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The Bioscience Cluster in Ohio

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August 2014

**THE BIOSCIENCE CLUSTER
IN OHIO**

**CENTER FOR
ECONOMIC
DEVELOPMENT**

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INTRODUCTION

The purpose of this report is to create a shared definition and understanding of the bioscience industry across the state of Ohio. Bioscience is a relatively small industry, but it is growing both globally, nationally, and in Ohio. It is also linked to many other industries through its technologies, suppliers, and customers. This report will not only develop a deeper knowledge of the industry and its role in the economy, but we will suggest selected standards on how to study this industry and how to track its progress over time. This report is the first phase of a larger study that will analyze the bioscience industry in Northeast Ohio and Ohio based on the definitions proposed in this phase. This phase of the research was intended to agree on common definitions, develop a shared model, and identify the NAICS codes associated with sector. Based on this, the next report will develop a model for the state of Ohio and sub-regions that includes biohealth companies based not only on the NAICS definitions detailed here, but also those companies that fall outside the NAICS definition that are known participants in the biohealth sector.

The first segment of this research involves the creation of an advisory board of experts throughout the state. The board includes members from BioEnterprise, BioOhio, JobsOhio, Regional Economic Development Initiative Cincinnati, and the Center for Economic Development research team. This board outlined the definition of *bioscience* and *biohealth*, reviewed a preliminary cluster model, and prepared a list of interviewees for the study.

The report has three sections following this introduction: a framework for bioscience and cluster map of the biohealth industry; industry definitions of bioscience, biohealth, and more; and an overview of themes that came out during the interviews.

METHODOLOGY

In order to develop a typology of the bioscience industry, the Center researched current economic development literature of bioscience. Since the bioscience industry includes a complex set of industries and technologies, the research team assembled a set of common definitions related to the industry in order to provide a common language for the advisory board and others (Definitions are included in Appendix A). The literature review was also used to develop a preliminary typology of the industry. The research team organized the typology as a cluster map. A draft of common definitions and a cluster map were developed and presented to the advisory board.¹

The next phase of the research involved conducting interviews with industry experts. Names and contacts were provided by members of the advisory group. Interviews included representatives from companies who work in some capacity in the bioscience industry as well as individuals who work to support the industry through various organizations. The goal of the interviews was to solidify the common understanding of the industry as well as to confirm the working definitions, framework, and cluster map. Appendix B includes a list of the interviewees.

Based on both the literature review and the interviews, a list of North American Industrial Classification (NAICS) codes were identified for the bioscience industries. The Center then compiled a list of the final NAICS codes to be included in future analysis of the bioscience industry in Northeast Ohio and Ohio.

¹ A cluster is a geographic concentration of interconnected businesses, suppliers, and associated institutions in a particular field.

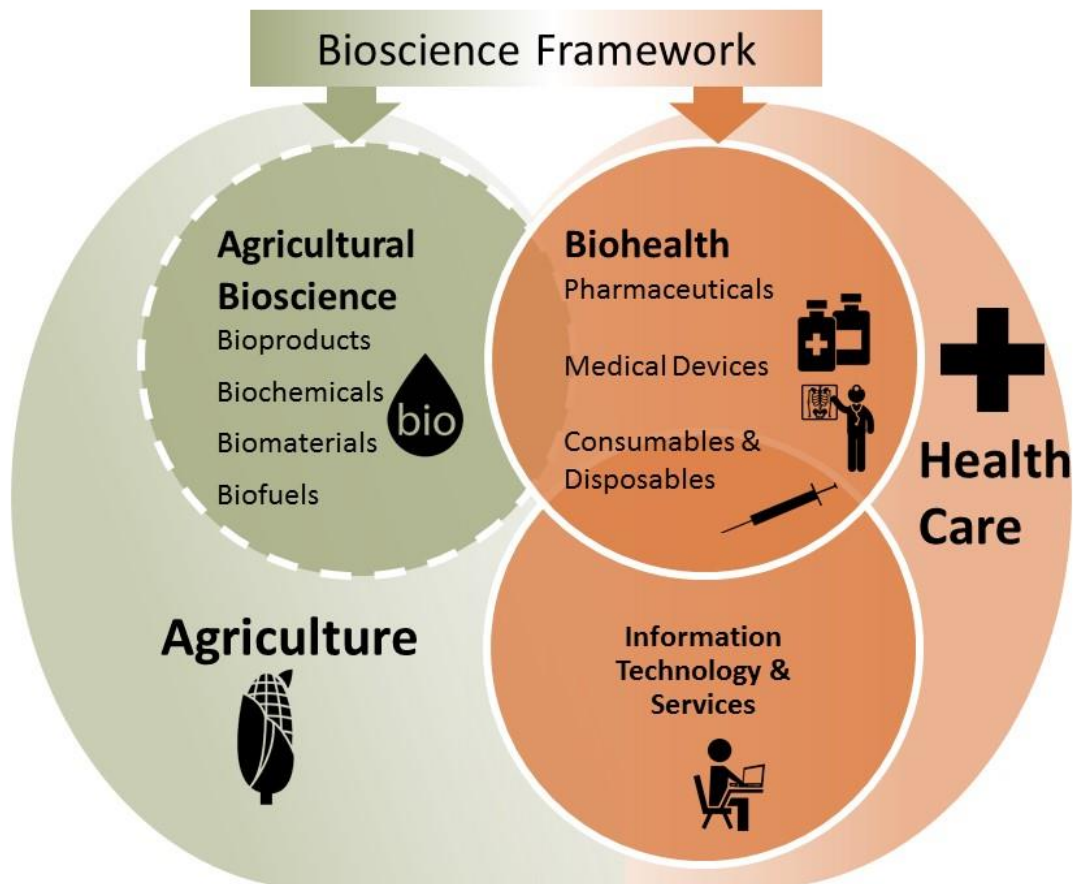
INVESTIGATING BIOSCIENCE

BIOSCIENCE FRAMEWORK

The bioscience cluster is difficult to measure because it crosses over many different industries and involves many players. Additionally, many companies do some or all of their work in bioscience, but because of the nature of their work, they are classified under a broader industry definition that does not relate solely to bioscience. For example, a software company that works only with hospitals would be classified under the software design industry, which includes software work in any type of business.

Gleaned from interviews and meetings with industry experts, a framework of the bioscience cluster is presented below (Figure 1). This framework shows that under the large umbrella term of bioscience, there are three main areas: agriculture bioscience; biohealth; and information technology and services. The biohealth field, which includes pharmaceuticals, medical devices, and consumables and disposables is a key component of innovation in the health care field. Information technology and services are important to both the biohealth and agricultural bioscience, and are thus represented separately in the framework. This study excludes the agricultural bioscience per the recommendations of the advisory board.

Figure 1: Bioscience Framework



BIOHEALTH CLUSTER MAP

The cluster map of the biohealth industry is presented in Figure 2. According to previous studies, including those performed by the Center in earlier years, the agricultural biology section is a key component of the bioscience industry. However, the focus of this present study investigates the intricacies of only the biohealth industry. It is important to note that with the complexities of the industry, one company may fit into more than one category, depending on its overall business or different business lines.

The cluster map shows the inter-related industries and their companies as having five components: Supplier Industries, Biohealth Core/Driver Industries, Downstream Industries, Specialized Infrastructure, and End Users. The left part of the cluster map shows the supplier industries. These are the industries that produce goods and services that are required for the production undertaken by the core biohealth industries. These include research, design, and development; clinical trials; select manufacturing; and enabling information technology. These industries support the core/driver biohealth industries. In Ohio, companies like WIL Research, Parker-Hannifin (which plays a role across different components of biohealth), and Battelle are found in this category.

The core or driver biohealth industries represent the companies whose central business is in biohealth. There are three types of core industries: products, health information technology, and services, each of which has a unique function. The core product industries are those that manufacture goods including drugs and pharmaceuticals, medical equipment and devices, and consumables and disposables. Health information technology includes bioinformatics, electronic medical records, and enterprise resources planning. This category represents the industry-specific software and analysis used in biohealth. Finally, the services category, which includes sterilization, labs, and wellness, offers support to the biohealth industry which is key to its success. Ohio companies considered to be driver biohealth industries in the products category include: Meridian Bioscience, Midmark, Neuros Medical, and Quidel (products). Hyland Software is an example of a health IT company, and Cleveland HeartLab is an example of a company in biohealth services.

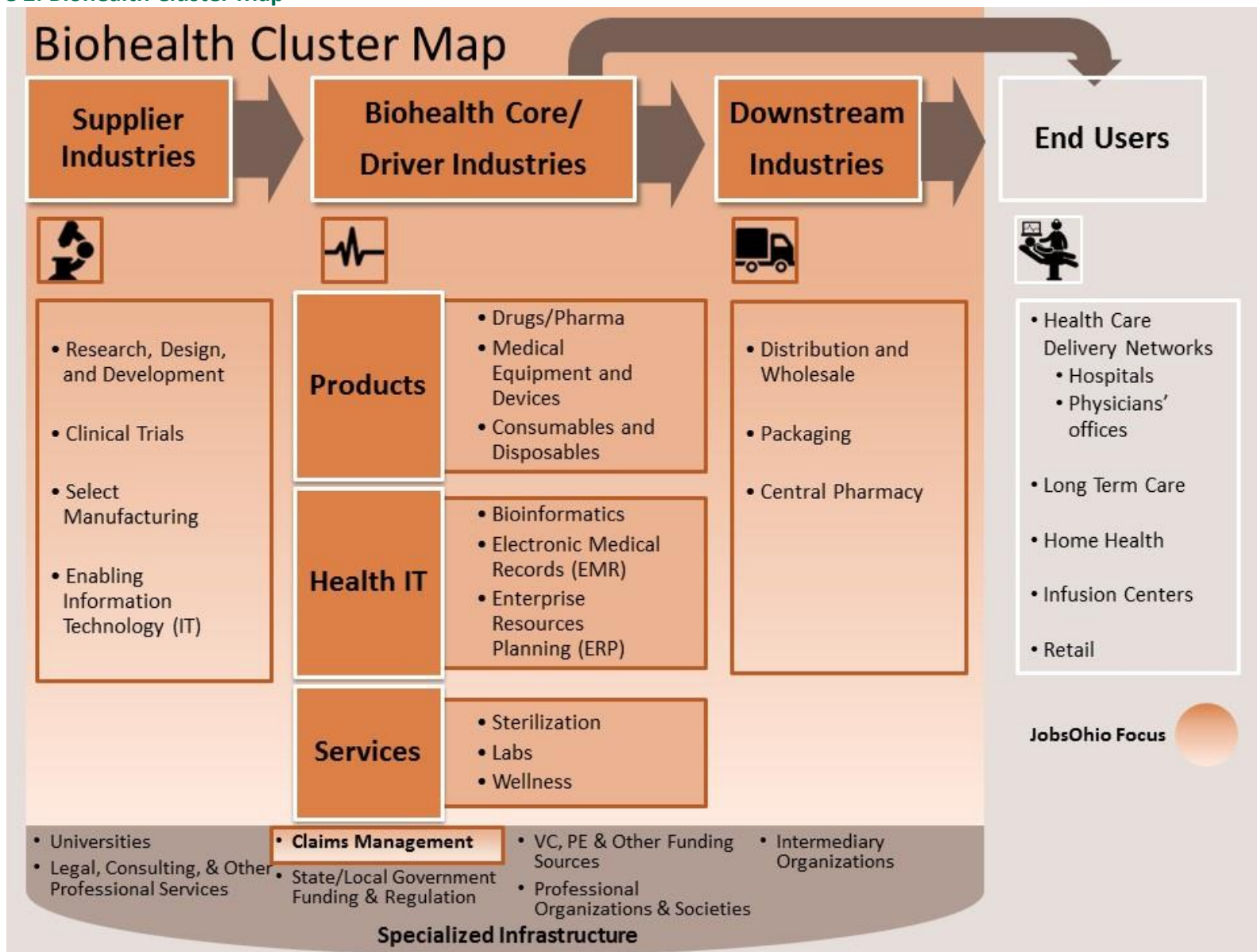
The biohealth industry, with its legal and safety requirements, and the necessity of just-in-time delivery requires specialized work around wholesale, distribution, and packaging – known as downstream industries. This group of companies includes those with specific knowledge and capabilities to serve this industry as well as central pharmacy functions. One example is Cardinal Health.

The end users in the biohealth cluster map are as varied as the industry itself. They include health care delivery, long-term care, home health, infusion centers, and retail functions. This group of companies includes all hospitals, clinics, offices of doctors, and retail pharmacies such as Drug Mart.

Underlying the cluster map is a key ingredient that exists in all industries. This is the specialized industry infrastructure which supports the industry and is critical to the continued advancement in innovation, product commercialization, and business growth. This infrastructure plays a key role throughout the supply chain, research, production, dissemination, and use of biohealth products and services. Included in this area are universities; legal, consulting, and other professional services; claims management; state/local funding and regulation; venture capital (VC), private equity (PE), and other funding sources; professional organizations and societies; and intermediary organizations. This infrastructure includes organizations ranging from the Technology Transfer Office at Case Western Reserve University, BioEnterprise in Northeast Ohio, and BioOhio and REDI Cincinnati.

The sections that are colored in orange in the cluster map, represent the JobsOhio target biohealth industries. JobsOhio targets companies in these industries for attraction and they span across supplier, core, and downstream industries, as well as claims management, which is part of the specialized infrastructure.

Figure 2: Biohealth Cluster Map



DEFINITION OF THE BIOHEALTH INDUSTRY

INDUSTRY DEFINITION

Because the biohealth industry encompasses so many different industries, it is difficult to measure it. Additionally, many companies that do some work in the biohealth industry are classified under different umbrella industries which is a clear restriction of the following list of industries in the biohealth definition.

For the purposes of this exploration, the following list of industries and their associated North American Industrial Classification System (NAICS) codes are presented. Table 1 presents the supplier industries to the biohealth cluster. This category is split into four subcategories: research, design, and development; clinical trials; select manufacturing; and enabling information technology. Other than the NAICS associated with research, design, and development, the other designations are too broad for any further investigation into what portion of each NAICS is associated with the biohealth industry, which is another limitation to the investigation of the industry using on NAICS codes.

Table 1: Biohealth Supplier Industries

Subcategory	NAICS Code	NAICS Description
Research, Design, and Development		
	541711	Research and Development in Biotechnology
	541712	Research and Development in the Physical, Engineering, & Life Sciences (except Biotechnology)
Clinical Trials		
	622110	General Medical and Surgical Hospitals*
Select Manufacturing		
	31-33	Manufacturing*
Enabling Information Technology		
	511210	Software Publishers*
	541511	Custom computer programming services*
	541512	Computer systems design services*
	541513	Computer facilities management services*
	541519	Other computer related services*

* Only select companies are biohealth, and thus these subcategories cannot be used to track trends in the biohealth industry.

The biohealth core/driver industries by NAICS code are presented in Table 2. There are three main categories in the core industries: products, health information technology, and services. All of the NAICS codes in the products and services category can be used to measure the performance of the biohealth industry. However, due to the nature of the information technology industry, these NAICS codes cannot be separated to determine what portion of these industries are related to biohealth.

Table 2: Biohealth Core/Driver Industries

Subcategory	NAICS Code	NAICS Description
Products		
	325411	Medicinal and Botanical Manufacturing
	325412	Pharmaceutical Preparation Manufacturing
	325413	In-Vitro Diagnostic Substance Manufacturing
	325414	Biological Product (except Diagnostic) Manufacturing
	333314	Optical Instrument and Lens Manufacturing
	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
	334516	Analytical Laboratory Instrument Manufacturing
	334517	Irradiation Apparatus Manufacturing
	339112	Surgical and Medical Instrument Manufacturing
	339113	Surgical Appliance and Supplies Manufacturing
	339114	Dental Equipment and Supplies Manufacturing
	339115	Ophthalmic Goods Manufacturing
	339116	Dental Laboratories
Health IT		
	511210	Software Publishers*
	541511	Custom computer programming services*
	541512	Computer systems design services*
	541513	Computer facilities management services*
	541519	Other computer related services*
Services		
	541380	Testing Laboratories
	621511	Medical Laboratories
	621512	Diagnostic Imaging Centers

* Only select companies are biohealth, and thus these subcategories cannot be used to track trends in the biohealth industry.

Table 3 presents the biohealth downstream industries. These industries are comprised of distribution and wholesale, packaging, and central pharmacy functions. Due to limitations of the data, central pharmacy and distribution and wholesale are combined. In this category, only one NAICS code includes data outside of biohealth (454113 Mail-Order Houses).

Table 3: Biohealth Downstream Industries

Subcategory	NAICS Code	NAICS Description
Distribution & Wholesale/Central Pharmacy		
	423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
	424210	Drugs and Druggists' Sundries Merchant Wholesalers
	424910	Farm Supplies Merchant Wholesalers (not included in original Battelle definition)
	423460	Ophthalmic Goods Merchant Wholesalers
Packaging		
	454113	Mail-Order Houses*
	532291	Home Health Equipment Rental

* Only select companies are biohealth, and thus these subcategories cannot be used to track trends in the biohealth industry.

Table 4 outlines the end users of the biohealth industry and is divided into five subcategories: health care delivery networks (hospitals and physicians' offices), long term care, home health, infusion centers, and retail. While all but the retail function can be measured, this category represents the overall health care sector and will not be used to measure the specific performance of the biohealth industry.

Table 4: Biohealth End Users

Subcategory	NAICS Code	NAICS Description
Health Care Delivery: Hospitals		
	622110	General medical and surgical hospitals
	622210	Psychiatric and substance abuse hospitals
	622310	Other hospitals
	621420	Outpatient mental health centers
	621491	HMO medical centers
	621492	Kidney dialysis centers
	621493	Freestanding emergency medical centers
	621498	All other outpatient care centers
	621991	Blood and organ banks
	621999	Miscellaneous ambulatory health care services
Health Care Delivery: Physicians' Offices		
	621111	Offices of physicians, except mental health
	621112	Offices of mental health physicians
	621210	Offices of dentists
	621310	Offices of chiropractors
	621320	Offices of optometrists
	621330	Offices of mental health practitioners
	621340	Offices of specialty therapists
	621391	Offices of podiatrists
	621399	Offices of miscellaneous health practitioners
	621410	Family planning centers
Long Term Care		
	623110	Nursing care facilities
	623210	Residential disability facilities
	623220	Residential mental and substance abuse care
	623311	Continuing care retirement communities
Home Health		
	621610	Home health care services
	621910	Ambulance services
Infusion Centers		
	621498	All Other Outpatient Care Centers
Retail		
	446110	Pharmacies and drug stores*

* Only select companies are biohealth, and thus these subcategories cannot be used to track trends in the biohealth industry.

Finally, Table 5 presents the specialized infrastructure of the biohealth industry. This category includes seven subcategories: universities; legal, consultants, and other professional services; claims management; state/local government funding and regulation; venture capital, private equity, and other funding sources; professional organizations and societies; and intermediary organizations. These specialized services are crucial to biohealth as they provide support to the entire industry. However, because of the nature of these industries, the portion of work that each has in biohealth cannot be determined from the data.

Table 5: Biohealth Specialized Infrastructure

Subcategory	NAICS Code	NAICS Description
Universities		
	611310	Colleges and universities*
Legal, Consultants, and Other Professional Services		
	541110	Offices of Lawyers*
	541211	Offices of certified public accountants*
	541310	Architectural services*
	541330	Engineering services*
	541360	Geophysical surveying and mapping services*
	541420	Industrial design services*
	541430	Graphic design services*
	541490	Other specialized design services*
	541611	Administrative management consulting services*
	541612	Human resources consulting services*
	541613	Marketing consulting services*
	541618	Other management consulting services*
	541620	Environmental consulting services*
	541690	Other technical consulting services*
Claims Management		
	524291	Claims Adjusting*
	524292	Third Party Administration of Insurance and Pension Funds*
State and Local Government Funding & Regulation		
	921190	Other general government support*
	923120	Administration of public health programs
	924110	Air, water, and waste program administration*
	926110	Administration of general economic programs*

	926140	Agricultural market and commodity regulation*
	926150	Licensing and regulating commercial sectors*
Venture Capital, Private Equity & Other Funding Sources		
	523910	Miscellaneous Intermediation*
Professional Organizations and Societies		
	813920	Professional organizations*
Intermediary Organizations		
	813910	Business associations*

* Only select companies are biohealth, and thus these subcategories cannot be used to track trends in the biohealth industry.

CURRENT JOBSOHIO DEFINITION

JobsOhio, the state's private, nonprofit organization that promotes jobs creation and economic development, has chosen the biohealth cluster as one of their target industries on which to concentrate their attraction and retention. JobsOhio is currently defining biohealth to include two categories, pharmaceuticals and therapeutics and medical device and equipment manufacturing, for a total of 12 NAICS codes (Table 6).

Table 6: JobsOhio Biohealth NAICS Definition

Group	NAICS	NAICS Description
Pharmaceuticals & Therapeutics		
	325411	Medicinal and Botanical Manufacturing
	325412	Pharmaceutical Preparation Manufacturing
	325413	In-Vitro Diagnostic Substance Manufacturing
	325414	Biological Product (except Diagnostic) Manufacturing
Medical Device & Equipment Manufacturing		
	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
	334516	Analytical Laboratory Instrument Manufacturing
	334517	Irradiation Apparatus Manufacturing
	339112	Surgical and Medical Instrument Manufacturing
	339113	Surgical Appliance and Supplies Manufacturing
	339114	Dental Equipment and Supplies Manufacturing
	339115	Ophthalmic Goods Manufacturing
339116	Dental Laboratories	

BIOHEALTH DEFINITION

Table 7 presents the culmination of this research in terms of what can be measured by NAICS code to analyze the scale of the biohealth industry. This list includes 23 NAICS codes which fall within the spectrum of the biohealth industry.

Table 7: Biohealth NAICS Definition

Group	Name	NAICS	NAICS Description
Supplier	Research, Design, and Development		
		541711	Research and Development in Biotechnology
		541712	Research and Development in the Physical, Engineering, & Life Sciences (except Biotechnology)
Core	Products		
		325411	Medicinal and Botanical Manufacturing
		325412	Pharmaceutical Preparation Manufacturing
		325413	In-Vitro Diagnostic Substance Manufacturing
		325414	Biological Product (except Diagnostic) Manufacturing
		333314	Optical Instrument and Lens Manufacturing
		334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
		334516	Analytical Laboratory Instrument Manufacturing
		334517	Irradiation Apparatus Manufacturing
		339112	Surgical and Medical Instrument Manufacturing
		339113	Surgical Appliance and Supplies Manufacturing
		339114	Dental Equipment and Supplies Manufacturing
		339115	Ophthalmic Goods Manufacturing
		339116	Dental Laboratories
		Core	Services
541380	Testing Laboratories		
621511	Medical Laboratories		
621512	Diagnostic Imaging Centers		
Downstream Industries	Wholesale & Distribution/Central Pharmacy		
		423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
		424210	Drugs and Druggists' Sundries Merchant Wholesalers
		424910	Farm Supplies Merchant Wholesalers (not included in original Battelle definition)
		423460	Ophthalmic Goods Merchant Wholesalers
	Packaging		
		532291	Home Health Equipment Rental

CURRENT THEMES IN BIOSCIENCE

A key piece of this study involved interviews with twelve industry experts from around the state of Ohio. The interviewees included business owners, managers, researchers, and nonprofit advocates. They represented manufacturing, construction, research, education, and information technology. The goal of the interviews was to assist in the development of the bioscience typology. Interviewees were asked about their company and how it fits into the bioscience industry, their supplier industries and the industries that buy from them, the infrastructure in place in Ohio to support bioscience, the current trends in workforce, and the future of the industry. They were also asked to review the Bioscience Framework and the Biohealth Cluster Map (presented earlier) for validity and to ensure that their company fits into the models. The next sections outline some key themes that emerged from the interviews.

DEFINING THE INDUSTRY

One of the key issues facing any analysis of the bioscience industry is the terminology. Therefore, the first topic researched through the literature review and the interviews was the definition of the industry and the different terminology used by different researchers and others working in this area. The term “bioscience” is defined clearly by Battelle/BIO in their study on the industry in the United States and by state:

Bioscience applies knowledge of the way which plants, animals, and humans function with the goal of developing new treatments, therapies, and processes and involves a grouping of diverse industries with a common link – the application of biological scientific knowledge.²

Life science has been defined as “...a diverse and robust industry from pharmaceuticals to medical devices to agricultural biotech, laboratories, and health information technology enterprises.”³ Another study described life science as including three industries: healthcare delivery, medical manufacturing, and bioscience/biotechnology.⁴ Finally, life sciences has been categorized not so much as an industry, but as a term used to capture companies that are focused on life processes.⁵ Life sciences was described as dealing with only human issues including the health and diagnosis of problems, while bioscience encompasses the human, animal, and plant arenas.

Biohealth is a subset of bioscience but is often used synonymously with the term. It is defined as a cluster of industries including biotechnology, biopharma, medical devices, healthcare services, health IT, e-health, mobile health, electronic medical records, health informatics, and biohealth cyber security.⁶

Agricultural biology, involves bio-based raw material production on farms, in aquaculture and forests, in the conversion of that raw material into useable feedstocks, and feedstock use for food and health

² Battelle/BIO, State Bioscience Industry Development, 2012.

³ BioCrossroads, 2013 Annual Report, 2013

⁴ ProDev Associates, Enhancing the Supply Chain of Workers to Bioscience, 2005

⁵ New Jersey Department of Labor & Workforce Development, New Jersey’s Biopharmaceutical Life Sciences Cluster, 2013

⁶ Economic Alliance of Greater Baltimore, BioHealth in Greater Baltimore: a State of the Market Report, 2013

goods production, biofuel and energy production, and biomaterials production.⁷ This term implies a focus on agriculture and food production.

THE ADVANTAGES OF OHIO

Interviewees described several advantages for the state to continue and grow its bioscience industry. These include quality of life in Ohio and ability to hire talent from outside the state, the Ohio Third Frontier Program, the strong manufacturing base that supplies the industry, university and hospital research and development, and the existence of large hospitals and several big companies.

Interviewees noted that one of the key ingredients in a successful venture is the Ohio workforce . Cooperation with colleges and technical schools is important for a specialized workforce, although some interviewees said that Ohio is sometimes lacking in engineering talent. Although it is currently a buyer's market in terms of hiring within the state, Ohio bioscience companies are having no trouble hiring and attracting talent from outside the Buckeye state. Additionally, one interviewee mentioned that in the past few years, it has become easier to attract talent to Northeast Ohio as people are taking note of the improvements and regional amenities.

Finances are always a consideration. The Ohio Third Frontier Program, a \$2.1 billion technology-based economic development initiative led by the state, was mentioned by interviewees as a great vehicle to grow the bioscience industry.⁸ Northeast Ohio companies received almost \$42.3 million in awards in 2014, over half of the statewide allocation.⁹ Other than this fund, however, interviewees felt that finding pre-seed and venture capital money was difficult for states and regions located between the two coasts of the country.

Ohio's manufacturing and research and development history and current strength were mentioned as key components to success. Close proximity to necessary parts of the supply chain is critical in the industry, as is the central location of the state which allows for the LEED certification that accounts for the close proximity of suppliers. Additionally, the infrastructure that supports the industry, including universities, hospitals, government, capital, consultants, professional organizations, and intermediaries, was noted as being wonderful but underutilized. This infrastructure helps to connect Ohio companies to each other, which is useful for creating networks and new business opportunities.

Ohio has unique assets that benefit the bioscience industry. Not only is the state home to popular brands like Invacare and Gojo, but the worldwide brand of the Cleveland Clinic brings a certain notoriety to work done here. Coupling this with the aforementioned assets, Ohio is uniquely poised to take advantage of new research, development, and manufacturing in the bioscience industry. The Brookings Institution took note of this recently when they highlighted Cleveland's Health Tech Corridor as an "innovation district" which they believe are "areas where leading-edge anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators. They are physically

⁷ Bush Consulting Group, Defining Northeast Ohio Cluster Opportunities in the Ag-Bioscience Sector, 2013

⁸ Ohio Third Frontier, http://development.ohio.gov/bs_thirdfrontier/

⁹ 12 Northeast Ohio companies win \$42.3 million from Ohio Third Frontier, http://www.cleveland.com/business/index.ssf/2014/06/12_northeast_ohio_companies_win_423_million_from_ohio_third_frontier.html#incart_river_default, 6/12/14

compact, transit-accessible, and technically-wired and offer mixed-use housing, office and retail.”¹⁰ The Health Tech Corridor is just one example of the distinctive reasons Ohio is well-poised for growth in the bioscience industry as it works in tandem with another new institution, the Global Center for Health Innovations, the only facility in the world that displays the future of health and healthcare.¹¹ The “Globe,” as it is called, is a tremendous platform for the expansion of local and regional companies according to one interviewee.

INDUSTRY TRANSITIONS AND THE FUTURE OF BIOSCIENCE

Several interviewees discussed the future of healthcare and bioscience. They noted that the bioscience and healthcare industries are changing rapidly. Work with animals is decreasing, costs are rising, and innovation is increasing at a rapid pace. Additionally, the industry is working across even more disciplines and industries.

A few interviewees also discussed the role of wellness and education in the future development of the industry. There is an increased focus on not merely treating patients, but improving their wellness and making patients accountable for their health through patient education. By encouraging patients to take an active role in their health, the old fee-for-service model is shifting to a fee-for-value model which is leading to selective care and can result in lower costs for patients. There is also evidence that there is a “gamification” of the health industry with products like Lumosity that work to improve brain functionality through games. Also, there is movement toward retail healthcare in small settings, which is moving simple treatments away from large hospital systems.

Finally, interviewees noted that research is shifting from the laboratory to the bedside as innovators have moved toward working directly with healthcare professionals to look for new ways of delivering care and new technologies to improve treatment. With the increased use of technology, data can be collected from patients along their entire spectrum of care, allowing for large data sets to be amassed and analyzed for further improvements in treatment.

¹⁰ The Rise of Innovation Districts, http://www.clevelandplus.com/News-and-Press/CLE_plus-News/2014/June/The-Rise-of-Innovation-Districts.aspx, 6/11/14

¹¹ Cleveland Convention Center, <http://www.clevelandconventions.com/about-us>, 6/18/14

APPENDICES

Appendix A: Industry Definitions

Bioscience

- Applies knowledge of the way which plants, animals, and humans function with the goal of developing new treatments, therapies, and processes. (BIO/Battelle 2012)¹²
- Grouping of diverse industries with a common link – the application of biological scientific knowledge. (BIO/Battelle 2012)

Biotechnology

- The application of science and technology to living organisms, as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods, and services. (Organization for Economic Co-operation and Development)¹³
- The application of biological knowledge and techniques to develop products and services. (BIO 2005)

Agriculture Bioscience

- The integration of scientific disciplines to address critical needs of food security, safety, and health; environmental sustainability; and biobased energy, fuel, and products. (ClevelandPlus)¹⁴
- A broad category of activity encompassing bio-based raw material production on farms, in aquaculture and forests, in the conversion of that raw material into useable feedstocks, and feedstock use for food and health goods production, biofuel and energy production, and biomaterials production. (Bush Consulting Group)¹⁵

Biohealth

- A cluster of industries that drive the new innovation economy...It is the intersection of healthcare, life science, bioscience, IT, and manufacturing. Industry sectors include biotechnology, biopharma, medical devices, healthcare services, health IT, e-health, mobile health, electronic medical records, health informatics and bioHealth cyber security. (Economic Alliance of Greater Baltimore)¹⁶

Life Science

- Encompasses three industries: healthcare delivery, medical manufacturing, and biosciences/biotechnology. (Thomas P. Miller and Associates, Inc.)¹⁷

¹² Battelle/BIO State Bioscience Industry Development, 2012

¹³ Organization for Economic Co-operation and Development, OECD Biotechnology Statistics, 2009

¹⁴ Cleveland Plus, The Emergence of the Ag-Bioscience Industry, 2014

¹⁵ Bush Consulting Group, Defining Northeast Ohio Cluster Opportunities in the Ag-Bioscience Sector, 2013

¹⁶ Combs, Michael & Dougherty, Patrick, Economic Alliance of Greater Baltimore, BioHealth in Greater Baltimore: a State of the Market Report, 2013

¹⁷ Thomas P. Miller and Associates, Inc., Enhancing the Supply Chain of Workers to Bioscience, 2005

- Life sciences – “...a diverse and robust industry from pharmaceuticals to medical devices to agricultural biotech, laboratories, and health information technology enterprises.” (BioCrossroads)¹⁸
- Life science industries...consist of firms operating in three business activities: manufacturing, wholesale distribution, and research and development. (Kelley School of Business)¹⁹
 - Note – Based on Battelle 2011 definition, this study referenced that they do not discuss Agricultural Feedstock and Chemicals (pg. 1 “biosciences is a broader industry definition that includes agricultural feedstock and chemicals)
- Life Sciences sector encompasses three industries: healthcare delivery, medical manufacturing and bioscience/biotechnology. (Thomas P. Miller and Associates, Inc.)²⁰
- Life science is not an industry, rather, it is a term used to capture companies that are focused on ‘life-processes’. (John Ehret)²¹

Biomedical Industry

- The biomedical industry, at heart, is dedicated to applying scientific advances to improve human health. (BayBio and the California Healthcare Institute)²²

¹⁸ BioCrossroads, Annual Report, 2013

¹⁹ Kelley School of Business, Indiana Life Science Industries, 2009

²⁰ Thomas P. Miller and Associates, Inc., Enhancing the Supply Chain of Workers to Bioscience, 2005

²¹ John Ehret, New Jersey Department of Labor & Workforce Development, New Jersey Bio-Pharmaceutical Life Sciences Cluster, 2013

²² BayBio and the California Healthcare Institute, California Biomedical Industry, 2013

Appendix B: List of Interviewees

Dr. Steve Barkyoumb, Senior Vice President of our US Operations, WIL Research Labs

R. Gregoire Blackmore, Chief Operating Officer, Midmark Corporation

Dr. Shauna Brummet, CEO BioHio Research Park

William G. Dunlevy, VP & General Manager, Consumer, Industrial & Medical, Battelle

Bob Geschke, Director, Healthcare Solutions, Hyland Software

Michael Gleeson, Owner, Gleeson Construction

Jack Kreutler, President and CEO of Meridian Bioscience

John Lehmann, Director of Business Development, imarc

Geoffrey Morgan, Vice President, General Manager, Quidel

Rudy Poussot, Corp. VP of Strategy, Cardinal Health

Arun Ranchod, Global Business Development Manager-Life Sciences, Parker-Hannifin

Jon Snyder, CEO, Neuros Medical