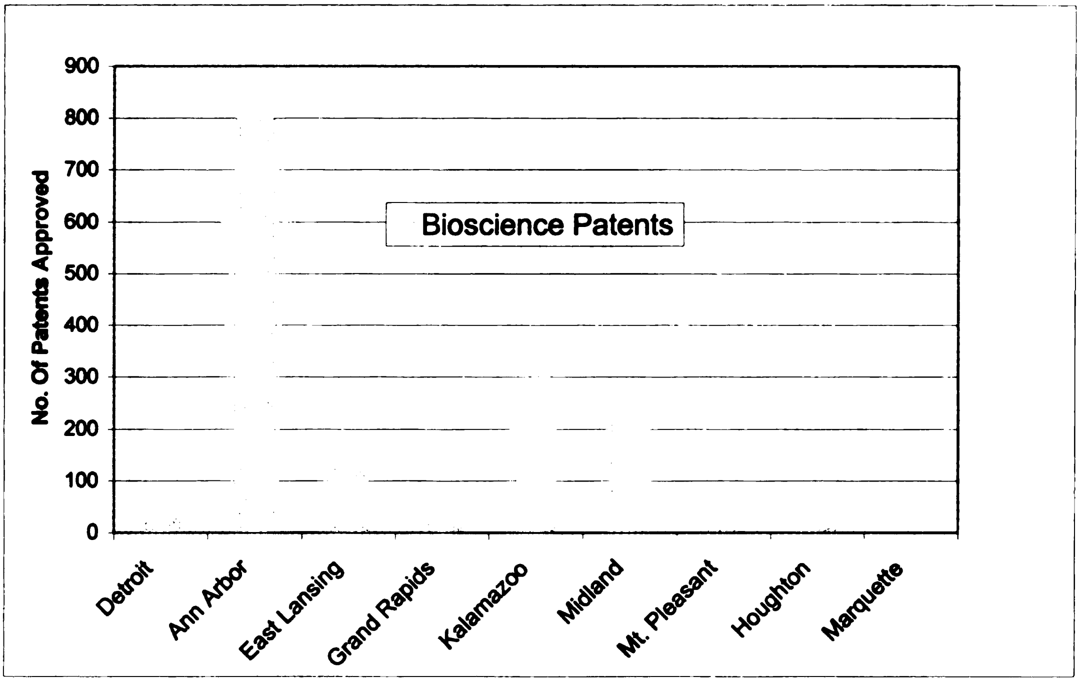
Utilizing the patent categories, a specific geographic search was conducted on patent approvals in the cities identified in table 19 between 1996-2004. Table 20 and figure 14 (graphic) helps to outline the biosciences based knowledge capacity of the cities

Table 20: Bioscience patent approvals by city between 1996-2004

Patent No.	*Detroit*	*Ann Arbor*	*East Lansing*	*Grand Rapids*	*Kalamazoo*	*Midland*	*Mt. Pleasant*	*Houghton*	*Marquette*
935	8	126	31	14	43	107	3	0	0
800	7	242	68	5	60	38	0	4	0
435	13	419	14	10	175	60	2	2	0
424	1	11	12	0	12	0	0	2	0
Total Patents	29	798	125	29	290	205	5	8	0

Source: USPTO

Figure 14: Total bioscience patent approvals by city between 1996-2004

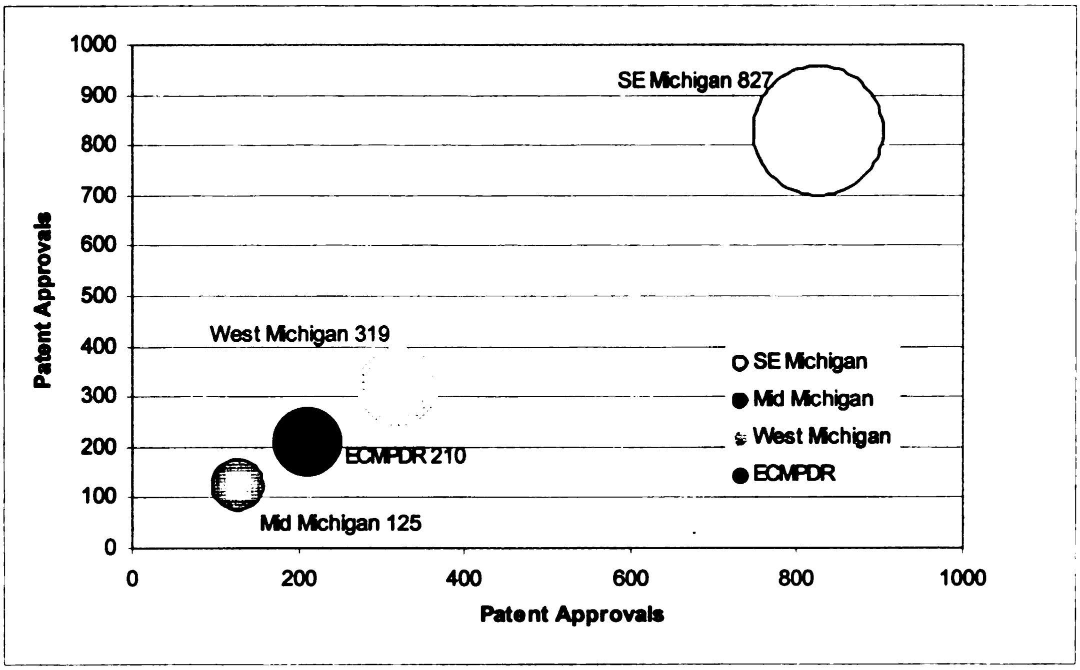


Source: USPTO

The bioscience knowledge capacity, measured by analyzing the patent approvals by city, begins to reveal an interesting spatial depiction within Michigan. In Michigan's Upper Peninsula (cities of Houghton and Marquette are located here) between 1996-2004, there have been minimal patent approvals, and in fact in Marquette, no bioscience based patents were approved during this time period. In the southern peninsula of Michigan, three clusters begin to emerge when analyzing the total patent approval data. These clusters (see figure 15) include the Detroit-Ann Arbor region in southeast Michigan (827 patent approvals), the Lansing-East Lansing region in middle Michigan (125 patent approvals), the

ECMPDR region comprising of Midland and Mt. Pleasant (210 patent approvals) and the Grand Rapids-Kalamazoo cluster is west Michigan (319 patent approvals).

Figure 15: Michigan's emerging bioscience knowledge clusters – Total bioscience patent approvals



Source: USPTO

Thus we can see that in the ECMPDR, where cities such as Midland and Mt. Pleasant, have the presence of research based institutions such as Dow Chemical and Central Michigan University, have a fairly strong knowledge capacity. Although, southeast and west Michigan have higher number of patent approvals, the ECMPDR should capitalize on the presence of existing research institutions, especially harnessing the patented technologies into profitable commercial ventures within the region.

Within this stage of the PPM, the specific empirical realities of Michigan and the ECMPDR's bioscience industries have been illustrated. In addition, the key issues to developing a bioscience based economy (along with the relevant data) have been introduced, and will help inform the forthcoming stages.

The following stage in the PPM evaluates the applicability of state of the art literature and planning practice in the field, specifically addressing the needs and issues identified in the problem exploration stage. Explored here are the pertinent and most state of the art solutions to the problem issue of developing a biosciences based economy in a region external to the largest metropolitan areas in Michigan. The following stage utilizes the knowledge of external experts, as well as important theoretical guidelines and comparative best practices and benchmarks, outlined in current technology based economic development and planning literature.

The solutions identified by the experts and the pertinent literature, will help inform the problems identified in stage 2, with the outcome being specific development actions to pursue the goals of the planning mandate, within a conceptual, theoretical and comparative framework. After a review of the actionable strategies and solutions by the planning steering committee, modifications are made, as well as a decision to continue the program planning effort.

Stage 3 along with stage 2 help to guide the actors and planners involved in the program design stage, through the integration of the problems and the pertinent theoretical and comparative solutions identified.

CHAPTER 5.0
KNOWLEDGE EXPLORATION – STAGE 3

The specific aim of this stage is to utilize empirical sources and literature external to the ECMPDR, and glean specific programmatic best practices to successfully strategize and connect to the information compiled in the problem exploration phase. Essentially, this section explores the question of what regions can do to create and attract bioscience firms with existing and future potential resources, and utilize the industry as a tool for economic development?

The key actors at this stage are external (to the ECMPDR) experts in the field, or key stakeholders utilizing the current best practices and literature to inform technology based economic development planning. In this stage, the expert actors serve to provide a range of possible solutions for the local actors monitoring the problem exploration stage, as the local economic development actors help to inform the application and tailoring of actions that might be effective for the specific region. The collaboration and relationships is key to creating successful and region specific knowledge solutions, which could facilitate local bioscience based economic development. In each of the following sub-sections in this stage, it is imperative to integrate local actor knowledge with the expert ideas, which will help advance the initial planning mandate. Furthermore, having external knowledge input in the planning steering committee, as well as local stakeholder views will help towards the fluid transition from exploration to implementation of the programmatic initiatives.

5.1 Best practices and benchmarking studies from states competing to attract bioscience industries

This section is a review and outline of the successful practices currently in place and adopted by two leading states attempting to capture economic growth potential from the biosciences. Specifically, the section introduces the concept of benchmarking and best practices, as well as strategies implemented by the states of Virginia and Massachusetts. In economic development circles, Virginia is known for its aggressive strategies towards attracting technology based companies by drawing on proximity to the Washington D.C. national capital area and through the presence of strong research institutions. Likewise, Massachusetts is renowned for its world-class research universities, and the city of Boston's route 128 corridor is a worldwide exemplar when it comes to identifying leading technology clusters.

State government initiatives into developing their biosciences based economy have taken on strategic importance on several state legislative agendas, utilizing technology based industries to develop state and regional economies. There has been increased public attention given to the positive results from the human genome project, and the availability of funds to states through the tobacco lawsuit settlements (such as in Michigan), has enabled the biosciences to receive positive media attention, especially as an economic development engine. Furthermore, the decline in the euphoria over dot.com businesses, and the realization that the biosciences are not only an economic development tool, but an industry that can help improve human lives through the creation of products, has led to considerable governmental efforts (throughout the United States) to boost state and local level biosciences based economies.

Although the bioscience industries are integrated in the global knowledge economy, the biosciences are based in local and regional communities. The bioscience industries employ people locally, work with local and regional institutions, such as hospitals and universities, and benefit through collaborations with other bioscience industries located in the region, as well as generating technologies and patents emanating from research laboratories. Thus the importance of developing a critical mass of bioscience industries has become imperative for some state, regional, and local level economic development initiatives. States are providing development help in a wide variety of forms, including financial help through the establishment of tax credits and venture capital funds, infrastructure capacity building – through the development of bioscience research parks, and business attraction through recruitment of industries targeted to advance state initiatives in the biosciences.

As stated above, a number of states have established a bioscience based economic development agenda since the burgeoning of the bioscience industry itself. The states of Virginia and Massachusetts particularly, were involved in the biosciences from the early to late 1980s and the biosciences industry has grown considerably in these states. These states were instrumental in adopting a biosciences based strategy, by establishing best practices and setting benchmarks to measure and ensure success of the state efforts in boosting this industry. Best practices are usually a set of programs and policies that have worked successfully, especially in implementing a biosciences driven economic development agenda.

These best practices are usually measured through a set of benchmarks, which can be used to establish goals to measure a level of success.

The next subsections (5.1.1 and 5.1.2) describe the programmatic initiatives of the two states, as well as provide some pertinent exemplary information about the benchmarks and best practices in both Virginia and Massachusetts. The intent here is to glean the two state's best practices and benchmarks, and utilize it to informatively plan for biosciences based economic development in the ECMPDR.

5.1.1 State of Virginia's Bioscience Initiative

The bioscience industries in Virginia are supported through a number of organizations, which provide assistance on financing, industry networking, infrastructure build-up, workforce development, and commercialization efforts. The following is a list of best-practices and programmatic initiatives helping to grow and foster a biosciences based economy in the state:

<u>Best Practices – Organizational Initiatives</u>

- **Virginia's Center for Innovative Technology (CIT)**, is a state supported, public-private organization with eight regional offices, and helps to provide bioscience companies access to research and technology transfer opportunities at Virginia's research institutions. The CIT aims to build a collaborative environment between publicly funded research and private commercialization ventures, targeting specifically the biomedical and biotechnology based industries.
- **The Virginia Biotechnology Research Park Authority**, is a statewide research park organization created in 1993 to create new jobs, facilitate growth and

investment in biotechnology companies, and advance scientific achievements in the life sciences within the state.

- **The Virginia Department of Business Assistance (DBA) and the Virginia Economic Development Partnership (VEDP),** are state government agencies involved in targeting the development of the biotechnology industry within the state, while providing the necessary financial and regulatory assistance (TPP, BMI and SSTI, 2001: 203).

<u>Best Practices – Financial Programs</u>

- The CIT provides financial award programs, which focus on the development of innovative technologies, by supporting technology infrastructure. These awards are given to foster collaborative research, particularly towards projects leveraging Federal and other external grant monies for developing a technology product or infrastructure. The awards range from small and short-term projects ($3,000) to about $90,000 for long-term development projects.
- The DBA manages the Virginia Small Business Incubator program, from which monies can be utilized towards the development of initial incubator operations, across a variety of sectors, including the biosciences. The program also focuses on the development of bioscience business incubators.
- In 2000, Virginia's general assembly, allotted $13 million to establish the Commonwealth Technology Research Fund, which requires a 1:1 match from the state's universities. The fund encourages the leveraging of Federal and private dollars to boost research facilities at universities, including bioscience departments (TPP, BMI and SSTI, 2001: 204).

Best Practices – Regulatory Programs

- Virginia provides a **research and development sales and use tax exemption,** which permits exemptions for property purchased that will be utilized for basic research, or for experimental and laboratory work. Some of the exempted activities include, but are not limited to, advancing knowledge, develop new uses for existing products and technologies, and the improvement of existing technologies, products and processes.
- Business and job development tax credits are provided to qualified firms locating or expanding in Virginia. These credits provide up to $1,000 of corporate income tax credit for each new job created.
- Tax abatement is provided for manufacturers inventory, office furniture, fixtures, and equipment used in non-production processes are not taxed within the state of Virginia. Best Practices – Industry Networking
- The **Virginia Biotechnology Association** (VABIO), is a bioscience industry organization that promotes the biosciences industry in Virginia through networking seminars and meetings. The association represents bioscience industries throughout Virginia, and coordinates networking and business events with several other state agencies and industry organizations, that are complementary with VABIO's bioscience development mission. The association has sub-state regional chapters, and partners with Virginia's regional councils, to hold special business networking events, such as luncheons, receptions, industry speakers and other forums.

- The CIT also sponsors a BioInfotech luncheon series, where CIT aims to connect the information technology and bioscience industries, particularly on the potentialities of cross-industry collaborations that are mutually beneficial (TPP, BMI and SSTI, 2001: 203).

Best Practices – Workforce Development

- The CIT sponsors a biotechnology summer intern program, which places university students (from all levels) at bioscience firms. The firms can gain access to qualified students, while students gain first hand experience working for companies within the industry.
- The state's community college system has identified bioscience industries as a growing part of the economy, and has catered their curricula towards the biosciences. For example, the Piedmont Valley Community College, Piedmont, Virginia, now has an approved biotechnology associate's degree program in which students can enroll.
- The CIT also has established a statewide biosciences training resource to collect and coordinate information on all bioscience based training programs across the state, from the secondary education level to post-graduate studies. The information is shared with prospective bioscience industry employers and or businesses located in the state.
- The CIT is also coordinating high school students to attend and participate in the state's bioscience economy, through internship, summer camps focused in bioscience and other collaborative efforts that will help develop a strong bioscience workforce in the state.

Best Practices – Commercialization Initiatives

- The CIT has established a network of technology development centers, including a Center for Bioprocess/Product Development, and a Center for Drug Design and Clinical Applications.
- There is also a non-profit business accelerator program, known as the Virginia Biosciences Development Center, which assists early stage bioscience firms in Central Virginia. The Center assists in networking activities, particularly providing bioscience firms with the area's professional services that benefit their growth. These professional services include assistance to service providers such as attorneys, accountants, bankers and venture capitalists who form a core network of people in advancing Central Virginia's bioscience economy. This network of people has pledged more than $183.5 million in pro bono services to assist early stage bioscience firms.
- The Carilion Biomedical Institute is a collaboration between Carilion Health Systems, Virginia Polytechnic University and the University of Virginia. The Institute aims to be a world-class biomedical research and development facility, working on engineering, technology and commercial applications to improve health related technologies. The Institute is an organization involved in early stage, discovery, research and development, and testing to the ultimate commercialization of health science products and applications.
- There are a number of bioscience based technology research parks, involved in incubating and developing bioscience firms, along with partnering with local and regional research institutions within the state of Virginia. The Virginia

Biotechnology Park, located adjacent to the Virginia Commonwealth University's Medical College in Richmond, provides business incubation and soon will host a $55 million consolidated state level laboratory facility. The Norfolk BioTech Incubator, is located in Norfolk, and is close to the Eastern Virginia Medical School's research institutes. The institutes include the Jones Institute for Reproductive medicine, Strelitz Diabetes Institute, and the Center for Pediatric Research. Other similar research parks include the University of Virginia's Fontaine Research Park, and the Virginia Tech Corporate Research Center located near the Virginia Polytechnic University in Blacksburg (TPP, BMI and SSTI, 2001: 204).

Benchmarks established by the State of Virginia

Utilizing job creation, tax revenues generated, academic research dollars generated, and other measures of economic impact to Virginia's economy as benchmarks, the Center for Public Policy at Virginia Commonwealth University (VCU), conducted a study in 1999 analyzing the biosciences industry in the state (Center for Public Policy at VCU, 1999). The Virginia Biotechnology Association commissioned the study, and although some of the empirical data predate certain established best-practices, it is informative towards understanding the success and the positive economic potential the biosciences industry can have on Virginia's state economy. Furthermore, since many of the best-practice programs were established prior to the study, the seeds embedded in developing the biosciences industry in the state during the early 1990's had come to fruition.

The study reported on the initial efforts made by the state in establishing the Virginia Biotechnology Research Park Authority and the requisite regulatory programs (in the early 1990s), helped in advancing bioscience based development in the state. Through the efforts of the authority, the state saw the emergence of bioscience industry clusters in Blacksburg (near Virginia Polytechnic University), in Richmond (near the University of Richmond and Virginia Commonwealth University), in Charlottesville, in Norfolk, Williamsburg and Newport News, as well as in Northern Virginia, a region abutting the nation's capital (Center for Public Policy at VCU, 1999). The establishment of bioscience parks near research intensive universities, and in strategic locations throughout the state has enabled the development of clusters in the aforementioned cities and regions. The study explicitly mentions the importance of research universities, particularly in their role towards advancing basic research and development that can ultimately lead to commercial opportunities in the biosciences.

The VCU study reported that the bioscience industry has grown by 9 percent between 1991 and 1997, and in 1997 employed over 17,000 people in about 370 organizations (Center for Public Policy at VCU, 1999). The average wage (in 1997) in the biosciences industry was about $54,000 or about 83 percent higher than the statewide average of $29,600. The study also reported that the industry contributed about 1% to the state's gross state product in 1997, a sum of $2.58 billion (Center for Public Policy at VCU, 1999). The study also concluded that besides having high wage people employed in the industry, each job in the bioscience industry will contribute nearly $3,500 in state income and sales taxes, generating nearly $245 million in 1997 (Center for Public Policy at VCU, 1999). The study also stated that if favorable regulatory programs towards the bioscience industry (such as research tax credits and support for research activities at bioscience parks) continue, the biosciences could contribute $8 to $10 billion to Virginia's economy by 2010 (Center for Public Policy at VCU, 1999).

In addition to the economic impacts towards the state economy, there also are fiscal contributions generated at the state level academic and research institutions. For example, the National Institutes of Health awarded Virginia's colleges and universities $121.6 million in research monies for the 1997 fiscal year (Center for Public Policy at VCU, 1999 : 16). Academic institutions are known to spawn innovative ideas through their research capacities and receiving NIH funding could provide the ability for universities to transfer their bioscience research technologies into commercial ventures.

The growth in the biosciences industry in Virginia coincides with the state level initiatives (across the United States) towards utilizing the biosciences as an engine for economic growth. These initiatives, including establishment of research parks focused on developing the biosciences industry, as well as certain regulatory programs (mentioned above) will benefit the industry, and have already provided positive impacts to the state's economy. Thus the benchmarks of economic impacts (jobs created and the potentiality of future jobs and companies), positive fiscal impacts (on state taxes), as well as monies awarded to universities conducting bioscience research and those which are closely aligned with research parks, help understand the contributions of the established best practices of aligning university research with commercialization opportunities in the biosciences.

In addition to the close collaboration of university research and commercialization of bioscience activities, Virginia has proven that a business network of professional services enables the growth of a burgeoning industry such as the biosciences. For example, in Central Virginia, the Biosciences Development Center already has committed over $180 million dollars towards assisting early stage bioscience firms through pro bono work. The practice of organizing, implementing and connecting the professional service firms and executives (such as attorneys, bankers, and other service professionals) has led to the investment in the development of a biosciences based economy.

5.1.2 State of Massachusetts's Bioscience Initiatives

The bioscience industries in Massachusetts are supported through a number of organizations, which provide assistance on financing, industry networking, infrastructure build-up, workforce development, and commercialization efforts. The following is a list of best practices and organizational initiatives helping to grow and foster a biosciences based economy in the state:

<u>Best Practices – Organizational Initiatives</u>

- **The Massachusetts Technology Collaborative (MTC)**, is a statewide sponsored public-private economic development organization that seeks to stimulate the growth of technology industries in the state, and establish successful technology clusters. The bioscience industries are a core part of their cluster development strategy, with the MTC providing support services to bioscience firms seeking Federal and extramural research and development grants.

- **The Massachusetts Biomedical Initiative (MBI),** works to help grow and expand the presence of biomedical and medical device firms, building on the academic research base in Central Massachusetts. MBI operates on a $2 million budget, and runs several successful programs.

<u>Best Practices – Financial Programs</u>

- Seed and venture capital funding is provided through several firms and organizations in the Boston, Route 128 corridor. Specifically, Bioventure Investors LLC, is a privately managed venture fund that aims to invest specifically in biotechnology, health care, medical devices, bioinformatics, drug-discovery and other bioscience related technologies.
- Formed in 1980, the Massachusetts Technology Development Corporation (MTDC) is a state sponsored venture capital company. The MTDC invests in Massachusetts based technology firms. Specifically, it invests in biomedical device and instrument manufacturing firms.
- The Massachusetts Development Finance Agency (MassDevelopment) is a state level agency, that provides a variety of asset based financing schemes, which could assist bioscience firms to leverage financial capital for developing infrastructure and or facilities.

<u>Best Practices – Regulatory Programs</u>

- Massachusetts offers several non-transferable tax credits to businesses involved in research and development. The state provides a credit against corporate excise tax, for R&D based business for up to 3% of the cost for federal income taxes. This tax credit can be claimed for any tangible properties (i.e. buildings erected or reconstructed), tangible personal property, and tangible property that comprise the structural components of buildings. A corporate excise tax credit also is provided for leased personal property, for businesses involved in R&D. In addition, tax credits are provided to R&D businesses, specifically those that are leasing or renting tangible property.

- The state provides a R&D tax credit, granted to foreign and domestic firms engaged in R&D within the state. The R&D credit is limited to a portion of all qualified research expenses occurring in a given tax year.

<u>Best Practices – Industry Networking</u>

- The Massachusetts Biotechnology Council (MBC), is a non-profit organization formed in 1985, and provides bioscience industry networking. The MBC provides policy and bioscience based educational materials, aimed at promoting the industry, while providing member services and programs. The MBC comprises 300 firms, academic institutions and related organizations involved in health care and biotechnology.
- The Massachusetts Institute of Technology (MIT) and the Worcester Polytechnic Institute provide university based technology based networking forums for start-up companies in the biosciences.
- The Massachusetts Medical Device Industry Council (MassMedic) is the state's trade association for medical device manufacturers. It aims to promote Massachusetts medical device industries, and develop and implement programs

that benefit its members. The MassMedic association currently has more than 200 members.

Best Practices – Workforce Development

- The state of Massachusetts has a strong presence of research universities and medical institutions, including a large cluster in the Boston area, comprising Harvard University, Boston University, Boston College, Tufts University and MIT. These universities are known for their world-class research and have renowned programs in the biological sciences.
- The state also runs a training and skill development program, through the Building Essential Skills through Training (BEST) program. This program has been actively utilized towards training bioscience firm employees.
- The Massachusetts Biotechnology Council runs a biotechnology scholars program that provides scholarships to state residents who wish to study in the field of biomedical sciences (TPP, BMI and SSTI, 2001).

Best Practices – Commercialization Initiatives

- MBI has several programs that aid biosciences commercialization efforts. The MBI Innovation Centers (in Boston and Worcester) provide commercialization and business development support to start-up bioscience firms. In addition, MBI has a Technology Commercialization Center, that provides academic researchers and entrepreneurs with the expertise needed to commercialize new technologies. Topics of assistance include, financing, licensing, technology transfer and business consulting.

- The Massachusetts Biotechnology Research Park, located adjacent to the University of Massachusetts – Amherst was founded in 1985. It currently hosts a dozen biotechnology firms and a variety of academic and non-profit organizations.
- BioSquare Technology Park is a private park located in Boston, and is affiliated with the Boston University Medical School and the Boston Medical Center. The facility includes a 60,000 square foot Animal Science Center and Transgenic facility, a cardiovascular imaging suite, a macromolecular x-ray facility, and a mass spectrometry resource core.
- Tufts Science Park is located near the Tufts University Veterinary Medical School, and the park is managed by the University and the Tufts Biotechnology Corporation – a private economic development company. The park provides space for R&D and pilot manufacturing for the pharmaceutical, biotechnology, and medical industries. In addition, there is incubator space for related technology industries involved in environmental and physical sciences.
- The University Park at MIT was created in 1983, and is considered one of New England's premier technology, biomedical and office parks. The park is located adjacent to MIT and is being expanded. Several sections within the park will focus on core biotechnology based research and development, taking advantage of the technology transfer and cross collaboration efforts between area universities, hospitals and businesses (TPP, BMI and SSTI, 2001).

<u>Benchmarks established by the State of Massachusetts</u>

In a report completed by the Boston Consulting Group (BCG) for the Massachusetts Biotechnology Council (MBC), BCG provides an understanding of the current and future impact of the biosciences industry to the state's economy. The report titled "MassBiotech 2010: Achieving Global Leadership in the Life-Sciences Economy, (BCG, 2002)" outlines the potential that the state's industry can have in creating jobs and boosting economic development, while harnessing existing strengths to capitalize on new opportunities in the global rise of bioscience industries. Utilizing the jobs created, fiscal and economic impacts, academic achievements, corporate success stories, and the potential of transferring research and development into profitable ventures, the report provides a set of established benchmarks (BCG, 2002: 12) to measure the success of the state's bioscience industries.

With a strong cluster of academic institutions, medical and research hospitals, local entrepreneurial efforts, and a core network of venture capitalists located in the state, the established best practices and organizational initiatives have proven successful for the state's economy. The report states that Massachusetts's researchers and entrepreneurs have created over 280 companies and employ about 30,000 people within the biosciences (BCG, 2002: 11). The report further states that the critical organizational (through the efforts of the MBI), workforce and commercialization development initiatives have made the state a haven for bioscience industries, attracting global capital and investments to the region, such as the world's ten largest pharmaceutical firms (BCG, 2002: 11). Investments made in developing the bioscience based research capacity of university and educational systems in the state, have made it an attractive location for bioscience firms looking to expand or locate their operations.

The industry has benefited from the organizational efforts of regulatory reform, and other best practice initiatives, and has helped boost the industry's impact on the state's economy. The state's bioscience industry has grown 10 percent annually between 1996 and 2001, and has contributed nearly half of the industrial jobs created in the state (BCG, 2002: 11). Between 1996 and 2001, the number of industrial jobs increased from 667,000 to 691,000, a net increase of 24,000, out of which the biosciences represented about 12,000 jobs (BCG, 2002: 17). Furthermore, the biosciences account for 18 percent of all venture capital investments made in the state, about 27 percent of research spending (out of $8.5 billion spent in the state), as well as account for a sixth of all public companies within Massachusetts (BCG, 2002: 11). The report concedes that with additional programmatic initiatives and state level efforts, the biosciences could employ nearly 100,000 people (an increase by 70,000 people from the 2002 employment level of 30,000) and generate fiscal contributions of about $1 billion dollars towards the Massachusetts economy (BCG, 2002: 11). The study concludes that with every job created by bioscience firms, there are two indirect jobs created in other industries, such as business supply firms, legal services and other support functions. Thus the biosciences industry currently is responsible for about 90,000 jobs within the state. Furthermore, the study states that jobs created by bioscience industries currently generate approximately $300 million annually in personal income tax, paid to the state. The report also states that early efforts in the 1990's made by the cities of Cambridge, Boston, Waltham, Framingham, Woburn, and Worcester in conjunction with local universities not only led to the development of bioscience research parks and firms, but also additional temporary jobs in construction and real estate development.

Thus we can see that the best practices and organizational efforts towards channeling state efforts in developing a biosciences economy have provided benefits to the Massachusetts economy, as well as created a set of benchmarks that can be used to evaluate future economic performance and practices. The commercialization initiatives through the establishment of research parks, not only provide bioscience jobs, but jobs in other ancillary support industries boosting economic development efforts. Workforce development practices, and the availability of world-class research scientists at universities have made the greater Boston metropolitan area an attractor of bioscience firms and capital. The state generates nearly 350 Ph.D. level professionals and researchers within the biosciences, and employs about 5,000 life scientists within the state – one of the highest concentrations in the world (BCG, 2002: 29). The proximity to research universities and a strong labor pool, has not only made Massachusetts an attractive location for companies, but also for Federal research and development dollars. In 2000, Massachusetts based universities and medical institutions received 314 high-technology patents, a direct outcome of research spending on technology development activities.

An exemplar of university research to commercial technology development in the state, is the former Harvard University based Genetics Institute. The Genetics Institute was formed by two research scientists at the University, and in 1996 was acquired by the pharmaceutical giant, Wyeth. Since the acquisition, Wyeth has expanded the original facility in Andover, to a 65 acre campus, with seven buildings, with 300,000 square feet of laboratory space and 365,000 square feet of manufacturing space. Wyeth employs about 2,000 people in a diverse range of occupations, including administrative, office support, manufacturing as well as scientific research jobs. The employees at Wyeth have been trained by local area schools that have partnered with Wyeth to design specific curricula, or have been trained internally at the corporate site (BCG, 2002: 32).

Some of the best practices adopted to ensure the economic success of this project, were undertaken by the city of Andover, as well as the state of Massachusetts. The project saw a collaborative effort by state and local agencies, including the Massachusetts Business Development Office (MBDO) – in accelerating permit reviews; the Massachusetts Highway Department – in making improvements and changes to the roadways; the state level Public Works Economic Development Department funded the town of Andover to provide additional access to the site; Assistance from the MBDO and the Highway Department to respond to litigation brought about by local residents that could have halted expansion; and state level support for employee training through the state funded Building Essential Skills through Training (BEST) program (BCG, 2002: 32).

The state and local efforts in developing a bioscience based economy, and particularly attracting Wyeth, has convinced the company to make Andover, the global bio-pharmaceutical manufacturing headquarters. Wyeth now partners with local schools, making presentations about the bioscience industry and educating students about careers in the sciences. The company also has created an active college internship program, bringing in about 100 college students as interns to the Wyeth facilities, in manufacturing and research development roles (BCG, 2002: 32)[30].

Therefore, state level policies that are facilitative towards developing bioscience industries have a positive impact on the state's economy. State programmatic initiatives and best practices, such as tax credits, research park development, venture capital funding among others help stimulate the development of firms and thereby create jobs and opportunities for further development. The aforementioned state level best practices and benchmarks, provide an insight into programmatic initiatives that have worked successfully and could provide similar potentialities and measurement tools for other regions and states across the United States.

5.1.3 Importance of the best practices and benchmarks to the ECMPDR

For the ECMPDR, these benchmarks and best practices can be compiled and organized in a fashion that is relevant to its regional economy. The members of the region's planning steering committee are instrumental in gathering the pertinent best practices and accordingly utilizing the information to inform planning for a bioscience based economy.

[30] Another example was set by the State of Massachusetts and the City of Boston, who convinced Genzyme Corporation - a large bioscience firm, to locate within the Boston through similar development incentives given to Wyeth, even though the firm was considering out of state locations (see BCG, 2002: 33)

Within Michigan, and particularly for the ECMPDR, it is imperative to understand the best-practices and benchmarks that have been successfully established in other states and regions. For the purposes of the thesis, the best practices and benchmarks can be gleaned and considered in program policy development for the ECMPDR to adopt while planning for a biosciences based economy. The best practices provide tried and tested policies that through careful implementation could prove to be successful in the ECMPDR. In addition, the benchmarks established to assess the program initiatives and policies, such as number of jobs created, firms created, technology patents generated, fiscal and economic impacts, among others, all provide measures to gauge best-practice policy and programmatic success.

Furthermore, the bioscience industries are known to have a complicated development process, which is part of the growth cycle in the industry. From access to capital and labor, to the potential of failing to receive regulatory approval, or simply due to the lack of market potential (of bioscience products) and or the slow development process of the industry itself, the aforementioned issues could create problems for certain bioscience industries, and the products developed by the industries. Thus, understanding the development cycle, in addition to the best practices and benchmarks is crucial towards developing a bioscience based economy, especially if public funds or publicly funded organizations are to be utilized.

The next section will help explicate industry and product development cycles, particularly as they pertains to the biosciences. Also, the intent here is to utilize an economic theory that helps to understand the development cycle specific to this industry, particularly for growing a biosciences based economy.

5.2 Definition of the Product Life Cycle Model – towards understanding the Industry Life Cycle and the biosciences development cycle

5.2.1 Product Life Cycle

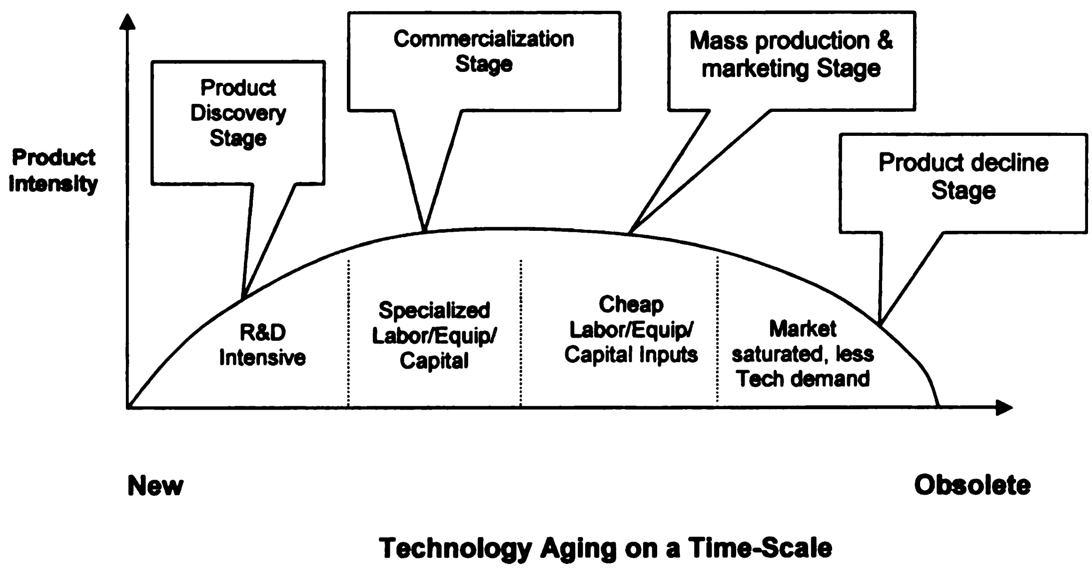
To help explain regional economic change, the product-cycle model was originally theorized as a framework to assess patterns of international trade (Taylor and Plummer, 2001). The core focus of the model is the process of technological change in multinational firms and the disbursement of multinational capital, and the progressing nature of the development, maturation, standardization and the outmoding of products.

"At the core of the model are technological change and the contention that, after the initial development of a product within an undefined business enterprise context,

1) market conditions and the structure of demand,
2) factor inputs (including human and financial capital)
3) the nature and intensity of competition, and
4) locational suitability, change in a systematic way as the technology ages" (Taylor and Plummer, 2001).

As the technology ages (and if there is positive market conditions and favorable demand), there is a need for commercialization of the technology through capital- intensive production, increasing the need for specialized equipment and labor to produce the product. Ultimately, as a critical mass of firms is reached in the production stage and there has been a widespread sharing of the technology, the product begins to decline in demand, requiring lesser specialized equipment, cheaper less skilled labor and fewer managerial or executive inputs. Thus we can see the transition from initial product discovery, to development, to marketing and mass manufacturing, and finally towards a stage of decline where the market is saturated, the product is of lesser demand, the production can be made routine and/or the technology is outmoded. Figure 16, explains the stages of development as they pertain to the product-cycle theory.

Figure 16: Product Life Cycle



Inherent within the product-cycle model is the spatial and production process based determinants of the products. The maturation of the production and technology functions lead to the relocation of production processes to de-concentrated and peripheral locations, as reliance on inputs of labor and capital, subcontractor firms and uncertainty in needs for space, inventory and labor costs are reduced (Taylor and Plummer, 2001).

5.2.2 Industry Life Cycle

Implicit within the stages of the product-life cycle is the notion that the model is embedded in technological change within multinational corporations (Taylor and Plummer, 2001), which themselves form industries. Thus, the product cycle can be used interchangeably with an industry life cycle, as products are produced within certain industries (composed of medical device manufacturers, pharmaceutical firms, contract R&D firms), and industries themselves undergo a similar aging process. Technological change within the industry life cycle context can follow similar patterns of progression (as compared to the product life cycle) and are outlined as follows

> 1) industry development (i.e., early stage industry formation), where the entrepreneur is the prime mover in the genesis of new industries through inventing and innovation of new products;
>
> 2) industry shakeout (similar to commercialization the stage), where an evolution occurs in the industry whereby a leading model emerges, permitting efficiencies to be realized and causing the subsequent increase in production (increasing the number of commercial firms in the industry, with increasing inter-firm competition relying on specialized inputs);
>
> 3) industry maturation and diffusion, where technological advances linked to the shakeout stage lead to only marginal improvements and efficiencies in operational product development (mass production based industries fit into this stage, and the technology is easily disseminated spatially with a distribution of a large number of firms, relying on less specialized inputs); and
>
> 4) industry decline, where the industry declines because of lack in demand, supply running out, congestion caused due to a lack of space for development, or the emergence of new technologies (possibly leading to stage 1 in the industry life cycle growth pattern). (http://www.rotman.utoronto.ca/~baum/v21_toc.html, last accessed May 5, 2004).

Furthermore, industrial production processes may have differing input requirements, leading to differential growth patterns both geographically and economically. For example, "technology and hi-tech industry originate in the 'core' and late-stage, low-wage production is shifted to the periphery (Taylor and Plummer, 2001)." This leads to a differential economic and geographic growth pattern within and between industries, especially those involved in early stage product R&D (needing high human and financial capital requirement, generally located in dense areas) to the eventual mass production of the product (low wage, labor intensive and less need for specialized human capital, generally located in the periphery) (Sternberg, 1996). "Technological maturity in this context was reckoned to reorient production and exports away from bases in developed countries towards new bases in developing countries (which, could be operated by entirely new firms or by branch plants of developed-country transnational corporations) (Taylor and Plummer, 2001). These "new firms" in new spaces, could in fact be new industries (in the biosciences or other industry sectors) or could simply be interregional shifts and the establishment of branch locations of the existing firms in the region (Sternberg, 1996).

Key concepts associated with the industry life cycle model are: *technological change, locally available human capital and knowledge, industry development, spatial diffusion, maturation, decline, core-periphery, differential economic and geographic/spatial development.*

5.2.3 The biosciences development cycle

Similar to any new technology based industry development, the bioscience industries have a long and complex development cycle. The bioscience industries and products made by the bioscience firms undergo a development cycle similar to that mentioned in sections 5.2.1 and 5.2.2.

The level of funding needed, advances made in R&D knowledge, type of products being researched, the required regulatory approvals needed from the U.S. Food and Drug Administration, and then the ultimate commercial market success of the products, all play an important role in the development of the industry, as well as the products. The intense financial and product competition, long time lags in the regulatory process, and potential failure of products and or the firms themselves, add to the uncertainty in the development process (Cortwright and Mayer, 2002; Oliver, 2000; MEDC, 2003). The following simple time-line (see figure 17 below) illustrates the staged process of development, and provides an understanding of the compound processes and the lengthy time scale within the biosciences.

In the discovery stage, researchers (both within companies or academia) find an innovative way to treat diseases, this phase is similar to the product discovery stage. The pre-clinical phase requires animal and non-human product testing of bioscience drugs, before it is tested on humans. Phases I-III test the bioscience products on humans, and if successful, the product receives regulatory approval. After receiving FDA approval, companies move into a production and mass manufacturing mode, and then the product is disseminated through medical doctor prescriptions and other health systems (BCG, 2002: 31). The production and manufacturing mode encapsulates the commercialization and mass-manufacturing stage identified in the product life cycle. After the product reaches maturity or the usage of the bioscience drug declines, the product and industries involved in mass manufacturing reach the decline stage within the life cycle.

The average bioscience product may take several decades to reach the potential market stage, and may transfer "hands" between different bioscience firms involved in alternate bioscience processes (Cortwright and Mayer, 2002; MEDC, 2003). For example, Oliver (2000) notes that the biosciences/biotech industry has high level of asymmetry in the types and sizes of firms. He notes that there are numerous, but small size firms involved in biosciences R&D (discovery stage), with a majority of them employing only 30 to 100 employees and focusing on core discovery R&D processes (Oliver, 2000: 22). Large pharmaceutical firms, traditionally involved in marketing bioscience products, now have entered into special partnerships with R&D based firms, in addition to their own in-house based product R&D. These partnerships involve moving the product successfully through Phase I, II, III testing, all the way to FDA approval, while providing financial and management support for many of the smaller firms (Cortwright and Mayer, 2002). Furthermore, firms from related industries that have been involved in chemical and production processes, such as Monsanto, DuPont and Novartis are now transforming their practices into life science and biotechnology concerns. For example, example Dow Chemical Corporation specifically has channeled its industrial chemicals business towards production and marketing for bioscience-based industries (Oliver, 2000: 22).

The product exchange between industries in the biosciences (from an R&D firm to a pharmaceutical manufacturing and marketing firm) may undergo geographic shift in the actual location of the product or industry. Thus, the spatial diffusion component (see section 5.2.2) of the life cycle model is incorporated within the biosciences development cycle. This situation may occur, with the research and development (discovery and clinical trial phases) occurring in one location, and the commercialization and mass manufacturing occurring in a location external to these phases. Furthermore, industries such as pharmaceuticals (a part of the biosciences) and even related industries such as agriculture may involve themselves (by technology transfer and company acquisitions) in the commercialization phases of a product life cycle. This involvement may lead to the diffusion of the product or the industry itself, closer to operational locations of the acquiring firm or organization, consequently brining new economic opportunities to the location of choice (i.e., often near headquarters or established technical/manufacturing centers). Although, there does occur a potential for the spatial diffusion of the industries or the products themselves (in different stages of the life cycle), it is not necessary for the industry to be diffused spatially. For example, because of the long regulatory permitting and approval process, certain R&D, manufacturing and production sites that receive approval to conduct bioscience based processes, cannot simply relocate due to the prohibitive time and costs involved with acquiring new permits (BCG, 2002: 33). The FDA's permitting process is stringent, and only certain manufacturing facilities pass the grade needed to produce health related bioscience products. Nonetheless, certain economic advantages, such as low cost production facilities or competitive advantages in local labor pools may guide the spatial location of bioscience industries to new geographies, in later staged of the life cycle.

5.2.4 The distribution of economic activity and potentialities for new regions like the ECMPDR

Through his article "The Internet and the Distribution of Economic Activity," Swann describes his skeptical view of the "death of distance" and the decline of agglomeration economies due to an increase in the production, dissemination and the low cost availability of information and communication technologies. His argument hinges on spatial advantages economies of agglomeration have (e.g. Silicon Valley) over peripheral low-cost areas (China and India), and believes despite low-cost advantages, the agglomerated economies of innovation will continue to have an economic dominance (Swann, 1999).

He avidly argues that in a global knowledge economy, information technologies do not erode the economies of agglomeration and scale, but in fact reinforce them. He furthermore states that the declining costs of transactions (using ICTs) will not themselves lead to dispersion of economic activity, unless the costs of agglomeration economies themselves are reduced by these technologies (Swann, 1999).

For regions outside the agglomeration (i.e. "de-populated" or less dense areas), Swann prescribes the use of product differentiation and niche-based marketing for economic growth and survival. This differentiation not only seeks products unique to the region, but also new space to develop innovative products, and it is here that the "de-populated" regions can have a locational and economic advantage (Swann, 1999).

With the biosciences industries and products undergoing a complex development process, and certain regions having pre-existing bioscience economies of scale in Michigan (i.e., the Ann Arbor-Detroit region in Southeast Michigan), the bioscience industries may be ripe for development in new spaces within the state.

These new opportunities may require new spaces for development of the biosciences, and thus regions (such as the ECMPDR) looking to harness economic growth through this industry can plan for a biosciences based development strategy. The benchmarks, best practices and theoretical literature all provide a guiding element towards the development of a bioscience based economy in the ECMPDR. It is imperative then for the stakeholders involved in developing the biosciences economy within the ECMPDR, to understand the successful programs and policies (from established best practices), as well as the theoretical guidelines, while planning strategically to develop their regional economy. In order to apply the learned best practices, set benchmarks and utilize the theoretical literature to guide economic development in the ECMPDR, the following section outlines a specific program design.

The program design stage of the PPM, utilizes the information gathered in stages 2 and 3 to help draft a specific proposal that will actively respond to the goals of the planning mandate. The proposal will integrate the problems identified in stage 2, with the solutions conceptualized in stage 3 into a clearly outlined set of action steps for the ECMPDR, including the required achievement criteria, towards creating an attractive biosciences based economy.

CHAPTER 6.0
THE ECMPDR PROGRAM DESIGN – STAGE 4

The main focus of the program design stage is to integrate the empirical problem exploration information with the relevant knowledge of strategic practices drawn from the current literature (discussed in chapter 5.0). This stage sets an operational and tactical framework to implement new planned programs, for local and regional technology based economic development through the biosciences.

The program design identifies local and regional actors, who contribute to operationalizing the planning program. They are specifically the key stakeholders involved in local economic development. These actors or their representatives are also involved in the early planning mandate stage, as planning steering committee members, enabling facilitative and comprehensive planning from policy inception to the design and ultimately the implementation of the planned initiative. The local and regional planners not only help design and plan the initiatives, but ensure operational success through guidance and the constant monitoring of the planned initiatives. Essentially this stage creates a strategic outline for planning, retaining, attracting and growing a bioscience based industry in the ECMPDR. The program design is implemented and monitored by a set of representative local stakeholders and planners.

In an effort obtain widespread acceptability for the program design proposal, it is necessary to incorporate the views of key actors (outlined in section 1.4.1) such as, local economic development agents, business, (i.e. large, small and organized labor) and non-profit leaders, as well as external experts who can help refine the programmatic action strategies. Consensus among these groups and members of the planning steering committee will help gain legitimacy from the ECMPDR and partner resource controllers, who are in charge of allocating resources towards the program's implementation. Approval from the planning steering committee and a commitment from the ECMPDR and partners is vital for the program design to be implemented on a pilot, demonstration or full program implementation basis (see chapter 7.0), for the program to be activated in the next stage of the PPM.

In order to design specific programmatic initiatives that will foster an attractive bioscience economy in the ECMPDR, it is necessary to review certain critical components of growing this type of economy. Following this section, the specific program design will be outlined, incorporating much of the necessary elements of bioscience based development discussed below (see section 6.1).

6.1 The requisites for growing a bioscience based economy

The bioscience industries face a complex development cycle from the early stage development of a product to the final commercialization and mass manufacturing industries involved in producing the product. Implicit in these developments, is the support from a wide variety of resources that help both the industries and the bioscience based local, regional and state level economies develop. A few core requisites are listed as follows (some of which were reviewed in chapters 4.0 and 5.0 respectively):

6.1.1 The importance of research institutes and universities conducting basic research in the Biosciences

Growth in the technology industries are dependent on strong academic research, in which early discoveries lead to the eventual breakthrough of viable and useful products. Universities and research institutes are critical to conducting this type of basic research and thus their linkage to development of the biosciences is vital, especially between universities and any commercial activity in the biosciences.

6.1.2 Access to capital is essential for the growth of new industries

The biosciences are a newly emerging industry, and early to late stage capital along all phases of development are critical to enable growth in this industry. The required facility fees, hiring of personnel and other regulatory and routine operation costs can be a large portion of early stage company budgets, and access to capital and funds can help through this process (BCG, 2002; Powell, et. al., 2002).

6.1.3 Successful technology transfer- from publicly funded research to commercialization opportunities

Publicly funded research at universities can gain commercial viability through the transfer of technology and patents generated at the university level. Businesses looking to harness these technologies and achieve commercial success are vested in the process of obtaining the patents and technologies, which ultimately lead to business expansion and overall economic development (BCG, 2002; MEDC, 2003).

6.1.4 Highly skilled workforce is needed for the development of bioscience firms

The biosciences require knowledgeable and a skilled workforce to conduct the type of work and understand the processes required in the industry. Having a trained and qualified workforce in the engineering and natural sciences can only benefit growth in this industry, and aid in the attraction and expansion of bioscience firms. Educational institutions should aim to work closely with the bioscience industries, and develop practical curricula that will aid in the development of the industry, while providing qualified candidates to employers (BIO, 2001).

6.1.5 Supporting infrastructure needed in the biosciences is highly specialized and expensive

The bioscience industries not only need specialized equipment to conduct research and or develop products, but need the appropriate physical laboratory space. The wet-laboratory space needed by the bioscience firms is expensive to construct and maintain, due to the sensitive research processes involved. Research parks and business incubators that do not provide such facilities, are unlikely to attract bioscience based firms (Herndon-King and Seline, 2000: 21).

6.1.6 Bioscience firms need a stable regulatory and public-policy environment

Due to the sensitive research and complicated development process, bioscience firms need a stable policy environment to operate. Rules against particular types of research, laws that prohibit certain types of drug development and other prohibitive measures can hamper the growth of bioscience based industries. In addition, a facilitative tax policy that encourages research and development in the biosciences can significantly assist biosciences based economic development (BIO, 2001).

In the discussion in section 6.1, the goal has been to convey an understanding of the complex growth and development process of the bioscience industries, and the required programs, initiatives and policies needed for developing a biosciences economy.

The next section outlines a program design, which should be used as a guideline for creating an attractive region for hosting and supporting bioscience based economic development. However, it is noted that the program is designed through an iterative process. The process development is dependent upon the success of the pilot, demonstration and the full implementation sub-stages of the program strategies, and need to be modified in order to ensure success and the achievement of benchmark criteria established in the design.

6.2 The program design for growing a biosciences economy in the ECMPDR

The ECMPDR is one of fourteen planning regions within Michigan, and planning for biosciences based development within the region should incorporate specific programmatic best practice initiatives, criteria and benchmarks established by the MEDC to develop Michigan's Life Science Corridor (see section 2.8). In addition, a program design incorporating the established exemplary best-practices and benchmarks, as well being informed by the theoretical guidelines will enable the ECMPDR to effectively develop their region through the biosciences. The following programmatic guidelines and benchmark criteria (i.e. program design) will utilize the aforementioned considerations, while providing applicable solutions towards implementing a bioscience development strategy in the ECMPDR.

6.2.1 Creation of a bioscience industry association for the ECMPDR

Benefits

- This organization can serve as an industry clearinghouse, providing relevant information to existing and potential bioscience firms. The information provided could include (but not be limited to) referral to professional service firms, access to labor and capital, university technology transfer opportunities and other industry statistics which are relevant to bioscience industries.

- The organization can conduct regional studies, assessing the needs and requirements of bioscience firms, including workforce needs, real estate requirements, as well as assessments of regions competing for bioscience firms. In addition, the organization can serve as a policy agent for bioscience industries in the region, enabling favorable regulatory legislation for firms in the region.

- The organization can help to foster regional industry networking seminars and luncheons, facilitating business relationships and partnerships between firms, organizations and universities, as well as linkages with external organizations and universities.

- The organization can facilitate technology transfer opportunities and market university patent licenses to organizations within and external to the region.

- The organization acts as a marketing agent for all the bioscience firms located within the region, promoting bioscience activities in the region, and highlighting firm level achievement through the popular media.

Benchmarks for assessing the level of success of a bioscience industry association

- The number of members actively participating in association level programs.

- The number of business relationships and partnerships created through the association networking seminars, and the subsequent revenues generated and investments made in the biosciences.

- The amount of monies raised for bioscience activities within the region. These activities could include direct lobbying of legislatures to obtain funding for research and development, or tax credits for bioscience firms among others.

6.2.2 Establish University – Industry Partnerships within and external to the region

Benefits

- Universities have a wealth of basic science and research and development capacity that can be harnessed for commercial development. Thus in the ECMPDR, for example, bioscience research being conducted at Central Michigan University could be transferred to commercial opportunities through the transfer of technology to a regional firm.

- Relationships may also be established with universities external to the region (through internship programs, technology sharing etc.) developing technologies in the biosciences. Furthermore, through the transfer of technology, commercial ventures within the region could harness these bioscience technologies and profit from the development of products. Thus, the spatial diffusion of the R&D product in a university/industry external to the region would benefit the ECMPDR, although the benefit may be accrued as a later stage phase in the life cycle.

Benchmarks for assessing the success of university – industry partnerships

- The number of bioscience based commercial venture spin-offs, jobs created and revenues generated from the transfer of technology from regional universities.

- The number of bioscience based commercial venture spin-offs, jobs created and revenues generated from relationships between regional industries and universities external to the region.

- The number of patents generated at the university level (from regional universities and colleges), and the subsequent licensing of revenues accrued from the transfer of technology or patent licensing.

6.2.3 Understand and harness regional bioscience industry strengths within the ECMPDR (within the theoretical framework of the product life cycle) – through the bioscience industry association or the appointing of a bioscience industry economic development champion

Benefits

- The ECMPDR has core strengths in the industrial chemicals R&D and manufacturing processes, with the presence of the headquarters of Dow Chemical Corporation. Understanding the specific bioscience products being researched and produced at Dow Chemical, as well understanding as supplier and ancillary industry firms could enable regional firms to tap into the downstream application of the product/industry life cycle.

- The core manufacturing strengths of the region can be harnessed to boost economic development. By specifically targeting companies (within the region or externally), involved in the clinical trial stages of bioscience development and soliciting them to locate in the region can help in job creation and increasing the number of biosciences firms.

- This programmatic initiative may also target firms looking to relocate manufacturing and other production opportunities in new locations, outside of the concentrated metropolitan areas where bioscience activities are conducted.

Benchmarks for assessing bioscience industry development within the theoretical framework of the product life cycle model

- The number of firms attracted, jobs created and revenues generated by tapping into potential downstream manufacturing and production opportunities from large firms in the region such as Dow Chemical.

- The number of firms attracted, jobs created and revenues generated from downstream life cycle opportunities created by relationships with firms/organizations external to the region.

6.2.4 Nurture and channel efforts at the secondary, post-secondary and tertiary education levels towards learning in the biosciences or natural science fields

Benefits

- The ECMPDR has a moderate number of college (masters and doctoral) level of graduates within the biosciences. By focusing strengths towards strengthening the science based curriculum at the middle, high school and college levels within the region, the region is apt to graduating students and professionals with an interest in the biosciences. Not only does this create an available labor pool, but also increases the possibility of stimulating new research in the biosciences and the subsequent potential of commercialization of the research.

Benchmarks for assessing regional efforts towards developing a bioscience based economy through the educational system and higher education curriculum in the region

- The number of students graduating from high school with specific interests in pursuing bioscience degrees at regionally based institutions.

- The number of students participating in science based scholarship opportunities, specifically conducting research or working within the biosciences at regionally based institutions.

The aforementioned program design guidelines and benchmarks will help towards planning for a bioscience based economy within the ECMPDR. However, it is important to note that the program guidelines are derived from the empirical realities within the region (as outlined in section 4.0), and driven by a theoretically informed understanding of the economic literature and best practices (outlined through section 5.0). Local and regional planning organizations attempting to replicate such a process, should conduct similar empirical and theoretical analysis, before creating policies for developing their local and regional economies.

Furthermore, and as stated earlier, the program design should be created through the input and review of the key stakeholders and representative members of the planning steering committee. Such an effort will ensure widespread participation, build consensus and momentum for activating and implementing the program design, and help achieve the goals of the planning mandate of developing a biosciences economy in a region external to the large metropolitan regions of Michigan.

CHAPTER 7.0
THE ECMPDR PROGRAM ACTIVATION – STAGE 5

At this stage, planners and local economic development actors operationalize the program design, through a pilot implementation in a specific region or county scale within the ECMPDR. The importance of knowledge sharing and collaboration continues to be evident at this stage, particularly if the planning mandate is to be implemented successfully. For the purposes of developing ownership in the planned change effort and program design, it is imperative for the representatives/actors involved in the implementation stage, to have helped in exploring, planning and designing the program mandate, as this would facilitate an efficient and open implementation process (see discussion on stakeholders in section 3.2). Furthermore, an evaluative review of the pilot implementation is conducted and helps to inform the program's evaluation (see chapter 9).

7.1 Overview of the Pilot program implementation

By way of scenarios, (see section 7.1.1 for a brief overview on scenario based planning) I will hypothesize the initial implementation within the ECMPDR on a county level scale, to test the applicability of the initiatives set forth in the design stage. Essentially, this creates a simple action to test the model in the planning region that may be applied later to a larger geographic scale, such as several counties in the ECMPDR, or regions across Michigan as deemed appropriate. At the pilot implementation stage, corrections can be made later in the implementation process or the design (stage 4) can be modified to ensure successful connection to the program mandate goals. The pilot demonstration will essentially help understand the potential feasibility of bioscience based development in a smaller geographic region, creating a guideline for future and full implementation.

The measured pilot implementation and a broader demonstration implementation within the ECMPDR, will provide an opportunity for an evaluative review based upon the criteria achieved (established in stage 4), before widespread or full implementation of the program design (see stage 6) in the entire region.

7.1.1 Scenario based planning for the ECMPDR

In the dynamic global knowledge economy, planning for implementing strategies such as developing a bioscience based economy on a local/regional/state level is a daunting task. Constant technological changes, economic restructuring processes and other geo-political situations make a definitive and sustainable economic response almost unknowable, as there are plenty of possible futures (http://www.manyworlds.com , last accessed on May 30, 2004). Although it is impossible to predict with certainty that any technology based industry will stimulate economic development, it is possible to set aside a group of possible futures that will in fact strategize towards creating a sustained economic environment. Scenario planning is such an approach that builds upon the existing realities and sets aside a group of possible futures through planned implementations. Scenario planning "builds on existing knowledge to develop several plausible future scenarios. These then can be used to construct robust strategies – strategies that should play out well in several possible futures (http://www.manyworlds.com, last accessed on May 30th, 2004)."

Therefore within the ECMPDR, planning for a bioscience based economy, especially with the region being external to large metropolitan areas in Michigan is a difficult task, but could be plausible through a planned scenario based approach. Furthermore, the program design being informed through theoretical literature in economic development planning, as well as successful best practices and benchmarks, the scenario planning approach can help in developing a bioscience based economy in the region. The ECMPDR, has core strengths in the chemical and manufacturing based industries, while having the presence of or proximity to renowned research and development based institutions. These industries and institutions (among other factors) can play a pivotal role in developing a thriving bioscience based economy within the ECMPDR, thereby providing economic development benefits to the region and beyond. Using a planning scenario approach, the next section hypothesizes this development as a pilot stage (i.e. on a smaller county level geographic scale).

7.2 Pilot Program Implementation in the Counties of Midland and Isabella within the ECMPDR using the scenario planning approach

As established in section 4, the presence of Dow Chemical Corporation in Midland County and the presence of Central Michigan University in Isabella, has contributed significantly towards the existing bioscience economy in the ECMPDR. Using these two counties, with core industries and organizations involved in the biosciences, the region could activate a pilot program to realistically measure the potentialities of a bioscience based economy.

7.2.1 Planning Scenario #1: Near-Term Development of the Biosciences in Midland and Isabella Counties – Target years 2004 – 2007

Creation of a Biosciences Industry Association

By the year 2007, the two county regions will have begun to understand and accordingly formulate strategic programs and policies aimed at developing the region within the context of a global knowledge economy and networked society. The ECMPDR will have effectively begun to organize efforts towards the creation of a bioscience industry association, as well as the necessary initiatives needed to understand the local existing bioscience economy at the two-county levels. The following outline identifies the necessary steps needed to help develop the region:

1) appoint/identify a champion to lead the development program;
2) select a diverse and representative group of members from the two counties to enable bioscience based economic development, including the selection of experts external to the region;
3) conduct an assessment of ICT and bioscience industries within and available to the two counties, including addressing accessibility of venture capital, existing manufacturing and R&D strengths, university technology transfer opportunities, as well as human capital, including the requisite training of the workforce at regional community colleges;
4) complete a best practices and contemporary literature review of economic development efforts made by other regions, specifically addressing the question of the potential distribution and equitable outcomes of economic activity throughout the two counties (i.e., cities, villages, townships and rural non-metro areas);

5) educate the public and the planning steering committee on different economic development models, including the product and industry life cycle model;
6) develop business and industry relationships with MLSC stakeholders and other national/global players, to advance the two-counties agendas, as well as sensitize them to the availability of development opportunities in "new spaces" in Midland and Isabella counties, as well other opportunities. These opportunities include, but are not limited to, licensing of patents from Central Michigan University or Dow Chemical, opportunities to partner with Dow Chemical as a supplier/manufacturing affiliate, among other economic and business potentialities

The two counties will have formed a bioscience industry association, as a precursor to the requisite steps needed to develop a bioscience economy in the counties. This bioscience industry association will have as its head, an experienced and knowledgeable executive championing the biosciences within the counties. The association will have documented the existing bioscience industries within the region, by the specific NAICS code (see section 1.0 for bioscience industry definition), and then will have begun to inventory the firms within the counties. This database then would help identify core strengths within the counties, as well as create an opportunity for business networking and bioscience based marketing services for the association to organize, conduct and disseminate. These networking sessions will take the form of luncheons, seminars and or informal sessions, enabling local leaders and stakeholders to discuss opportunities for growing the biosciences in the two counties.

In addition, the database of core companies, research institutions and organizations will provide executives and leaders the opportunity to participate within the bioscience association, as members of the planning steering committee in charge of developing the biosciences and or as members of the necessary task forces charged with the implementation of the planning mandate. It is suggested that the planning steering committee, be led by executives from Dow Chemical Corporation and or Central Michigan University, the two relevant institutional cores within the counties. These organizations can lead the effort towards harnessing their existing strengths in chemical based manufacturing by Dow Chemical in Midland, or product R&D by Dow Chemical researching new chemical products or processes, and generate economic opportunities within the region. Similarly, Central Michigan University can capitalize on its strength in the biosciences curriculum, creating a strong bioscience workforce, while stimulating opportunities for scientific research, or product discovery.

Once the bioscience association has been established within the two counties, other requisite studies can be conducted on gathering pertinent information such as, availability of venture capital, availability of professional services catering to the biosciences, existing manufacturing and R&D strengths, university technology transfer opportunities, as well as human capital, including the requisite training of the workforce at colleges and universities. The association also will act as a local educational and marketing arm for bioscience industries in the two county regions, educating the public about opportunities for careers in the industries, and or the tangible health care products emanating from R&D conducted within the region.

The association will have also established good working relationships with the members of the Michigan Life Sciences Corridor Steering Committee, as well as officers from the MEDC, encouraging them to invest monies within the two-county region. Furthermore, the association will encourage the active participation of executives and officers (experienced in planning for bioscience based development) in the planning steering committee strategy meetings, or request them to be members of the committee themselves, as external experts. The association will also highlight opportunities for licensing technologies emerging as patents from the two-county regions, specifically from Dow Chemical and CMU, which combined have a strong base of patent generation.

Benchmarks to measure the success of the near term planning scenario will include, the number of members actively participating in association level programs. In addition, the number of business relationships and partnerships created through the association networking seminars, and the subsequent revenues generated and investments made in the biosciences. Furthermore, another quantifiable benchmark could be the amount of monies raised for bioscience activities within the region. These activities could include direct lobbying of legislative bodies to obtain funding for research and development, or tax credits for bioscience firms, and developmental incentives among other.

Establish University and Industry Partnerships

The bioscience industry association will have created a strong network of executives across industry and academia, through its sponsored networking sessions. These business exchange or networking sessions provide a venue for stakeholders and leaders in the biosciences, particularly from CMU, Dow Chemical and other large supplier firms in the area of discussing the potentialities of partnering with each other. In addition, small and medium sized enterprises (SME), private and public institutions, help stimulate the economy through their job creation and strategic policies, and will play a vital role in developing the biosciences in the two counties. SME's are the core of the bioscience innovation and R&D processes and can contribute significantly towards developing new therapeutic drugs, and partnerships between SME's and the two core institutions in the area will lead to profitable partnerships. The partnerships will have resulted in the sharing of technologies, licensing of patents and thereby the creation of new products and or industries. Although the potentiality of product development and or the creation of a large number of jobs is fairly long-term in the biosciences, the initial seeds of development through the creation of university-industry partnerships will have been ingrained for a sustained biosciences based development.

The longer term benchmarks for measuring the level of success of this initial stimulus towards creating university and industry level partnerships include, but are not limited to: number of bioscience based commercial venture spin-offs, number of jobs created and revenues generated from the transfer of technology from regional universities; number of bioscience based commercial venture spin-offs, number of jobs created and revenues generated from relationships between regional industries and universities external to the two counties; and the number of patents generated at the industry and university level (from industries, universities and colleges in the counties). Furthermore, the subsequent licensing revenues accrued from the transfer of technology or patent licensing is also an important measure for the two counties. The benchmarks to measure immediate levels of success, will be initial contracts signed between university-business leaders, and or confirmation of potential partnerships in the near term.

<u>Encourage all levels of Educational Institutions to Create a Curriculum Specific to the Biosciences</u>

The bioscience industry association will form scholarships funds that help students financially, specifically for local students interested in pursuing degrees at the tertiary education level within the biosciences. The association also will partner with local schools and colleges, linking association members with potential employees or student interns, wishing to learn about the biosciences industry while advancing their academic interests. Specifically, Dow Chemical will partner with local high schools, bringing in students over the summer for internships, while also providing educational seminars on Dow R&D and types of products developed for the bioscience industries. Central Michigan University, will conduct summer camps for students, focusing in the biosciences, while also nurturing college level students into teaching, researching and developing products in the biosciences. Benchmarks to measure the achievements of educational institutions as well as the success of training and mentoring students towards careers in the biosciences include, but are not limited to: number of students graduating from high school with specific interests in pursuing bioscience degrees at regionally based institutions, and the number of students participating in science based scholarship opportunities, specifically conducting research or working within the biosciences.

7.2.2 Planning Scenario #2: Medium-Term Development of the Biosciences in Midland and Isabella Counties – Target years 2007- 2015

By the year 2015, the geographic identity of the counties as a burgeoning player within the biosciences will begin to form, as sustained planning and development efforts in terms of policies, programs and monetary investments take effect.

Understanding and harnessing the bioscience industries strengths within the two counties

By the year 2015, the two counties will have an increasingly diverse industrial base, and will have begun to see fruition of earlier planned programs/strategies and investments in bioscience based technology development (i.e., investment in forming a bioscience association, creating and fostering university and industry partnerships, among others). The bioscience association will be equipped with a succinct understanding of bioscience based industry strengths available to the two counties, and accordingly will have codified and shared this knowledge with public and private organizations, including the planning steering committee members. The region will begin to see a moderate increase in working access to the number of venture capital firms and or venture capital flowing into the two counties, increase in R&D firms in the biosciences, and emerging relationships amongst university and firms through technology transfer. Specifically, there will have been an increase in the number of bioscience patents licensed out by CMU to Dow Chemical and other technology development or manufacturing firms (including SME's), which now begin advanced research and development, and some mass manufacturing.

Furthermore, there will be a resuscitation of a previously declining automobile industry specific manufacturing sector – now focused on bioscience based drug and advanced product development and production. The region's competitive skill base, trained in the manufacturing industries, will now be trained in bioscience based industries and utilize this advantage to begin the creation and attraction of bioscience firms. The increase in manufacturing activity, jobs and economic development will lead to an increase in membership and brand recognition of the two-county specific bioscience industry association. The association will then build upon its strength from the regional brand position and help create effective policies and programmatic initiatives that benefit the biosciences within the two-counties, marketing the two-counties emerging biosciences cluster.

The counties will begin to capitalize on the R&D of certain products (core strengths – chemicals used in drug development, advanced medical devices, polymers used in medically oriented manufacturing), harnessing local knowledge, industrial skills and strengths, although the spatial dissemination within the counties will remain somewhat localized and proximate to the R&D centers (i.e., high-density urban areas and not rural villages, townships, etc.). However, R&D and licensed technologies emanating from industries and or research institutions may not have reached the maturity stage of mass manufacturing, and this is congruent with the nature of general product development cycle in the biosciences. Certain commercialization and mass manufacturing efforts will occur, through importation of external (from the MLSC or national/global locations, through business relationships) or development of internal (from R&D firms located within the two counties) technologies in the biosciences. R&D products developed within the counties will be transferred to commercial industries within the region, although the spatial transfer maybe proximate to the R&D center in dense urban areas.

These commercial and mass manufacturing efforts will potentially give rise to inter-related industries, as well as industries that can advance product development, enabling both growth in new products and or industries, some of which could be potentially located in "new spaces" within the region. For example, Dow Chemical may need certain pre-processed products or technologies as inputs for its bioscience based polymers, and new industries can emerge as suppliers to Dow, developing new products and potentially locating in a new space within proximity to Dow Chemical. The planning and development efforts (through business incentives, labor force readiness and the general awareness bioscience based development) at this stage will be critical to channeling growth in both product and industry life-cycle development to areas across the region (new spaces), including rural and outlying areas outside key metropolitan cities. These planning and development efforts will be operationalized by a plan implementation team (PIT) aiming to develop the region as a bioscience technology cluster, and could include members from the planning steering committee, working in close interaction with regional businesses and non-profit leaders to sustain growth. In addition, the PIT will have developed strong business relationships with key players from the MEDC, and other national and global firms and non-profits to help market and gain recognition for the emerging bioscience economy in the two counties.

Benchmarks to measure the level of success of this planning scenario include, but are not limited to, the number of firms attracted, jobs created and revenues generated by tapping into potential downstream (i.e., later stage in the product/industry life cycle) manufacturing and production opportunities from large and SME firms in the region such as Dow Chemical, or other emerging and existing firms. Furthermore, another quantifiable measure would be the number of firms attracted, jobs created and revenues generated from downstream product and industry life cycle opportunities created by relationships with firms/organizations external to the two counties.

7.2.3 Planning Scenario #3: Long-Term Development of the Biosciences in Midland and Isabella Counties – Target years 2015 – 2025

By the year 2025, the two counties will have a diversified industry base and the key sustaining ingredients to develop a technology based economy, particularly in the biosciences. There will be a sufficient number of venture capital firms (providing the necessary investments), research and development firms in the biosciences, collaborative research efforts and fluid and responsive technology transfer between higher education institutions and commercial enterprises in the biosciences, bioscience specific manufacturing firms, and a facilitative non-profit/bioscience trade organization to help develop, sustain and market a core bioscience based economy within the two counties.

Through sustained planning & development efforts and a supportive investment strategy targeted at attracting, retaining and growing bioscience industries, there will be ample opportunities for the development of bioscience products. The patents or early discoveries for these products will have been conducted at research institutions or firms such as Dow Chemical, with the downstream product development and industry cycle stages being conducted by new and or established firms in the region. The products (multiple – medical devices, cancer drugs, early detection systems) will be developed following the product life-cycle model, utilizing both product and industry based development, allowing for spatial (development in "new spaces") as well as economic growth of bioscience products and industries. Spatially, the development of the biosciences industry now will disseminate to regions outside the metro areas of Mt. Pleasant and Midland, in outlying areas of the county. This diffusion may take place due to the lack of appropriate development space in the metro areas, as well as due to the development of new ideas and firms in unused spaces. In addition, the sustained efforts of bioscience development strategies will have created a cluster, concentrated in the metro areas of the two counties leading to some congestion, or lack of developable space. This congestion of the bioscience cluster, may have an effect on new development potentialities, possibly leading to the diffusion or spread of bioscience firms to develop a new or emerging cluster in an outlying geographic area within the two counties.

The two counties will help grow bioscience based firms from within (harnessing localized industry and product development strengths), as well as help to attract firms (developing either bioscience based products or industries) from locations external to the regions, based upon the (regionally available) requisite human and financial capital, local knowledge residing in R&D firms and research institutions, and the legacy manufacturing and production strengths. The competitive advantages of having large R&D institutions, a research university, and the availability of a skilled workforce in bioscience manufacturing (among other industries), as well as the availability of developable land near large metropolitan regions (i.e., Detroit – Ann Arbor) will help create an attractive economic environment. The biosciences sector within the two-counties will be healthy, based upon sustained planning and investment strategies/programs, and will begin to grow local firms and attract national and global level firms aiming to capitalize on the regions strengths and yet looking for new spaces and markets to develop their product and or industry.

Furthermore, the developed bioscience industry sector could import specific R&D technologies (through developed industry and business relationships) and channel development in the appropriate product/industry life cycle stage within the two counties, as well as export technologies (to regions within Michigan's Life Sciences Corridor and/or national and global regions) and products as they reach maturation or are outmoded. For example, CMU and Dow Chemical could transfer technology patents to firms located in Michigan, or to another global location, as they become cost prohibitive or inefficient to produce within the two counties, and specifically after the products have been in the commercial market development stage for a long period of time. Products also could be licensed out directly from the research institution/university level, thereby generating revenues for conducting further R&D and opportunities for working on new bioscience discoveries. This healthy bioscience cluster/agglomeration would have been made possible by the efforts of strong leadership, a creative planning steering committee comprised of stakeholders within the region's economy, effective public input through the support of educating the county residents on the economic development efforts, and through the efforts of the biosciences industry association.

These planning scenarios are a thoughtful and measured approach towards planning for a biosciences economy within the two counties of Midland and Isabella. The scenarios are rooted in the implicit realities of the counties existing bioscience strengths, while trying to build upon these economic strengths and plan for future economic development potentialities. As stated earlier, the pilot implementation stage has a built in component of measuring the programs success, re-evaluating program options, and then subsequently conducting the pilot implementation again. This evaluative and iterative process helps towards the implementation in larger and or different geographic scales, as suggested in the following section. The measured pilot implementation and a broader demonstration implementation within the ECMPDR, will provide an opportunity for an evaluative review based upon the achievement of criteria in the program design stage (and program evaluation stage – stage 9.0), and before widespread implementation of the program design in the ECMPDR or other regions in the State of Michigan.

CHAPTER 8.0
THE ECMPDR PROGRAM OPERATION AND DIFFUSION – STAGE 6

At this stage for program operation and diffusion of the PPM, the planned program can be operationalized within the entire ECMPDR, as well as in regions across Michigan. This diffusion takes place in two phases, the demonstration phase and full implementation stage.

After incorporating the pilot lessons into a re-designed program, the demonstration program operation and diffusion can occur by implementing the newly tested and modified pilot program into wider geographic area, such as a larger number of counties within the ECMPDR, specifically outside the two counties of Midland and Isabella. Once again, at the demonstration phase, similar evaluative review is conducted as was done in the pilot implementation stage. After consensus on the demonstration phase among the planning steering committee members, and satisfaction is achieved with the performance of the evaluative criteria, the program now can be moved to the full implementation phase. The full implementation phase, activates the program in all counties within the ECMPDR, after successful operations in the pilot and demonstration program implementation. The program is activated throughout the ECMPDR member counties, and programmatic initiatives are strategized, monitored and evaluated similar to the aforementioned pilot implementation stage.

The program can now be administered and managed by existing operating organizations within the regions and the targeted sectors (i.e., a bioscience industry association, or a bioscience economic development organization), or continue to be operated through the regional planning director's organization and under the guidance of the planning steering committee. The key actors at this stage are the operational service providers, local level planners and "field" agents (as represented in the planning steering committee), directly involved in implementing the program design in counties across the ECMPDR. These actors are closely involved in implementing as well as monitoring and evaluating the program initiative in the ECMPDR (or other regions, if implemented in regions, states and or locales external to the ECMPDR). The specific program evaluation is discussed in the following stage. It is integral to the PPM and critical towards achieving programmatic success in developing a biosciences economy within the ECMPDR.

CHAPTER 9.0
THE ECMPDR PROGRAM EVALUATION – STAGE 7

The program evaluation stage is an essential phase of the PPM. It helps to assess and measure the level of success of the initial program mandate and the planned programs. Specifically, is the program mandate to benefit bioscience based economic development in regions outside the core metropolitan cities feasible? And furthermore has it succeeded? The evaluation design set-forth should provide an indicative approach to policymakers, planning practitioners, and program implementers for evaluating specific planning programs for technology based economic development.

The evaluation effort begins at stage 4 and continues iteratively through stage 6, and is best completed by stakeholders external to the design and implementation stage, albeit working in close collaboration with the local actors and economic development planners.

The close relationship (established by the planning steering committee comprised of region specific representative actors who are involved at each stage) and networking assure more likely success, and helps to monitor and evaluate the program from the program design to the pilot implementation, demonstration implementation, and finally through the full implementation. The evaluation program may be an iterative process until success is achieved or may merit discontinuation of the program mandate, and or a complete redesign of stages 4-6.

9.1 Evaluation Objectives for Creating an Attractive Biosciences based Economy in the ECMPDR

To assess and measure the objectives of the program mandate, the specific objectives outlined in the planning mandate stage need to be revisited. The program objectives include the tangible goals desired, including the diffusion and dissemination of bioscience firms in regions outside the metro areas, increase in the number of jobs and the related economic spillover effects. Here the evaluators work closely with the program mandate and the planning steering committee to help identify the principal objectives and then incorporate them within the evaluation stage.

The two principal objectives of the planning mandate as stated in stage 1 include the following:

- Utilization of the biosciences industry as an economic growth engine for developing the regional economy in the ECMPDR; and
- Activate a dynamic and responsive approach to governance that is needed to test the feasibility of biosciences based planning and development, while accounting for the aforementioned tangible goals.

9.2 Evaluation Criteria used to Measure the Success of the Planned Programmatic Initiatives

The evaluation criteria will help ascertain the degree to which the goals have been reached. For example, criteria could be established on the basis of programmatic effort, effectiveness, efficiency, and the potential positive or negative externalities (Van de Ven and Koenig, 1976). For the purposes of the thesis research, and specifically for the ECMPDR, the evaluative criteria used to measure the programmatic success for planning for a biosciences based economy include the criteria established in sections 2.7.4 and 6.2. These sections provide evaluative measures utilized by the MEDC, as well as summarized measures of criteria used to assess the best practices programmatic efforts in Virginia and Massachusetts. However, it should be noted that bioscience industries have long industry and product development cycles and certain criteria can only be measured after a long gestation period. This time period is when the bioscience industries within the region are supported to grow and mature (through investment in strategic and stimulative economic policies and programs), before a succinct and measurable evaluation can be conducted.

The evaluation criteria help to review the successes of the programmatic initiatives within the ECMPDR and include the following:

<u>Criteria to measure the success of the creation of the Biosciences Industry Assocation in the ECMPDR</u>

- The number of members actively participating in association level programs;
- the number of business relationships and partnerships created through the association networking seminars, and the subsequent revenues generated and investments made in the biosciences; and
- the amount of monies raised for bioscience economic activities within the region.

<u>Criteria to measure the success of University and Industry Partnerships in the ECMPDR, towards developing a Biosciences Economy</u>

- The number of bioscience based commercial venture spin-offs;
- the number of jobs created and revenues generated from the transfer of technology from regional universities;
- the number of bioscience based commercial venture spin-offs;
- the number of jobs created and revenues generated from relationships between regional industries and universities external to the region;

- licenses issued to life science research outcomes
- status and results of clinical trials and attainment of other product development milestones
- the number of patents generated at the industry and university level (from industries, universities and colleges in the region); and
- the revenues accrued from the transfer of technology or patent licensing

<u>Criteria to measure the success of channeling efforts in the high school educational system within the ECMPDR towards encouraging studies in the bioscience based fields</u>

- The number of students graduating from high school with specific interests in pursuing bioscience degrees at regionally based institutions with established bioscience programs; and
- the number of students participating in science based scholarship opportunities, specifically conducting research or working within the bioscience industries in the region.

<u>Criteria to measure the Strength of the Bioscience Economy in the Region</u>

- The number of firms attracted, jobs created and revenues generated by tapping into potential downstream (i.e., later stage in the product/industry life cycle) manufacturing and production opportunities from large and SME firms in the region such as Dow Chemical, or other emerging and existing firms;
- the number of firms attracted, jobs created and revenues generated from downstream product and industry life cycle opportunities created by relationships with firms/organizations external to the region;
- sales revenues from bioscience based organizations; and
- royalty income from licenses and patents accrued for ECMPDR based organizations

9.3 Program Evaluation Design

Evaluation design requires the evaluators to include the value judgments of the end users, key stakeholders in the program and other relevant actors involved in developing a biosciences economy in the ECMPDR. The actors/interested parties are representative members of the planning steering committee, the external experts, key stakeholders, program operators, service providers and local business leaders and investors interested in achieving the program mandate.

It is suggested that the evaluation design component (of the PPM) be completed by the relevant stakeholders within the ECMPDR, upon the initial program mandate. The actors/interested parties contributing involvement at each stage, enables them to effectively evaluate or modify the design program. The design is reviewed by the interested parties and is determined to be useful or not for proceeding with each of the sub-steps of the implementation stage. The close coordination and the strength of relationships among the relevant stakeholders in the ECMPDR is critical for the needed consensus, agreement, and successful evaluation of the program.

9.4 Program Evaluation analysis and feedback

This sub phase of the PPM conducts the designed evaluation through a systematic process, and provides analysis to the key stakeholders, actors and all members of the planning steering committee in the ECMPDR. Based upon the analysis, the stakeholders respond from their specified roles and contributions to the program mandate. If the program is evaluated to be a success, the program mandate team transfers the program responsibilities to the routine and functional arm of the organization (i.e., a bioscience industry association, a bioscience economic development organization or firm), while refocusing their energies on emerging ideas and or the development of new planning mandates.

CHAPTER 10.0 - CONCLUSION

10.1 The Feasibility of developing a Bioscience hub external to Metropolitan Areas

In Michigan, are the bioscience industries likely to benefit the economies of regions external to the large metropolitan cities and the Life Sciences Corridor, which have an existing built up mass of bioscience firms? Yes, this research permits one to conclude that in the case of the ECMPDR, it may well be feasible, and to be successful with such development, it will be critical to put in place the initial conditions noted at the end of this section. The chapter concludes with a brief review of the limitations of the research, while providing realistic challenges and pragmatic lessons for urban and regional planners involved in implementing strategies discussed through the thesis.

The biosciences, are clearly a sunrise industry – an industry that is still emerging, creating useful products and adding positively to the economies of regions and locales where the industries are clustered. The economic potentialities of the bioscience industries are alluring to many state and regional planning and development organizations. This attraction stems from the opportunity to create high-wage and high-skilled job opportunities, enabling development with the possibility of accruing higher revenues for the region, and ultimately creating a self-sustaining biosciences cluster that acts as an engine for economic growth. However, Cortwright and Mayer (2002) indicate that successful clusters of bioscience industries is a phenomenon occurring in large metropolitan areas of the United States, especially in those metropolitan areas with established bioscience activities (such as regions with large research hospitals and universities, a large number of venture capital firms, and with successful university-industry based research alliances)[31].

The present research intended to examine the potentiality of creating an attractive biosciences cluster in "new spaces", and specifically in regions external to large metropolitan areas in the state of Michigan. The thesis utilized theoretical literature, best practice strategies from states leading in biosciences based economic development, and a measured scenario planning approach that informed the research. It should be noted that the research simply utilized one economic theory (the product life cycle) as an informative basis to guide the research, and that there are other applicable economic theories that may assist in the planning and development processes of the regions. In addition, the thesis utilized the best practice strategies developed by the two states of Virginia and Massachusetts as exemplary guidelines, and other states, regions or global bioscience clusters could also inform planning and development organizations. Furthermore, the biosciences is but one emerging sector in the global economy. In Michigan, apart from the biosciences, the state has focused development efforts on two other large growing industries with strong economic potentialities, namely the advanced automotive technology and the homeland security technology sectors. These sectors also may provide economic development potentialities to regions planning

[31] Clusters are a group of companies and associated organizations that are geographically proximate to each other, and are linked by commonalities, complementary services and other business relationships and linkages (Porter, 1998: 199). Clusters can be formed by a group of companies within one industry sector, i.e., the biosciences, or clusters can be formed through the locational and geographic advantages, i.e., the furniture industry cluster in West Michigan.

for development, and for their economies to parallel the growth experienced in Silicon Valley, California or Route 128 in Massachusetts.

The thesis research revealed that there are two obvious bioscience clusters within the state – the Detroit-Ann Arbor regional cluster in Southeast Michigan, and the Kalamazoo-Grand Rapids regional cluster on the Western side of the state. The specific scale of inquiry in the thesis research is the East Central Michigan Planning and Development Region, a region external to the large metropolitan regions mentioned above. Through the research, analysis, and the planning scenarios, the ECMPDR does have some potentialities for developing an attractive biosciences cluster, however with some caveats which act as prerequisites to this development.

The research revealed that the core strengths of the ECMPDR lie in chemical and ancillary industries within the biosciences. The presence of large firms such as Dow Chemical, as well as the existing small to medium sized enterprises that are present as supplier firms in inter-related industries are a strength upon which planning organizations can build their regional bioscience economy. In addition, the region historically has had the automobile manufacturing and complementary industries, with a workforce skilled in manufacturing processes. This workforce is an asset to the region, particularly if the region develops as an advanced bioscience manufacturing cluster, having a workforce skilled in manufacturing can poise the region at a competitive advantage. Furthermore, having the presence of Central Michigan University, adds to the strengths of the region, specifically in terms of potential research and development capacity as well as training and graduating a strong workforce in bioscience fields, all key requisites to growing a bioscience cluster. Understanding and harnessing these strengths and creating a development strategy based upon this niche may enable planning organizations to successfully emerge as a contender in the biosciences economy. Furthermore, the organization of firms and emergent research universities (such as CMU or Saginaw Valley State University), towards developing business relationships is critical to establishing a cluster and or an attractive bioscience economy in the region. The region is also is proximate to the large metropolitan area and the bioscience cluster in the Detroit-Ann Arbor area, and through established research alliances, the ECMPDR could benefit through economic spillovers of business partnerships. In addition, the ECMPDR offers lower costs in terms of developable land, as well as natural amenities that can be attractive to bioscience industries interested in locating in the region.

The ECMPDR, clearly has a few positive strengths that will benefit its development towards creating an attractive biosciences based economy. However, the region has some high hurdles to overcome as well, especially if the ECMPDR wants to create a biosciences cluster. The ECMPDR presently, does not have a region wide bioscience industry association, coordinating industry activities and promoting bioscience based development in the region. CMU leads the region through its participation in an MEDC sponsored research university collaboration program, however the organizational efforts are focused within Mt. Pleasant in Isabella County. Creation of a bioscience industry association should be the first strategy adopted by the region's planning organizations. Second, bioscience firms generally do not relocate, especially away from regions having the presence of large research universities and a stable supply of skilled workers and or ideas emanating from the university based R&D laboratories. The association should help foster policies that stimulate R&D in the biosciences, encourage the local school and college educational systems to integrate biosciences focused subjects in their curricula. This will help sustained development of needed regional workforce skills and may attract firms external to region, and potentially create a knowledge base that can stimulate the development of firms from within the region. Next, through the efforts of the bioscience industry association, the region should aim to stimulate the local entrepreneurial culture towards the commercialization of bioscience patents and technologies, as well as attract venture capital to the region to invest in bioscience based industries. The bioscience industries have a long development cycle, and having strong executive entrepreneurs as well as sustained investments in the industries will help garner strength for an emerging cluster in the ECMPDR. In addition, an enterprise culture that is replete with entrepreneurs and local small to medium sized businesses is critical for biosciences based development. The bioscience industry life cycle is dependent on small to medium sized firms involved in the early stages of discovery and the testing of products, and the ECMPDR can benefit greatly by fostering the development of a vibrant and sustained entrepreneurial culture as well as small industries. Furthermore, the region's bioscience industry association, should foster relationships with universities and industries external to the region. The transcending of geographic space, may lead to new business relationships, attracting technologies and firms to the region that may be new, or simply those industries wishing to capitalize on the region's pre-existing strengths, including in the biosciences.

For the region to emerge as a healthy bioscience cluster, it is imperative to include development efforts and initiatives in all parts of the region. The thesis research has been focused on assessing the feasibility or diffusion of the biosciences industry in regions external to large metropolitan areas, the issue of equity is of primary concern. Within the ECMPDR itself, the industry association should assist in the development of the industry in distressed area communities, and consider the active encouragement of the connectivity of peripheral locations, the participation of minorities and under-represented groups in the industry. This participation may be in the workforce or through incentives provided to encourage the creation of minority owned bioscience businesses and or contracts. This not only assures the participation of a wide variety of regional residents, but may also help build consensus for long-term regional biosciences based economic development initiatives.

If the ECMPDR is to benefit from the biosciences economy, a planned, measured and systematic approach is needed to develop the region as a bioscience cluster. It is important that the ECMPDR or any region external to large metro areas undertaking such a development initiative, conduct a comprehensive assessment of their region's competitive advantage. This assessment will help optimize strategies for developing their regional economies, even though the development of a biosciences industry cluster is knowingly long-term and the certainty of knowledgeable profitable outcomes are not guaranteed. These following strategies emerged as the principal components of bioscience based development and may provide a starting point for planners interested in utilizing the biosciences as an engine for economic development:

- Create a bioscience industry association that fosters the growth of the industry in the region;
- Stimulate investments in the biosciences, while educating the stakeholders and regional residents about the potentialities from the bioscience industries;
- Encourage the development of small to medium sized enterprises, while harnessing localized strengths towards developing a bioscience economy;
- Fundamental to the successful development of a biosciences cluster in the ECMPDR, is both short-term and long-term investment in human resources and human capital capacity, and the maintenance of a sustained innovative enterprise culture throughout the region and its communities; and
- Plan for economic development through assessments, regional reviews, monitoring and benchmarking studies, as well as incorporating ICT; and bioscience based development specific policies in the Comprehensive Economic Development Strategies (CEDS).

In conclusion, in addition to the continuous planned development of its other sectors of strength, the ECMPDR does have certain opportunities to develop the region as a bioscience cluster. Through a planned and thoughtful approach, e.g., PPM, the region could seriously consider creating an attractive bioscience economy while removing some of the uncertainty associated with any emerging industry sector.

10.2 Limitations of the research

The thesis research provides an overview of Bioscience research and development initiatives in Michigan as well as in the ECMPDR. The research also initiates a scenario based planning approach towards developing the biosciences in a region external to large Metropolitan areas, specifically in Michigan. However, given the nuances in the bioscience industry development cycle, and the importance of regional actors and stakeholders, the thesis would have benefited from an understanding of the power networks and the local relationships structure among the stakeholders or regional players. The researcher would have employed an in depth understanding of local and regional relationships, including key personnel and organizations involved in economic development and innovation, as it pertains to the bioscience industries in the region. Further analysis and empirical information could have been gathered on key bioscience industries on a sub regional scale, through surveys and fieldwork interviews with private and public organizations. In addition to reviewing data on a sub regional scale (e.g. at a Metropolitan area scale), the scenario planning approach could have been adopted for a sub regional area as well. Furthermore, the research here utilizes one key economic theory (i.e. the product life cycle theory), but other economic theories could have been appropriately applied towards understanding the bioscience industry development.

The aforementioned limitations do not in anyway detract from the thesis initiative and or the research focus, but are suggestions for future research and study by scholars undertaking a similar study. Having a macro level understanding biosciences based development is critical for any region utilizing the biosciences as an engine for economic development, and the thesis provides a core understanding as such.

10.3 Challenges for planners during the stages of development

Chapters 3.0 to 9.0 provide a guideline for planners towards implementing the biosciences within their economic development strategies. The biosciences provide much promise, not only in terms of health and scientific benefits, but as an engine for innovation, economic growth and the potentialities of creating high skilled and high wage jobs. With bioscience industries being concentrated in certain geographic regions of the country, and within the life sciences corridor in Michigan, regional planners external to these regions (e.g. planners in the ECMPDR) face an aggressive and challenging task of developing a bioscience based economy.

The initial stages require that a few key organizations and or stakeholders in the region take on additional responsibilities of spearheading the bioscience based development initiative. This may require additional personnel and fiscal resources, but will be crucial in creating an actionable planning strategy. Furthermore, these key stakeholders need to be aware of the pertinent industry statistics, as well as coordinate or oversee the gathering of empirical information that may require the hiring of additional personnel or a data analyst. Apart from the human resources involved in initializing biosciences (through a planning mandate) based development in a region such as the ECMPDR, the region should sensitize itself to the needs and understanding of the bioscience industries. Considerable time should be allotted by key stakeholders or members of the regional planning steering committee towards reviewing the empirical findings, meeting with bioscience industry executives and utilizing their understanding to formulate region specific development strategies. Furthermore, a region wide educational and awareness program should be adopted, sensitizing private, public and non-profit organizations, as well as the region's residents towards the potentialities of the bioscience industries. These activities are bound to utilize time, money and personnel as well as financial resources of the regional stakeholders.

In addition, the key stakeholders need to build partnerships with local agencies within the region, especially those involved in economic development and with the potential of carrying out the formulated development strategies. This may particularly be a challenge, as local and or regional agencies may be averse to change, regional governance and or may not understand the potentialities of bioscience industry development.

From a marketing and deployment (of the planned development strategies) standpoint, the region faces considerable challenges. There are clearly established bioscience economic clusters located throughout the country, such as Boston, Massachusetts and San Diego, California or the Life Sciences Corridor in Michigan, which have developed relationships with the industry and are recognized as regions where the core investment dollars flow into. The ECMPDR will have to focus energies towards creating awareness not only among regional stakeholders, but also with external industry leaders, business executives and state and national level governmental organizations, if the region wishes to compete actively in the global biosciences economy.

The ECMPDR is bound to face challenges while developing and creating a strategy towards developing a bioscience based economy. Through sustained planning efforts, a long term vision, and establishing actionable strategies that achieve set goals, the region will be able to compete and benefit from actively participating in the global bioscience economy.

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