2011 Iowa Bioscience Strategy

Prepared for: Innovate Iowa

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Table of Contents

Executive Summary

Iowa's public and private sector leaders recognized as early as 2001 that the biosciences represented an area of economic opportunity for the state. In 2004, the Iowa Department of Economic Development (IDED) commissioned a strategic roadmap that outlined a comprehensive approach to growing the state's bioscience industry cluster.

It has been 10 years since Iowa first targeted the bioscience industry for development, six years since the state's bioscience roadmap was adopted, and much has changed in terms of the development and evolution of the bioscience sector. Major advancements have taken place on a host of fronts, ranging from high-precision personalized human biomedical applications to widespread biomass-based innovations in agbioscience, bioenergy, and industrial biotechnology. The biosciences today are a key engine of economic growth in the U.S., with the industry supporting 8 million jobs, taking into account the additional jobs created in the economy as a result of the sector's direct jobs.[1]

Significant progress has been made in growing Iowa's bioscience industry cluster since 2001. Employment in Iowa's bioscience sector grew 26 percent between 2001 and 2008, outpacing rapid growth of 15.8 percent at the national level. The sector directly employed about 14,500 workers in 2008 and employment grew 4.5 percent between 2007 and 2008, the first year of the recession.

Iowa's academic bioscience research and development (R&D) expenditures totaled more than $450 million in Fiscal Year (FY) 2008. Major investments have been made in bioscience R&D facilities and the universities have increased support for faculty entrepreneurship and commercialization. Industry-university collaborations also have increased.

But while Iowa has been investing in its bioscience sector and the infrastructure to support it, the national and global bioscience landscape has evolved, and states and regions across the U.S. and across the globe, are advancing bold initiatives to capture both the economic and social benefits of new bioscience discoveries—discoveries that are increasingly finding their way into new applications and products leading to new medical treatments, new sources of energy, and new industrial products made out of biomaterials.

Defining the "Biosciences"

The biosciences are a diverse group of industries and activities with a common link—they apply knowledge of the way in which plants, animals, and humans function. The sector spans different markets and includes manufacturing, services, and research activities. By definition, the biosciences are a unique industry cluster and are constantly changing to incorporate the latest research and scientific discoveries.

The bioscience industry sector is defined as including the following four subsectors:

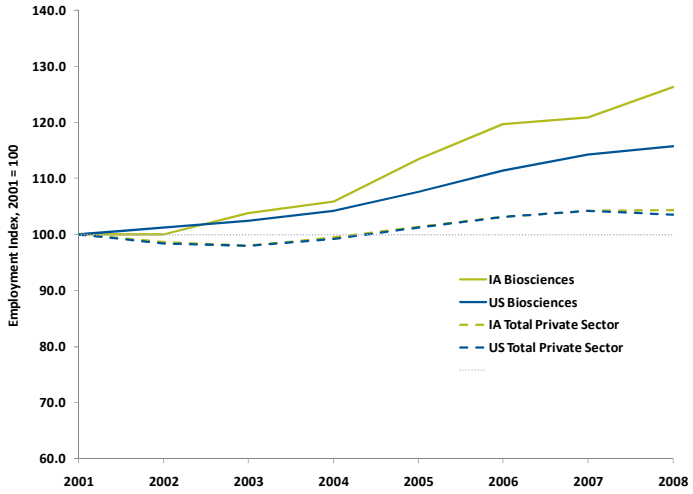
- *Agricultural Feedstock and Chemicals*
- *Drugs and Pharmaceuticals*
- *Medical Devices and Equipment*
- *Research, Testing, and Medical Labs*

Recognizing these trends, Innovate Iowa, a public/private partnership that includes senior leaders from industry, academia and other organizations interested in growing Iowa's economy and at the same time advancing medical innovation in the state, engaged Battelle's Technology Partnership Practice to assess Iowa's competitive position in the biosciences, identify new opportunities for bioscience-driven economic development, address challenges that face the state's bioscience industry and research institutions and develop a new path forward for achieving Iowa's bioscience vision.

Key Findings

Iowa has a sizable and rapidly growing bioscience industry sector that outpaced growth at the national level. See Figure ES-1. In 2008, Iowa's bioscience industry employed 14,494 across 525 individual business establishments.[2] The sector is sizable, and has grown by just over 3,000 jobs since 2001 with three of the four major industry subsectors contributing job growth between 2001 and 2008. Battelle's national report for BIO found Iowa stands in the middle quintile among state bioscience industries in employment, ranking 26th among all states and Puerto Rico (compared with 30th in overall state population rank).[3]

Figure ES-1: Iowa and U.S. Bioscience and Total Private Sector Employment Trends, 2001–08 (Index, 2001=100)



Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

Iowa is a highly specialized leader in agricultural feedstock and chemicals, with an extremely high concentration of jobs compared with the U.S. as a whole. In fact, in Battelle's 2010 report for BIO, Iowa's location quotient (LQ) of 5.99 was highest among all states and Puerto Rico in the subsector. Location quotients are a standard measure of the concentration of a particular industry in a region relative to the nation. An LQ greater than 1.2 denotes employment concentration significantly above the national average. Iowa's LQ of 5.66 means that Iowa has six times the concentration of employment in the agricultural feedstocks and chemicals subsector than is found nationally.

The bioscience industry remained resilient even through the first year of the recent recession. While national private sector jobs declined and unemployment rates rose, the biosciences continued to create jobs, particularly in Iowa. Table 1 presents employment changes not only for the full 2001 through 2008 period, but also for 2007-08, isolating job trends over the first year of the recession. While national private sector payrolls declined (down 0.7 percent) and were essentially flat in Iowa (up 0.2 percent), the biosciences continued to add jobs. The national sector increased its job base by 1.4 percent and in Iowa, the rate was even greater, increasing by 4.5 percent over the year.

The biosciences is a high-wage industry in Iowa and nationally. The average annual wage paid by the bioscience sector in Iowa was $60,833 in 2008, more than $24,000 or 67 percent above that paid on average in the overall Iowa private sector. Wage premiums in the biosciences reflect a greater degree of value-adding activities relative to other major industries. In addition, a knowledge-based industry like the biosciences requires high-skilled workers whose higher wage requirements reflect the greater value of their education and skills in the labor market. And while this holds true relative to other industries, even within the biosciences, wages across states and regions can vary considerably based on the occupational and industry composition or mix within each.

Table ES-1: Average Annual Wages for Iowa and the U.S., Biosciences vs. Other Major Industries, 2008

Industry	Average Annual Wages, 2008	
	Iowa	United States
Agricultural Feedstock & Chemicals	**$ 68,065**	**$ 72,279**
Management of Companies & Enterprises	$ 66,265	$ 94,842
Total Biosciences	**$ 60,833**	**$ 77,595**
Finance & Insurance	$ 56,653	$ 85,274
Drugs & Pharmaceuticals	**$ 56,288**	**$ 93,378**
Research, Testing, & Medical Labs	**$ 55,678**	**$ 80,785**
Wholesale Trade	$ 49,623	$ 61,847
Professional, Scientific, & Technical Svcs	$ 49,373	$ 74,354
Manufacturing	$ 47,173	$ 54,392
Medical Devices & Equipment	**$ 44,675**	**$ 63,606**
Construction	$ 44,031	$ 49,014
Information	$ 43,234	$ 70,780
Transportation & Warehousing	$ 37,165	$ 42,969
Total Private Sector	**$ 36,359**	**$ 45,229**
Health Care & Social Assistance	$ 35,641	$ 42,150
Real Estate	$ 33,436	$ 43,239
Agriculture, Forestry, Fishing & Hunting	$ 30,157	$ 25,982

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN

Iowa has made significant investments in its bioscience research infrastructure and achieved significant progress in growing its bioscience R&D base in specialized niche areas. Key accomplishments include:

- The University of Iowa's (UI) NIH Clinical and Translational Sciences Award (CTSA), which places UI's Institute for Clinical and Translational Science, and its consortium partners, among an elite cadre of 55 institutions designated to participate in this major NIH program to accelerate discoveries from bench to bedside.
- The ongoing development of the John and Mary Pappajohn Biomedical Discovery Building and the Pappajohn Biomedical Discovery Institute at UI.
- The development of the BioVenture building at the UI research park in Coralville—a major facility dedicated to the development and incubation of bioscience, biotechnology and biomedical companies.
- The growth of Iowa State University's Bioeconomy Institute, which now has 160 affiliated member faculty with over $51 million in cumulative sponsored grant funding from federal agencies and industry partners
- Creation in 2008 of the Biobased Industry Center at ISU which brings together research and education initiatives to address key issues for biobased industry and supply chain development.
- Development of the BioCentury Research Farm, the nation's first integrated research and demonstration farm devoted to biomass production and processing.

In addition, Iowa's Regent Universities have made significant strides in encouraging multi-disciplinary and inter-institutional collaborations, advancing support for faculty entrepreneurship and innovation commercialization, and expanding business incubation and science/research park assets and infrastructure.

Iowa's Bioscience Opportunities

In 2004, Battelle identified those areas of the biosciences, referred to as bioscience platforms, which appeared to offer the greatest opportunity for development. As part of this bioscience strategy update, Battelle revisited the bioscience technology platforms identified previously, assessed progress in growing the platforms, evaluated Iowa's R&D core competencies and further refined the technology platforms that appear to offer the most opportunity for future development. The Battelle analysis suggests that the following four technology platforms offer the greatest opportunity for development in Iowa:

Iowa's 2010 Bioscience Technology Platforms

- Bioeconomy Platform
- "One Health" Infectious Disease Platform
- Personalized Medicine Platform
- Advanced Foods Platform

- **Bioeconomy Platform.** Focuses on the use use of biomass as feedstocks for the production of a broad range of industrial products including fuels, chemicals, polymers and materials. This platform includes two primary subcomponents: 1) advanced biofuels development and 2) value-added biobased chemicals and materials.
- **"One Health" Infectious Diseases Platform.** Leveraging multi-institutional expertise across UI, ISU, the USDA and industry for tackling human and animal infectious diseases—in particular

vector-borne, zoonotic and reemerging infectious diseases. The opportunity here embraces the development of surveillance tools, technologies and models, diagnostics, vaccines, and therapeutic products.

- **Personalized Medicine Platform.** A development and commercialization platform for diagnostics, therapeutics and regenerative medicine tools and technologies using genomic information and stem cells for refined treatment of diseases (especially diseases in which Iowa has acknowledged basic and clinical science strengths—such as cardiovascular disease, cancer, ophthalmic diseases and disorders, and diabetes).
- **Advanced Food Products.** Using Iowa's multi-institutional established strengths in plant and animal sciences, production agriculture, food science, nutrition, and processing technologies to produce both functional foods and nutraceuticals.

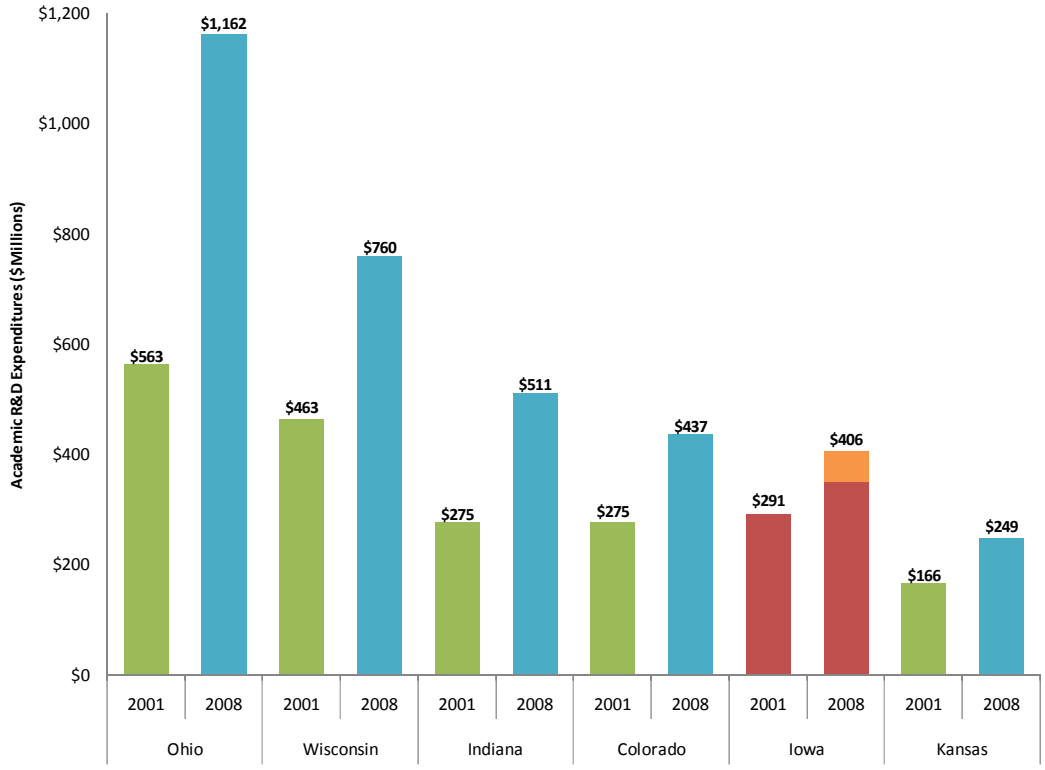
Iowa's Competitive Position in the Biosciences

Iowa has made significant progress in growing both its bioscience R&D base in specialized niche areas and its industry cluster. Indeed the state is well positioned to capitalize on rapidly expanding markets for advanced foods, personalized medicine and a wide range of bio-based products. But realizing the opportunities described above will require that Iowa maintain a competitive position in the biosciences and address any gaps in its bioscience infrastructure that exist. To maintain its competitive position, Iowa must ensure that the state has a robust bioscience R&D infrastructure, a significant pool of bioscience talent, and capital markets able to support bioscience companies through all stages of their development.

The 2004 report identified Iowa's strong academic bioscience R&D base as a key strength but it also identified actions to be taken to enable the R&D enterprise to continue to grow and to further support the development of the state's bioscience industry cluster. As discussed above, significant progress has been made in positioning the state's bioscience R&D infrastructure.

At the same time, however, the state's academic bioscience R&D base has not kept pace with growth at the national level. Between 2004 and 2008, academic bioscience R&D grew 13.8 percent in Iowa as compared to a 22.3 percent increase at the national level. Iowa's bioscience academic R&D expenditures totaled more than $450 million in FY 2008, but this is less than a number of peer and competitor states. See Figure ES-2. Iowa will need to continue to invest to expand its bioscience R&D enterprise in order to remain, not only nationally but globally competitive.

Figure ES-2: Academic R&D Expenditures in Iowa & the Benchmarks, FY 2001, FY2008



Source: NSF Survey of Research and Development Expenditures at Universities and Colleges. Calculations for Iowa Academic R&D include $55 million from the University of Iowa that was not included in NSF data due to reporting differences.

With regard to talent, Iowa's bioscience executives suggested that Iowa's workforce is both a strength and a challenge. Iowans have a strong work ethic and are excellent workers. But finding more senior talent can be a challenge and firms often have to recruit people willing to relocate to Iowa. Some company representatives, particularly those located in more rural areas, expressed serious concerns about meeting their future workforce needs in Iowa. It is clear that Iowa must consider ways to develop, recruit and retain bioscience talent.

Lack of available capital for bioscience firms was identified as a key challenge facing Iowa in 2004. In 2006, the legislature provided $8.2 million to fund projects at the Regent Universities designed to build research capacity around the bioscience technology platforms identified in the 2004 strategy. The funds were used to support proof-of-concept activities. The universities report that these funds were very beneficial and helped to support faculty entrepreneurship and commercialization but the dollars dedicated to this activity were limited and are no longer available. A number of initiatives were taken to address the need for seed and venture capital, including creation of the Iowa Fund of Funds and implementation of an angel investor credit and a credit for investing in seed funds.

Unfortunately, some of the initiatives put in place to address the need for early-stage capital are no longer available. In 2009, the legislature reduced the tax credit authorization for the Iowa Fund of Funds to $60 million, and eliminated the angel investor and seed capital tax credits. Access to early-stage capital remains a challenge for Iowa's bioscience companies and entrepreneurs.

Realizing Iowa's Bioscience Potential

Iowa's public and private leadership has developed the following Vision for Iowa's bioscience future.

> ***By 2020, Iowa's bioscience industry is a key driver of the state's economy, providing high-wage jobs and a high quality of life for its citizens. Iowa has a robust cluster of companies and a highly talented workforce that are developing innovative products that provide nutritious and healthy foods, renewable sources of energy, sustainable and environmentally-friendly products and medical innovations that promote wellness and health care.***

Four strategies are proposed to achieve Iowa's vision of having a very robust bioscience industry cluster.

- **Strategy One:** Invest aggressively to build Iowa's bioscience R&D enterprise around the state's key bioscience platforms and incentivize commercialization of bioscience discoveries in Iowa
- **Strategy Two:** Build Iowa's Risk Capital Market
- **Strategy Three:** Develop Iowa's Bioscience Talent Pool
- **Strategy Four:** Create a business climate that is supportive of bioscience firm growth and expansion

The strategies and the actions proposed to achieve them are listed in Table ES-2. Each action is discussed in more detail in the full report.

Table ES-2: Proposed Bioscience Strategies and Actions

	Strategy	Action
STRATEGY 1	*Invest aggressively to build Iowa's bioscience R&D enterprise around the state's key bioscience platforms and incentivize commercialization of bioscience discoveries in Iowa*	Action 1: Provide adequate resources to Iowa's universities to enable them to recruit and retain bioscience faculty and invest in bioscience R&D infrastructure
		Action 2: Continue to streamline technology transfer processes and incentivize the state's research institutions to increase support for technology transfer and commercialization
		Action 3: Provide funding for assessing the commercial potential of university-developed technologies and advancing those judged to have commercial potential
		Action 4: Create a university/industry matching grant program
		Action 5: Hold technology partnering events to showcase university-developed IP that is available for commercialization
STRATEGY 2	*Build Iowa's Risk Capital Market*	Action 6: Enact legislation reinstating the angel investor and seed capital tax credits
		Action 7: Create a state-funded but privately-managed bioscience seed fund
		Action 8: Undertake an aggressive SBIR outreach and technical assistance effort and provide matching funds for Phase I awards
		Action 9: Continue and enhance the Demonstration Fund
STRATEGY 3	*Develop Iowa's Bioscience Talent Pool*	Action 10: Continue and expand efforts to improve STEM education
		Action 11: Increase student awareness of local bioscience opportunities through internships and other activities that expose students to Iowa's bioscience industry
		Action 12: Initiate an effort to identify and address bioscience workforce education and training needs
STRATEGY 4	*Create a business climate that is supportive of bioscience firm growth and expansion*	Action 13: Review and refine Iowa's economic development programs to focus on innovation and high value-added industry growth
		Action 14: Better market and support Iowa's entrepreneurial support initiatives
		Action 15: Provide in-depth support to bioscience entrepreneurs and start-up companies
		Action 16: Enhance and extend the R&D Tax Credit

Conclusion

Iowa has made progress on many fronts in growing its bioscience cluster. Bioscience employment has been growing rapidly outpacing growth at the national level and Iowa is a national leader in the agricultural biosciences. In addition, the state has an emerging presence in research, testing and medical labs and in drugs and pharmaceuticals. Significant progress has also been made in advancing the state's biomedical and agbioscience-related technology R&D platforms. While these are positive developments, it also must be acknowledged that gaps remain in Iowa's bioscience infrastructure. Iowa has limited sources of investment capital and bioscience firms struggle to find top management talent. It is time to reassess the state's approach to advancing bioscience development and recommit to investing the resources that will be needed to make Iowa a leader in the biosciences.

Achieving Iowa's Bioscience Vision will require strong leadership and long-term commitment on the part of Iowa's research and higher education institutions, business community, economic development organizations, and state and local governments. Iowa must commit to

- Invest in its research and industry base to achieve world-class leadership in targeted bioscience fields.
- Accelerate the commercialization of research discoveries to benefit the growth and expansion of existing and formation of new businesses and jobs.
- Create a culture that supports and encourages entrepreneurship and new firm creation by nurturing talent, fostering capital formation and forging public/private partnerships.

Looking forward, the biosciences offer enormous potential for linking basic research innovations with new market opportunities. Iowa can seize the opportunities presented by the biosciences and build an industry that will not only benefit economic development but also improve the health and well-being of both Iowans and the global community.


PASS BOX

Introduction

Iowa's public and private sector leaders recognized as early as 2001 that the biosciences represented an area of economic opportunity for the state. In 2004, the Iowa Department of Economic Development (IDED) commissioned a strategic roadmap that outlined a comprehensive approach to growing the state's bioscience industry cluster. The roadmap called for

- Investing in the further development of the state's bioscience research and development (R&D) platforms at Iowa's regent universities
- Putting in place incentives, programs and organizations to facilitate and accelerate the translation of bioscience innovation into commercial products and processes and the creation of new companies
- Expanding sources of capital to provide the financial resources to move innovative technology from the research bench to commercialization and allowing bioscience companies to grow and expand in Iowa
- Creating an educational, economic and social environment that would create, attract and retain bioscience talent.

It has been 10 years since Iowa first targeted the bioscience industry for development, six years since the state's bioscience roadmap was adopted, and much has changed in terms of the development and evolution of the bioscience sector. Major advancements have taken place on a host of fronts, ranging from high-precision personalized human biomedical applications to widespread biomass-based innovations in agbioscience, bioenergy, and industrial biotechnology. The biosciences today are a key engine of economic growth in the U.S., with the industry supporting 8 million jobs, taking into account the additional jobs created in the economy as a result of the sector's direct jobs.

Recognizing the opportunities provided by this sector, numerous states, regions, and countries have targeted this sector for development and are making very significant investments designed to build bioscience R&D capacity, accelerate commercialization of bioscience discoveries, and create, attract and grow bioscience companies. States that are already considered leaders, such as Maryland and Massachusetts, are continuing to invest in their bioscience infrastructure. Other states, such as Kansas and Ohio, are committed to diversifying their economies by developing a robust bioscience industry cluster. (See text box). It is therefore appropriate, that Iowa take stock of its position in the biosciences and chart a path for continued growth of this industry.

Examples of State Investments in Bioscience Development

The **Kansas Bioscience Authority (KBA)** was created in 2004 and is funded by a percentage of the increases in state taxes paid by bioscience companies, a mechanism expected to raise $500 – $600 million over ten years. The Authority offers a comprehensive set of programs designed to attract and grow bioscience companies.

Maryland's BIO 2020 Initiative is a commitment to invest $1.1 billion to support the state's life-science industry over a 10-year period. The Maryland Biotechnology Center, designed to serve as a one-stop center for linking bioscience companies with a variety of services and programs, opened in 2009.

Massachusetts enacted its Life Science Initiative, a commitment of approximately $1 billion over 10 years, in 2007. The state offered $25 million in tax credits for life science companies and provided $15 million for its Life Science Investment Fund, which makes investment to stimulate bioscience R&D in FY 2009. Another $15 million was appropriated for the Life Sciences Infrastructure Fund.

Ohio's Third Frontier is a $2.3 billion initiative launched in 2002 aimed at growing the state's technology industry sectors, including the biosciences. OTF includes a comprehensive set of programs aimed at building research and development excellence, recruiting world-class researchers, increasing access to early-stage risk capital, encouraging and supporting entrepreneurs and start-up companies, and accelerating commercialization by facilitating collaborative partnerships between companies and research institutions.

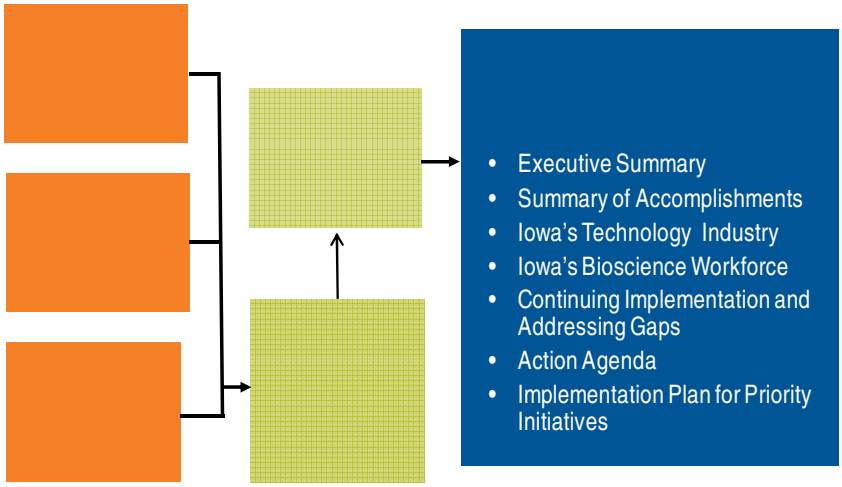
Innovate Iowa, a public/private partnership that includes senior leaders from industry, academia and other organizations interested in growing Iowa's economy and at the same time advancing medical innovation in the state, has taken responsibility for updating the state's Bioscience Roadmap. Innovate Iowa engaged Battelle's Technology Partnership Practice (TPP) to assist in this effort. TPP, which served as a consultant to IDED to develop the original roadmap, is the economic development consulting arm of Battelle, the world's largest, nonprofit independent research and development organization. Battelle is recognized worldwide for technology-based economic development of industry/government/university partnerships. TPP, which includes leading analysts and practitioners in technology-based economic development, helps clients develop, implement and evaluate technology strategies, policies, and programs. TPP has worked with numerous states and regions in the U.S. and internationally on the design of programs and policies to support bioscience industry and biomedical development. Battelle also produces a biennial report on State Bioscience Initiatives, which tracks bioscience employment and other bioscience performance metrics on a state-by-state and metropolitan basis and also tracks trends in state bioscience policies and programs.

This Roadmap was developed with guidance and input from a project steering committee that included representatives of Iowa's bioscience companies, research universities and community colleges, state government, and business and economic development organizations. Every effort was made to obtain

as much input as possible from the state's bioscience community. Battelle conducted approximately 75 interviews and the Iowa Biotechnology Association arranged two focus group meetings held in Des Moines and Cedar Rapids.

The Battelle team assessed the progress that has been made since the original strategy was developed, identified areas that still need to be addressed to fully realize the potential of the biosciences in Iowa, worked with the committee to develop a vision and mission statement, and recommended a set of strategies and actions to be taken to continue and accelerate bioscience development in Iowa. Figure 1 displays the project methodology.

Figure 1: Project Methodology for Developing the Iowa Bioscience Strategy.



This report

- Identifies key accomplishments that have been achieved in growing Iowa's bioscience base during the last 5 years
- Reviews Iowa's competitive position in the biosciences and identifies gaps in policies and programs that need to be addressed if Iowa is to continue to grow its bioscience industry cluster
- Identifies the specific bioscience technology areas, referred to as "platforms," that offer the greatest opportunity for Iowa moving forward
- Presents a set of strategies and actions for addressing gaps and capitalizing on opportunities.

Iowa's Bioscience Industry Cluster

In 2004, Battelle conducted an economic analysis that identified the level of bioscience activity in Iowa. Battelle updated this analysis examining employment, establishment, and wage data for both the overall bioscience sector and for four industry subsectors. A series of methodological techniques, including location-quotient analysis, were used to assess the performance of the region's bioscience cluster. Location quotients are a standard measure of the concentration of a particular industry in a region relative to the nation. Battelle also examined the impact of the recession on Iowa's bioscience economy to the extent data were available.

The analysis revealed that **Iowa is home to a well-concentrated, sizable, and rapidly growing bioscience sector, and is a national leader in the agricultural biosciences**. Amidst the severe recession, the state continued to advance the industry with strong growth in 2008 across three of its four major subsectors. Growth in the state bioscience sector accelerated in 2005, about the time the first bioscience roadmap was adopted and has continued to outpace growth of the bioscience sector at the national level. The findings from the economic analysis are presented below.

Defining the Biosciences

As an industry, the biosciences are constantly evolving and broadening in scope which makes it difficult to define under existing federal industry classifications. To encompass the range of relevant private sector life science activity in the U.S., many detailed industries must be combined. Battelle has assisted many states and local areas throughout the U.S. in identifying and developing their bioscience industry base. After years of research and field work, Battelle has identified four major subsectors that engage in core bioscience activity. These subsectors and their definitions have been adopted by the Biotechnology Industry Organization (BIO) in the biennial Battelle/BIO national bioscience sector reports.[4] The four primary subsectors are described below.

- **Agricultural Feedstock and Chemicals**. This subsector applies life sciences knowledge and biotechnologies to the processing of agricultural goods and production of organic and agricultural chemicals. The subsector includes the emerging activity around the production of biofuels. Product examples include: ethanol, fertilizers, pesticides, sustainable lubricants and oils, and food and feed additives.
- **Drugs and Pharmaceuticals**. The subsector produces commercially available medicinal and diagnostic substances. Firms are generally large and multinational and are heavily engaged in R&D activities to bring drugs to market. Product examples include: vaccines; oncology, neurology, and cardiology treatments; tissue and cell culture media; herbal supplements; and diagnostic substances.
- **Medical Devices and Equipment**. Firms in this subsector produce biomedical instruments and other health care products and supplies for diagnostics, surgery, patient care, and laboratories. The subsector has integrated advanced electronics and information technologies to improve and automate testing and patient care capabilities. Product examples include: bioimaging

equipment; orthopedic and prosthetic implants and devices; walkers, wheelchairs, and beds; dental instruments and orthodontics; laser eye surgery equipment; defibrillators (AEDs); and stents and other implantable devices.

- **Research, Testing, and Medical Laboratories**. The subsector includes a range of activities, from highly research-oriented companies developing and commercializing new drug discovery/delivery systems, to more service-oriented medical or other testing firms. Product examples include: functional genomics and drug discovery techniques; diagnostic testing; preclinical drug development; biomarkers; nanoscale drug delivery systems; and research models and laboratory support services.

An important element of the bioscience industry, the research conducted at academic health centers, research hospitals, and other research-driven institutions might be considered a fifth bioscience subsector but unfortunately this component cannot be isolated from the overall hospital sector. Ideally, one would separate out and include those research centers in order to identify only the life sciences R&D that occurred within those establishments. Unfortunately, there are not reliable ways in which to isolate these components from the three existing hospital NAICS industries that are dominated by health services.

Measurement Challenges: Seed and Hybrid Seed Testing and R&D, a Related Industry

Highly related to multiple bioscience industries included in this analysis and highly relevant to Iowa's current and historical strengths in the agbiosciences is the NAICS industry "Farm Supplies Merchant Wholesalers." While agricultural research and development activities are included in the Battelle bioscience industry definition within the R&D NAICS codes and related seed testing is sometimes found within testing laboratories (also in the Battelle definition), evidence reveals that when an individual establishment is engaged not only in seed-related R&D or testing *as well as* wholesale shipping of seeds, it is often coded within this broad farm wholesale classification.

Similar to the issue relating to academic and research hospitals, there is no reliable method by which to isolate and estimate this seed R&D activity within the broader industry that also includes the wholesaling of agricultural chemicals, livestock feeds, flower bulbs, hay, mulch, and other non-equipment farm supplies.

In 2008, data from the BLS, QCEW program show Iowa farm supplies wholesalers employed 9,977 across 731 establishments, clearly a large industry and one in which Iowa has an extremely high specialization with a LQ of 8.31. The hybrid seed R&D activity within this industry, though it cannot be accurately measured without access to underlying QCEW microdata files, is critical to the Iowa and U.S. bioscience sectors and must be acknowledged.

Iowa's Bioscience Industry: Overview and Key Trends

Iowa has a sizable and rapidly growing bioscience industry sector. In 2008, Iowa's bioscience industry employed 14,494 across 525 individual business establishments (Table 1).[5] The sector is sizable, and has grown by just over 3,000 jobs since 2001 with three of the four major industry subsectors contributing job growth between 2001 and 2008. Battelle's national report for BIO found Iowa stands in the middle quintile among state bioscience industries in employment, ranking 26th among all states and Puerto Rico (compared with 30th in overall state population rank).[6]

Iowa's location quotient in the industry, a metric used to gauge the relative concentration of bioscience jobs in the state relative to the nation, is just below the national average. A regional LQ greater than 1.0 is said to have a greater concentration than the national average. When the LQ is significantly above average, 1.20 or greater, the region is said to have a "*specialization*" in the industry. In 2008, Iowa continued to approach the key 1.0 threshold with a LQ of 0.93 in the biosciences or a concentration of jobs in the biosciences just 7 percent below the national average. Though not yet considered to be specialized overall, this concentration places Iowa 19th (2nd quintile) among all states and Puerto Rico for 2008.

Iowa is a highly specialized leader in agricultural feedstock and chemicals, with a LQ in the subsector of 5.99 indicating an extremely high concentration of jobs compared with the U.S. as a whole. In fact, in Battelle's 2010 report for BIO, this LQ was highest among all states and Puerto Rico in the subsector. Though not specialized in their concentration, other state subsectors are clearly emerging with strong recent job growth. Each of the four major subsectors and its underlying industry niches and drivers is discussed in more detail later in this analysis.

Table 1: Iowa and U.S. Bioscience Employment Metrics, 2008

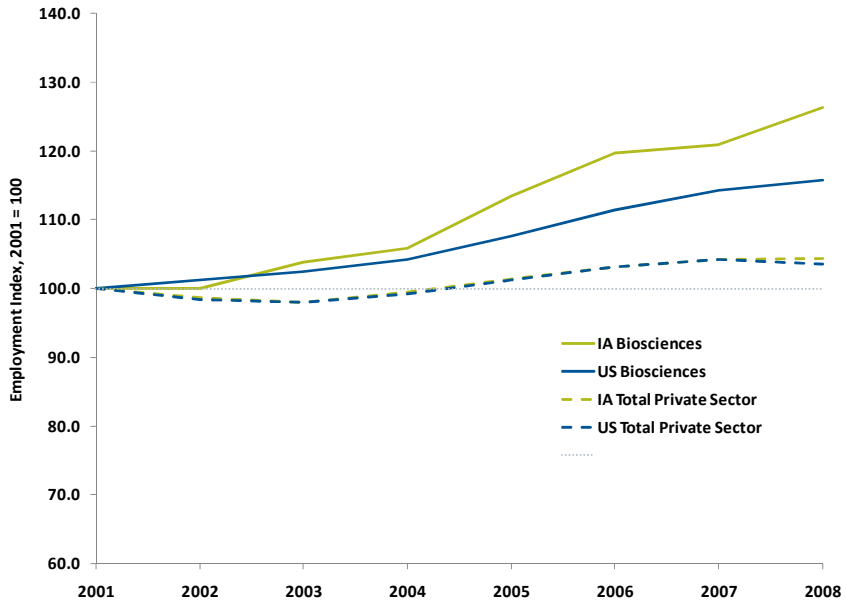
Bioscience Subsector	2008 Estab.	Percent Change Estab, '01-08	2008 Employment	Percent Change Empl, '01-08	Percent Change Empl, '07-08	2008 Location Quotient
Iowa						
Total Private Sector	**88,134**	**3.2%**	**1,254,655**	**4.4%**	**0.2%**	**n/a**
Agricultural Feedstock & Chemicals	144	43.4%	7,568	31.3%	5.7%	5.99
Drugs & Pharmaceuticals	42	0.0%	2,793	16.6%	-1.1%	0.81
Medical Devices & Equipment	137	-0.3%	1,885	-2.0%	3.4%	0.39
Research, Testing, & Medical Labs	202	21.4%	2,248	61.7%	8.7%	0.37
Total Biosciences	**525**	**17.6%**	**14,494**	**26.3%**	**4.5%**	**0.93**
United States						
Total Private Sector	**8,860,956**	**13.8%**	**113,917,377**	**3.5%**	**-0.7%**	**n/a**
Agricultural Feedstock & Chemicals	2,440	16.0%	114,793	1.9%	4.6%	n/a
Drugs & Pharmaceuticals	2,771	6.4%	311,882	2.3%	-2.3%	n/a
Medical Devices & Equipment	15,227	0.4%	435,509	2.0%	2.4%	n/a
Research, Testing, & Medical Labs	27,154	57.7%	558,140	46.1%	2.1%	n/a
Total Biosciences	**47,593**	**28.3%**	**1,420,324**	**15.8%**	**1.4%**	**n/a**

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

The bioscience industry remained resilient even through the first year of the recent recession. While national private sector jobs declined and unemployment rates rose, the biosciences continued to create jobs, particularly in Iowa. Table 1 presents employment changes not only for the full 2001 through 2008 period, but also for 2007-08, isolating job trends over the first year of the recession. While national private sector payrolls declined (down 0.7 percent) and were essentially flat in Iowa (up 0.2 percent), the biosciences continued to add jobs. The national sector increased its job base by 1.4 percent and in Iowa, the rate was even greater, increasing by 4.5 percent over the year. Similar to the national experience, three of four subsectors grew in 2008 and only in drugs and pharmaceuticals was there a decline. While final 2009 data for detailed industries are not yet available, this shows the industry maintained momentum heading into the severe economic downturn and amidst very difficult labor market conditions.

Figure 2 shows indexed employment trends for 2001 through 2008 for both the Iowa and national bioscience industry and the overall private sector for comparison.

Figure 2: Iowa and U.S. Bioscience and Total Private Sector Employment Trends, 2001–08 (Index, 2001=100)



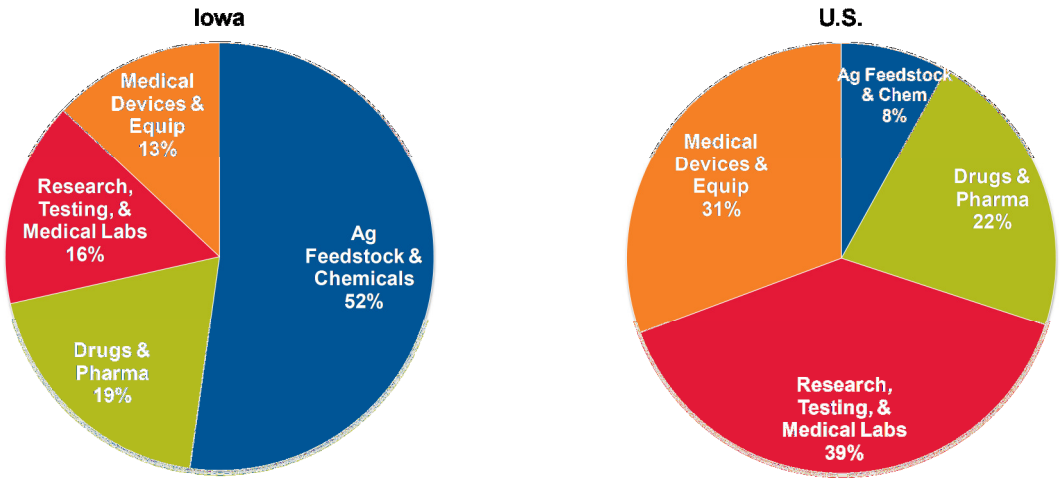
Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

Iowa has experienced strong growth in the biosciences relative to its own private sector and the U.S. Key recent trends in Iowa include:

- Since 2001, the state industry has grown its job base by 26.3 percent or more than one and a half times the national growth rate (15.8 percent).
- Iowa outpaced U.S. growth in three of four bioscience subsectors since 2001 and during the first year of the recession.
- While its private sector closely tracked that of the U.S., growth in the state's bioscience sector accelerated in 2005 and has generally continued its strong growth since.

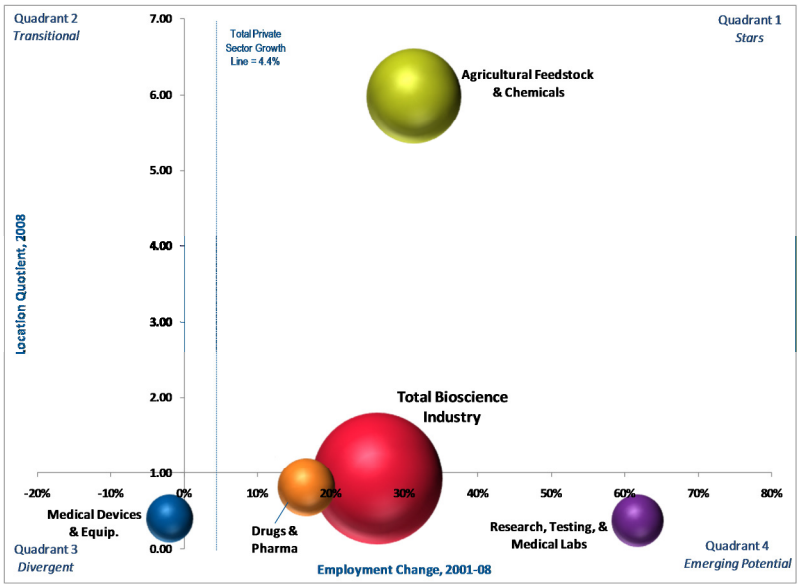
Iowa has a definite presence in each of the four subsectors, though its large and leading agricultural bioscience subsector dominates, comprising more than one in two Iowa bioscience jobs. The pie charts below show the composition of Iowa bioscience industry employment in 2008 compared with the national sector.

Figure 3: Employment Composition of the Bioscience Industry in Iowa and the U.S., 2008



To truly understand the industry in Iowa and its current position and recent trends, it is important to carefully examine each of the major subsectors as well as their underlying niche industry strengths and emerging trends. The bubble chart (Figure 4) begins by visually presenting the current position of each subsector relative to the others, then each subsector is examined in turn in more detail. A bubble chart is useful in mapping the subsectors and overall bioscience industry across three key employment variables—employment size (size of bubble), relative employment concentration (LQ), and recent employment growth (2001 through 2008).

Figure 4: Iowa Bioscience Subsectors—Degree of Specialization, Job Growth, and Size, 2008



Immediately evident from Figure 4 is the fact that all but one of the state's industry subsectors in this case, are to the right of the vertical axis, indicating job growth for each of these subsectors since 2001. Also made clear is their position to the right of the vertical blue line which indicates the growth position of Iowa's overall private sector during this same period. While agricultural feedstock and chemicals is the only highly specialized subsector and well up the vertical axis (LQ), it is clear that these growth industries are emerging and heading in the right direction. Medical devices and equipment is the only subsector that experienced a slight decline in employment (-2.0 percent) during this period.

Agricultural Feedstock and Chemicals

Reflecting Iowa's traditional strengths and specializations in agriculture, the state's leading agricultural feedstock and chemicals subsector of the biosciences is its largest and most specialized. The state subsector, often referred to as the "agbiosciences," spans 144 establishments employing more than 7,500. The industry is highly specialized in its concentration of state jobs, and is in fact the nation's most concentrated at 6 times the U.S. average relative to its overall private sector.

Since 2001, Iowa agbioscience companies have increased employment by 1,800 jobs or 31 percent. Much of the growth has occurred since 2004 after the subsector shed jobs in 2002 and had slower growth in 2003 and 2004.

The average size of Iowa agbioscience establishments, with 53 employees per location, is larger than those typically found in the U.S. (47 jobs per establishment sector-wide) and reflects the footprint of large, multinational agricultural biotech companies. These include Monsanto, Pioneer, Cargill, Syngenta, and Kemin industries. With commercial and research activities in agricultural chemicals, seed testing and R&D, as well as primary production, processing, and biofuels, these companies and their individual establishments span multiple bioscience subsectors including agricultural feedstock and chemicals as well as research and testing. Most of their operations, however, do fall within the agbiosciences subsector.

In Iowa, there are several key components of the agricultural feedstock and chemicals subsector. Those driving the subsector are *large* (400 or more jobs) and regionally *specialized* (LQ greater than or equal to 1.20):

Detailed Industry Component	Employment, 2008	Location Quotient, 2008	Employment Growth, 2001–08
Wet Corn Milling	3,279	35.24	7.2%
Ethanol Mfg	1,308	12.85	18402.5%
Soybean Processing	1,100	8.74	0.8%
Pesticide & Other Ag Chemical Mfg	687	4.21	-8.6%
Nitrogenous Fertilizer Mfg	549	7.11	6.6%
All Other Basic Organic Chemical Mfg	471	1.20	172.2%

Among these six large and specialized industries in Iowa, all but one (pesticides) have grown, with two truly emerging as key drivers. Ethanol and biofuels production has emerged from virtually no presence

in the early 2000s to more than 1,300 direct jobs in 2008 and a highly specialized concentration in the state with its focus on corn production as a primary feedstock. The "all other basic organic chemicals" industry has emerged in recent years and includes those companies engaged in the production of sustainable industrial oils and lubricants, biocatalysts, and other organic chemicals.

Drugs and Pharmaceuticals

Iowa's drugs and pharmaceuticals subsector is mid-sized and grew during the economic expansion that lasted through 2007 before experiencing a modest job loss as the recession took hold in 2008. Currently, the subsector employs nearly 2,800 in Iowa across 42 individual business establishments. Its LQ is 0.81 in 2008 or about 20 percent below the national average concentration of pharmaceutical jobs.

Iowa's major niche strength and specialization within drugs and pharmaceuticals is in the production of biologics and appears to be driven by a focus in animal health and therapeutics. This detailed industry is the subsector's largest with more than 1,000 jobs and a LQ of 3.78. Over the 2001-08 period, this industry shed about 100 jobs or 9.1 percent while the nation saw an 8.5 percent gain over this same period.

Iowa's large and specialized detailed industry components of drugs and pharmaceuticals reveal specific niches that drive its subsector and differ from those typically seen in large drugs-producing regions that largely focus on pharmaceutical preparations.

Detailed Industry Component	Employment, 2008	Location Quotient, 2008	Employment Growth, 2001–08
Biological Product (except Diagnostic) Mfg	1,085	3.78	-9.1%
Medicinal & Botanical Mfg	557	2.17	81.8%

Boehringer Ingelhiem develops vaccines and prescription medications for both pets and livestock. Example products include swine flu vaccines, cattle reproductive and respiratory management products.

Research, Testing, and Medical Laboratories

Businesses engaged in the biosciences are driven by scientific advances, innovation, and cutting-edge technologies and rely heavily on investments and successes in R&D. Within the biosciences industry, biotechnology and other R&D focused companies represent a critical component of the industry. The research, testing, and medical labs subsector of the biosciences includes this key component sector as well as the research and testing conducted in medical and other life sciences testing laboratories.

Iowa, like the nation as a whole, has seen strong growth in this subsector during both the last full business cycle and through the first year of the recession. The state added nearly 49 percent to its modest job base over the 2001–07 period (the full business cycle) and despite the recession in 2008, added 8.7 percent to its employment base that year. Nationally, the subsector has driven the overall employment growth in the biosciences with large gains during both the economic expansion (up 43 percent) and in the first year of the recession (up 2.1 percent).

In Iowa, research, testing, and medical lab firms employ more than 2,200 across 202 business establishments. While the subsector has been gaining jobs, it remains modest in size compared with other states and its concentration is well below the national average with a LQ of just 0.37 in 2008.

While none of the individual detailed component industries within Iowa's research, testing, and medical labs subsector are considered to be specialized in their concentration, each component has contributed to job growth since 2001. The state subsector is generally evenly split in its composition of jobs in R&D (48 percent) and those within medical labs and diagnostic imaging centers (52 percent). This differs from the national sector somewhat where strong recent growth in the R&D component has resulted in a 60 percent share of jobs within the larger subsector.

Medical Devices and Equipment

Medical device manufacturing represents a modest-sized subsector of Iowa's bioscience industry with almost 1,900 jobs and spanning 137 state establishments. Its location quotient is 0.39 in 2008. Employment in Iowa medical device companies was generally flat during the early 2000s then saw some gains before declining in 2007. Much like the national sector, state medical device jobs declined, on net, over the full business cycle from 2001-07 before experiencing a modest job gain in the first year of the recession—increasing by 3.4 percent in Iowa and by 2.4 percent in the U.S. overall.

Though none of the individual component industries in the state's medical device subsector have a specialized location quotient, two of the industries are large and growing with more than 500 jobs—surgical appliances and supplies (530 jobs; up 64 percent since 2001); and dental labs (509 jobs; up 3 percent since 2001).

Bioscience Wages

Bioscience industry wages for Iowa are presented in the following table and provide insight into the relative supply of and demand for workers in the industry and its subsector components. Relative to other industries and the overall private sector, the biosciences pay well with a wage premium paid to Iowa's bioscience workers that is more than $24,000 or 67 percent above that paid, on average, in the Iowa private sector—$60,833 versus $36,359. This premium is similar to that observed nationally, where bioscience workers out-earn their counterparts in the overall private sector by more than $32,000 or 72 percent.

Table 2. Average Annual Wages for Iowa and the U.S., Biosciences vs. Other Major Industries, 2008

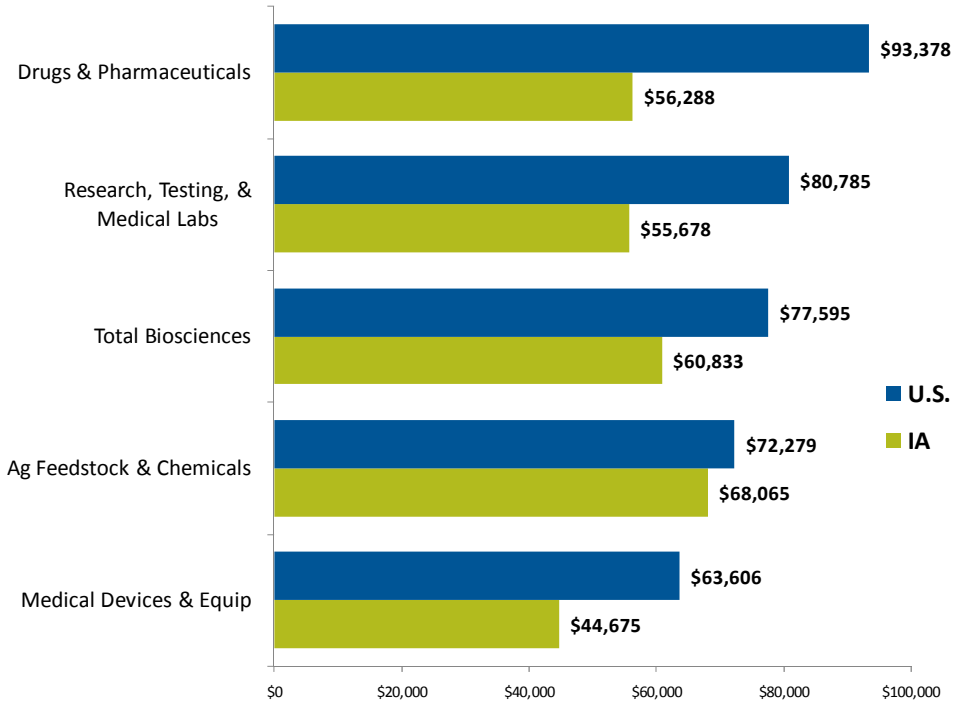
Industry	Average Annual Wages, 2008	
	Iowa	United States
Agricultural Feedstock & Chemicals	**$ 68,065**	**$ 72,279**
Management of Companies & Enterprises	$ 66,265	$ 94,842
Total Biosciences	**$ 60,833**	**$ 77,595**
Finance & Insurance	$ 56,653	$ 85,274
Drugs & Pharmaceuticals	**$ 56,288**	**$ 93,378**
Research, Testing, & Medical Labs	**$ 55,678**	**$ 80,785**
Wholesale Trade	$ 49,623	$ 61,847
Professional, Scientific, & Technical Svcs	$ 49,373	$ 74,354
Manufacturing	$ 47,173	$ 54,392
Medical Devices & Equipment	**$ 44,675**	**$ 63,606**
Construction	$ 44,031	$ 49,014
Information	$ 43,234	$ 70,780
Transportation & Warehousing	$ 37,165	$ 42,969
Total Private Sector	**$ 36,359**	**$ 45,229**
Health Care & Social Assistance	$ 35,641	$ 42,150
Real Estate	$ 33,436	$ 43,239
Agriculture, Forestry, Fishing & Hunting	$ 30,157	$ 25,982

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

Wage premiums in the biosciences reflect a greater degree of value-adding activities relative to other major industries. In addition, a knowledge-based industry like the biosciences requires high-skilled workers whose higher wage requirements reflect the greater value of their education and skills in the labor market. And while this holds true relative to other industries, even within the biosciences, wages across states and regions can vary considerably based on the occupational and industry composition or mix within each. Iowa's niche strengths in agricultural feedstock and chemicals result in the highest average wages across the four major subsectors whereas nationally, drugs and pharmaceuticals workers earn the most, on average.

Iowa's bioscience workers earn about 28 percent less, on average, compared with their industry counterparts nationally (see Figure 5). While part of this wage differential can be explained by Iowa's position as a relatively low-cost place to conduct business and to live, much of it can also be explained by the composition of the state industry relative to the U.S. Specifically, the national sector is much more concentrated in drugs and pharmaceuticals and in high-value biotech R&D that not only produce significantly more in terms of value-added economic output compared with the other subsectors, but in turn pay higher wages.

Figure 5. Average Annual Wages in the Biosciences, Iowa vs. U.S., 2008



Iowa's Competitive Position in Bioscience Industry Development

The previous section focused on Iowa's bioscience industry and its current employment position and recent trends compared with the U.S. In this section, the state is compared with a set of five benchmark or comparison states viewed as peers and/or as targets to aspire to in the biosciences. These comparison states include:

- Colorado
- Indiana
- Kansas
- Ohio
- Wisconsin

Bubble charts are used to provide industry employment snapshot comparisons of these states relative to Iowa across each of the major bioscience subsectors. Table 3 presents a summary of comparative industry statistics that underlie the charts.

Table 3. Bioscience Industry Employment Metrics, Iowa and Comparison States, 2008

Employment Metric	KS	IA	CO	WI	OH	IN
Employment, 2008:						
Agricultural Feedstock & Chemicals	1,682	7,568	440	2,951	6,836	5,134
Drugs & Pharmaceuticals	2,239	2,793	3,051	3,489	5,105	18,822
Medical Devices & Equipment	1,877	1,885	9,988	11,800	11,633	20,868
Research, Testing, & Medical Labs	6,162	2,248	7,789	6,454	12,876	8,008
Total Biosciences	**11,960**	**14,494**	**21,268**	**24,694**	**36,450**	**52,832**
Location Quotient, 2008:						
Agricultural Feedstock & Chemicals	**1.49**	**5.99**	0.22	**1.23**	**1.51**	**2.07**
Drugs & Pharmaceuticals	0.73	0.81	0.57	0.53	0.42	**2.79**
Medical Devices & Equipment	0.44	0.39	**1.34**	**1.29**	0.68	**2.22**
Research, Testing, & Medical Labs	1.12	0.37	0.82	0.55	0.59	0.66
Total Biosciences	**0.86**	**0.93**	**0.88**	**0.83**	**0.65**	**1.72**
Employment Growth, 2001-08:						
Agricultural Feedstock & Chemicals	-6.0%	31.3%	2.8%	41.8%	-2.1%	-3.0%
Drugs & Pharmaceuticals	120.2%	16.6%	3.6%	34.0%	16.5%	1.5%
Medical Devices & Equipment	-26.1%	-2.0%	13.3%	-7.8%	-14.7%	42.2%
Research, Testing, & Medical Labs	54.4%	61.7%	64.4%	68.1%	92.1%	21.6%
Total Biosciences	**28.1%**	**26.3%**	**25.7%**	**15.8%**	**15.0%**	**17.2%**

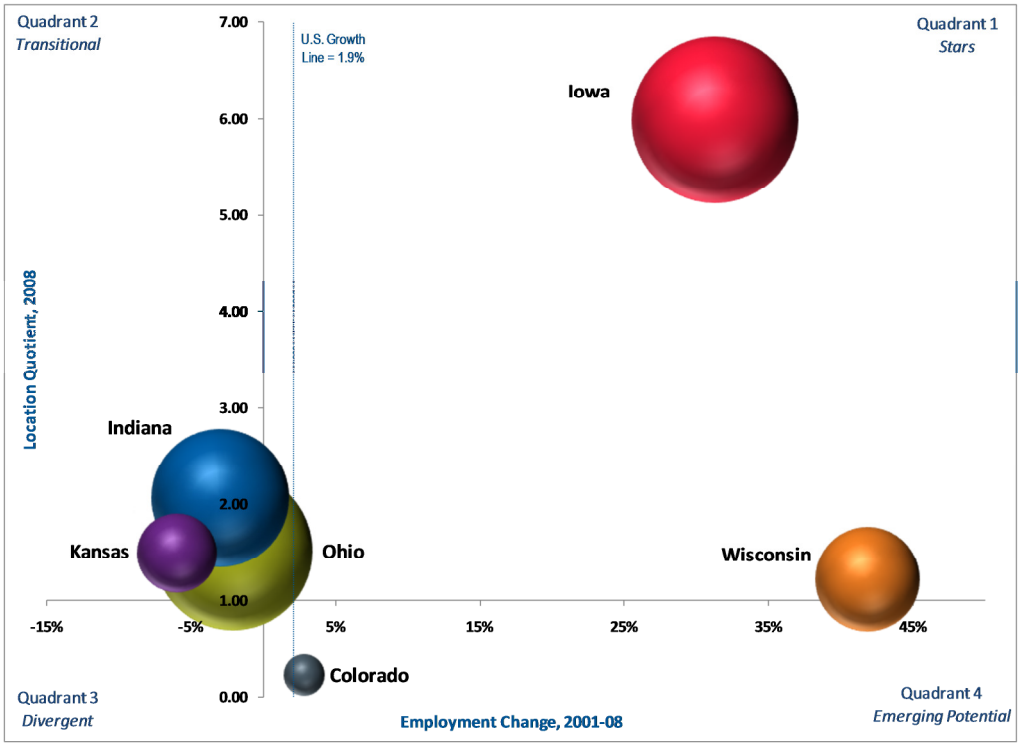
Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

Iowa's leading subsector, **agricultural feedstock and chemicals**, clearly is large, highly specialized, and leading relative to the comparison states (Figure 6). Iowa has outpaced all but Wisconsin in terms of recent employment growth in the subsector. More than any of the four subsectors, the agbiosciences represent a specialization for nearly all of the Midwestern states analyzed here—Iowa and four of the five comparison states have a specialized employment concentration in the subsector.

After Iowa, Ohio and Indiana have the largest and most specialized subsectors—Ohio with more than 6,800 jobs and Indiana with just over 5,100. Despite this, both Ohio and Indiana have shed jobs in the agbiosciences since 2001. Another state with a specialized concentration, Kansas, has also seen its jobs base decline.

Like Iowa, Wisconsin has a specialized and growing agricultural feedstock and chemicals subsector.

Figure 6. Agricultural Feedstock and Chemicals Subsector, Iowa and Comparison States, 2008

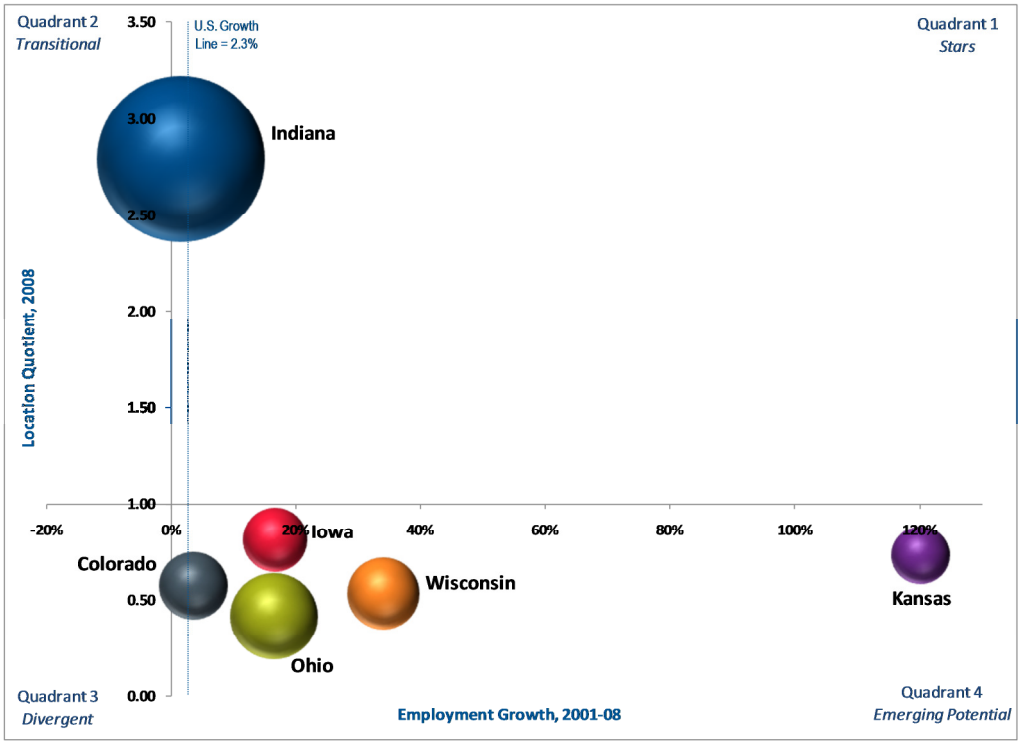


In **drugs and pharmaceuticals**, just one of the comparison states can be considered to have a large and specialized subsector—Indiana. Indiana pharmaceutical firms employ nearly 19,000 or nearly 14,000 more jobs than Ohio, the next closest state in terms of overall size. While Indiana did not outpace overall U.S. job growth in drugs and pharmaceuticals during the 2001-08 period (up 2.3 percent), the state did grow its sector by 1.5 percent (Figure 7).

In fact, Iowa and each of the 5 benchmark states had net employment growth over the 7-year period in the subsector. Though its job base is modest in size, Kansas outgrew the other states by more than doubling its pharmaceuticals jobs during this period to over 2,200 in 2008.

While many of these states are considered to be "emerging" in this subsector, future job growth may be difficult given the challenges facing the drugs and pharmaceuticals industry and the job losses of recent years including during the first year of the recession in the U.S. where employment declined by 2.3 percent.

Figure 7. Drugs and Pharmaceuticals Subsector, Iowa and Comparison States, 2008

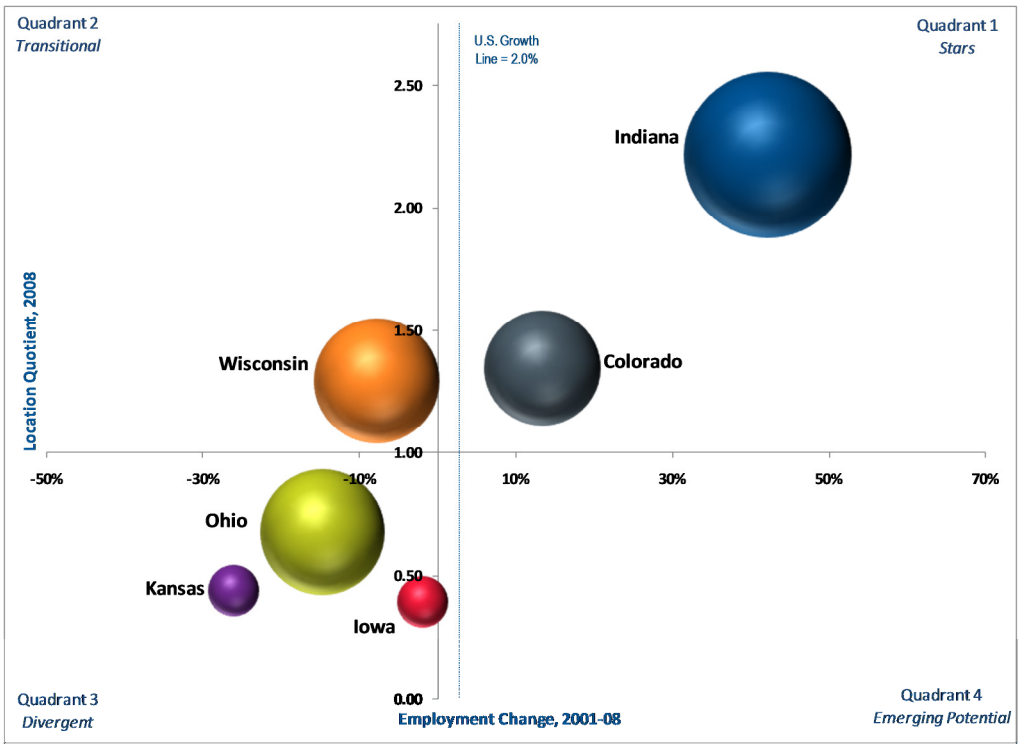


In **medical devices and equipment**, several of the comparison states have large and specialized sectors including Indiana, Wisconsin, and Colorado. Each of these states, plus Ohio has 10,000 or more jobs in the medical device and equipment manufacturing and Indiana's subsector exceeds 20,000.

Kansas' subsector is virtually the same size and relative concentration as Iowa's, though Kansas experienced a greater net job loss during the 2001–08 period.

While U.S. medical device employment gained just 2.0 percent over the 7-year period to 2008, just Indiana and Colorado exceeded this modest growth.

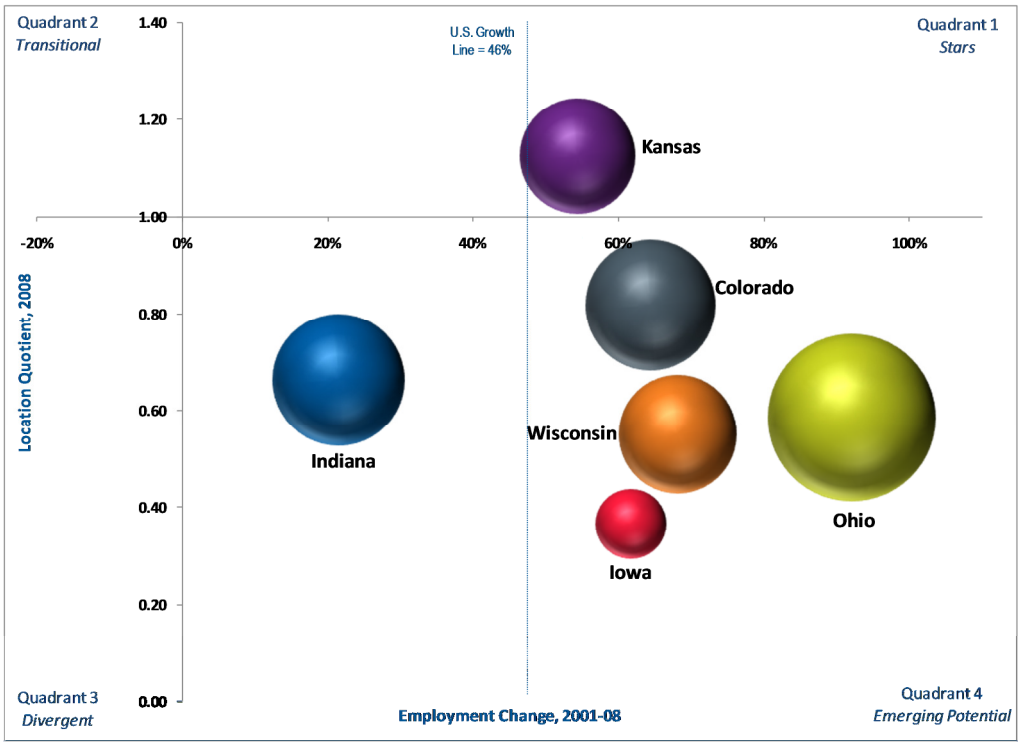
Figure 8. Medical Devices and Equipment Subsector, Iowa and Comparison States, 2008



Reflecting the strong, driving growth of the **research, testing, and medical labs subsector** nationally, the bubble chart in Figure 9 shows Iowa and all five comparison states growing employment since 2001 (i.e., to the right of the vertical axis). In fact, all but Indiana exceed the national subsector growth rate of 46 percent.

While each has grown its job base in research, testing, and medical labs, none of the states presented here have a specialized concentration, though Kansas with a LQ of 1.12 is close. Iowa's employment base in the subsector is, at more than 2,200, the smallest by far. Each of the comparison states has at least 6,000 jobs in the sector and Ohio's reaches nearly 13,000.

Figure 9. Research, Testing, and Medical Labs Subsector, Iowa and Comparison States, 2008



Conclusion

Iowa's industry employment base in the biosciences is sizable, growing, and led by a truly niche strength in agricultural feedstock and chemicals. In addition to its leading position in the agbiosciences, the state has an emerging, though still modest, presence in other subsectors including research, testing, and medical labs and drugs and pharmaceuticals. Each of these have growth areas and/or areas of specialization that represent opportunities for development—from biotech and agricultural R&D and medical labs to biological therapeutics and vaccines. In addition, the state is positioned to grow and leverage its leading agbioscience subsector through continued growth in ethanol and biofuels production, organic industrial chemicals, and agricultural processing.

In the midst of a recession, a robust and resilient industry such as the biosciences represents a unique opportunity to advance Iowa economically while other industries struggle.

Iowa's Bioscience Opportunities

In 2004, Battelle undertook both quantitative and qualitative analysis to identify Iowa's bioscience core competencies and to identify those areas of the biosciences, referred to as bioscience platforms, which appeared to offer the greatest opportunity for development. The 2004 analysis concluded that Iowa's bioscience core competencies and market opportunities aligned to support the development of six near-term platforms:

- **BioEconomy Platform** – Using plant and animal biomass and waste streams to generate chemicals, energy, fuels, and materials for industrial and commercial applications.
- **Integrated Drug Discovery, Development, Piloting and Production Platform** – Leveraging Iowa's strengths in basic biomedical research, drug development, and GMP production into an integrated pipeline of new drugs and therapeutics.
- **Advanced Food Products Platform** – Using Iowa's established strengths in plant and animal sciences, production agriculture, food science, nutrition, and processing technology to develop and produce functional foods and nutraceuticals.
- **Integrated Post-Genomic Medicine Platform** – Using Iowa's genomics expertise and specific disease/disorder skills, in conjunction with epidemiologic data and Iowa's stable population, to produce rapid advances in post-genomic medicine and associated discoveries.
- **Animal Systems Platform** – Using Iowa's bioscience expertise to establish a leadership position in the modeling of animal systems and in the development of technologies and applications for transgenic animals, chimeric animals, and cloning.
- **Integrated Biosecurity Platform** – Deploying the strengths of Iowa's institutions in human, animal and plant disease prevention, protection, and treatment to establish an integrated approach to securing the environment, food production systems, human health and safety.

These six areas represented broad platforms showing significant potential for near-term development success. In addition to the broad technology platforms, several additional areas of emerging, longer-term opportunity were identified in 2004. These additional identified areas consisted of relatively compact groups of people working in leading edge fields, newer formative centers that had just recently been pulled together, or established areas of expertise in which further investment in infrastructure and/or personnel were thought to be required to sustain or accelerate development momentum. The four longer-term opportunities identified were:

- **Host-Parasite Biology and Systems** – Examining the interaction and symbiotic beneficial relationships between hosts and parasitic organisms, with an initial emphasis on immunologic response.
- **Instrumentation, Devices and Sensors** – Using Iowa's skills in engineering, chemistry, biology and related fields to produce novel tools for instrumentation, analysis, invasive and non-invasive imaging, diagnostics, and biosensors.

- **Formation of a Cardiovascular Research Institute** – Mirroring Iowa's success with The University of Iowa's Comprehensive Cancer Center to build a similarly resourced and dedicated scientific institute for advancing cardiovascular and cardiopulmonary research and development.
- **Formation of a Free Radical Research Institute** – Cementing Iowa's existing world leadership position in free radical and oxygen biology research within a formal institute with associated facilities and funding.

Overall, Battelle's 2004 assessment concluded that Iowa's position in the biosciences showed a state with significant promise to be among the nation's bioscience research leaders in selective fields. Iowa institutions were seen to have substantive strengths in the "three principal legs of the bioscience stool"—human, animal, and plant biosciences. As part of this bioscience strategy update, Battelle revisited the bioscience technology platforms identified in 2004, assessed progress in growing the platforms, evaluated Iowa's R&D core competencies and further refined the technology platforms that appear to offer the most opportunity for future development.

For the 2010 re-assessment, Battelle concentrated efforts on interviews, seeking to understand changes and emerging areas of excellence in biosciences across Iowa bioscience research institutions. Working with offices of research at the Iowa Regent Universities, key leaders of research theme areas (established, growing and emerging) were identified and interviewed.

Key Accomplishments

It is clear that significant progress has occurred since 2004 across a range of platform areas. Some key achievements include advancements in both human biomedical and agbioscience related platforms.

Biomedical Platform-related Advancements 2004–2010

Key advancements with the biomedical-related platforms include:

- The **University of Iowa's NIH Clinical and Translational Sciences Award** (CTSA), places the University of Iowa's Institute for Clinical and Translational Science, and its consortium partners, among an elite cadre of 55 institutions designated to participate in this major NIH program to accelerate discoveries from bench to bedside.
- The ongoing **development of the John and Mary Pappajohn Biomedical Discovery Building and the Pappajohn Biomedical Discovery Institute** (BDI) at the University of Iowa. The building represents an environment designed to foster multi-disciplinary research in biomedical sciences—bringing together biologists, chemists, engineers, clinicians and representatives of other science and technology disciplines to advance biomedical innovation and application. Moving forward the Institute will focus on key themes, including:
    - Cardiovascular diseases
    - Cancer
    - Neurosciences
    - Regenerative Medicine (including stem cell research and other potential avenues to address degenerative diseases and traumatic injury)
    - Diabetes, obesity and metabolic diseases.

- The **development of the BioVenture building** at the UI research park in Coralville—a major facility dedicated to the development and incubation of bioscience, biotechnology and biomedical companies. One of the key emerging developments at the BioVenture building is the John Paul II Stem Cell Research Institute focused on adult stem cell lines for therapeutics targeting and regenerative medicine. As a collaborative, the for-profit Iowa company Cellular Engineering Technologies (CET) and the John Paul II Stem Cell Research Institute house the largest repository of adult stem cells in the world and have been the first to provide disease-specific somatic stem cells to the NIH.

Agbioscience and Bioeconomy Platform-related Advancements 2004–2010

Key advancements with the agbioscience and bioeconomy-related platforms include:

- The growth of Iowa State University's **Bioeconomy Institute** has been a significant achievement, with the Institute now having 160 affiliated member faculty with over $51 million in cumulative sponsored grant funding from federal agencies and industry partners. This is further reinforced by the 2008 development of the **Biobased Industry Center** at ISU which brings together research and education initiatives to address key issues for biobased industry and supply chain development.
- ISU has continued to invest in building the infrastructure necessary to keep the institution at the forefront of bioeconomy development. Existing centers such as the Center for Crops Utilization Research (CCUR), the Center for Catalysis, the Centers for Plant Breeding and Plant Transformation, and the Plant Sciences Institute continue to leverage key assets and infrastructure for bioeconomy development. Furthermore ISU has developed the BioCentury Research Farm, the nation's first integrated research and demonstration farm devoted to biomass production and processing. This facility incorporates biomass production innovations, processing technologies and biobased product development to accelerate the introduction of sustainable biobased products and renewable resources. ***Taken together—ISU's infrastructure is perhaps the most unique in the nation in being able to take a holistic approach to bioeconomy development—ranging from plant biomass development at the front end, through harvesting, transportation, preprocessing and processing into end-use demonstration and scale-up products.***

In addition to the above noted projects, Iowa's Regent Universities have made significant strides in:

- Encouraging multi-disciplinary and inter-institutional collaborations
- Using the Grow Iowa Values Fund program and Iowa Energy Center funds to seed innovation and technology advancement in key platform areas
- Further advancing support for faculty entrepreneurship and innovation commercialization
- Expanding business incubation and science/research park assets and infrastructure.

Proposed 2010 Bioscience Technology Platforms

While significant advancement has occurred in bioscience platform development within Iowa, Battelle's reassessment of opportunities and challenges facing the sector, and discussions with bioscience leadership in the state, suggest that further bioscience-based economic development in Iowa would be facilitated by simplifying and consolidating platforms into a smaller number. By consolidating into a tighter group of platforms, the state will be better able to focus limited resources on platforms with a robust line-of-sight to market based on a substantive base of research and development assets in Iowa. To this end, Battelle's analysis suggests that four primary platforms would accommodate the key bioscience-based development opportunities observed for Iowa:

- **Bioeconomy Platform.** With two primary subcomponents: 1) advanced biofuels development and 2) value-added biobased chemicals and materials.
- **"One Health" Infectious Diseases Platform.** Leveraging multi-institutional expertise across UI, ISU, the USDA and industry for tackling human and animal infectious diseases—in particular vector-borne, zoonotic and reemerging infectious diseases. The opportunity here embraces the development of surveillance tools, technologies and models, diagnostics, vaccines, and therapeutic products.
- **Personalized Medicine Platform.** A development and commercialization platform for diagnostics, therapeutics and regenerative medicine tools and technologies using genomic information and stem cells for refined treatment of diseases (especially diseases in which Iowa has acknowledged basic and clinical science strengths—such as cardiovascular disease, cancer, ophthalmic diseases and disorders, and diabetes).
- **Advanced Food Products.** Using Iowa's multi-institutional established strengths in plant and animal sciences, production agriculture, food science, nutrition, and processing technologies to produce both functional foods and nutraceuticals.

It is clear that, taken together, these four platforms embrace most, if not all, of the more complex suite of 2004 near-term and longer-term platforms. See Table 5.

Table 4: Platform Crosswalk 2004–2010 Revised

	2010 BioEconomy Platform	2010 "One Health" – Infectious Diseases Platform	2010 Personalized Medicine	2010 Advanced Food Products Platform
2004 Primary: BioEconomy	X			
2004 Primary: Integrated Drug Discovery, Development, Piloting and Production			X	
2004 Primary: Advanced Food Products				X
2004 Primary: Integrated Post-Genomic Medicine			X	
2004 Primary: Animal Systems		X	X	
2004 Primary: Integrated Biosecurity		X		
2004 Longer-term: Host-Parasite Biology and Systems		X		
2004 Longer-term: Instrumentation, Devices and Sensors	X	X	X	X
2004 Longer-term: Cardiovascular Research Institute			X	X
2004 Longer-term: Free Radical Research Institute			X	X

These platforms are supported by a variety of cross-cutting support disciplines and capabilities across R&D institutions in the state, as illustrated in Table 5.

Table 5: Observed Cross-Cutting Supports for 2010 Recommended Platforms

	2010 BioEconomy Platform	2010 "One Health" – infectious Diseases Platform	2010 Personalized Medicine	2010 Advanced Food Products Platform
Drug development, piloting and production		X	X	X
Bioimaging	X	X	X	X
Bioinformatics		X	X	
Visualization, Simulation and Modeling		X	X	
Plant Sciences	X	X		X
Animal Sciences		X	X	X
Catalysis	X		X	
Bioeconomy Piloting and Scale-up	X			
Materials Science	X			
Cardiovascular Diseases			X	X
Stem cells and regenerative medicine			X	
Ophthalmology			X	
Cancer			X	X
Diabetes			X	X
Toxicology		X	X	X
Animal Respiratory Diseases		X		
Host-Parasite Relationships		X		
Genetics/Genomics/RNA Biology	X	X	X	X

These four platforms thus can accommodate most of the core competencies and strengths evident in Iowa biosciences and associated disciplines—and channel the innovations from these platforms to significantly sized markets. Following are findings and market size projections pertaining to each of the four platforms:

Bioeconomy Platform

Why is this an area of opportunity?

The use of biomass as feedstocks for the production of a broad range of industrial products including fuels, chemicals, polymers and materials represents a win-win scenario for agricultural powerhouse states such as Iowa. The bioeconomy provides a pathway to additional value-added farm output, benefiting Iowa's rural economy, but also provides an opportunity for local processing of biomass and the development of Iowa-based industries for the conversion of biomass into value-added fuels, chemicals and materials. Furthermore, the development of this bioeconomy will also have import substitution effects, benefiting the Iowa economy through the use of home-grown biomass for industrial

products manufacturing (rather than the use of imported feedstocks, most notably those currently produced from foreign oil). Helping the farmer, helping industry and displacing imports are a rare alignment of economic development benefits—an alignment unique to the bioeconomy.

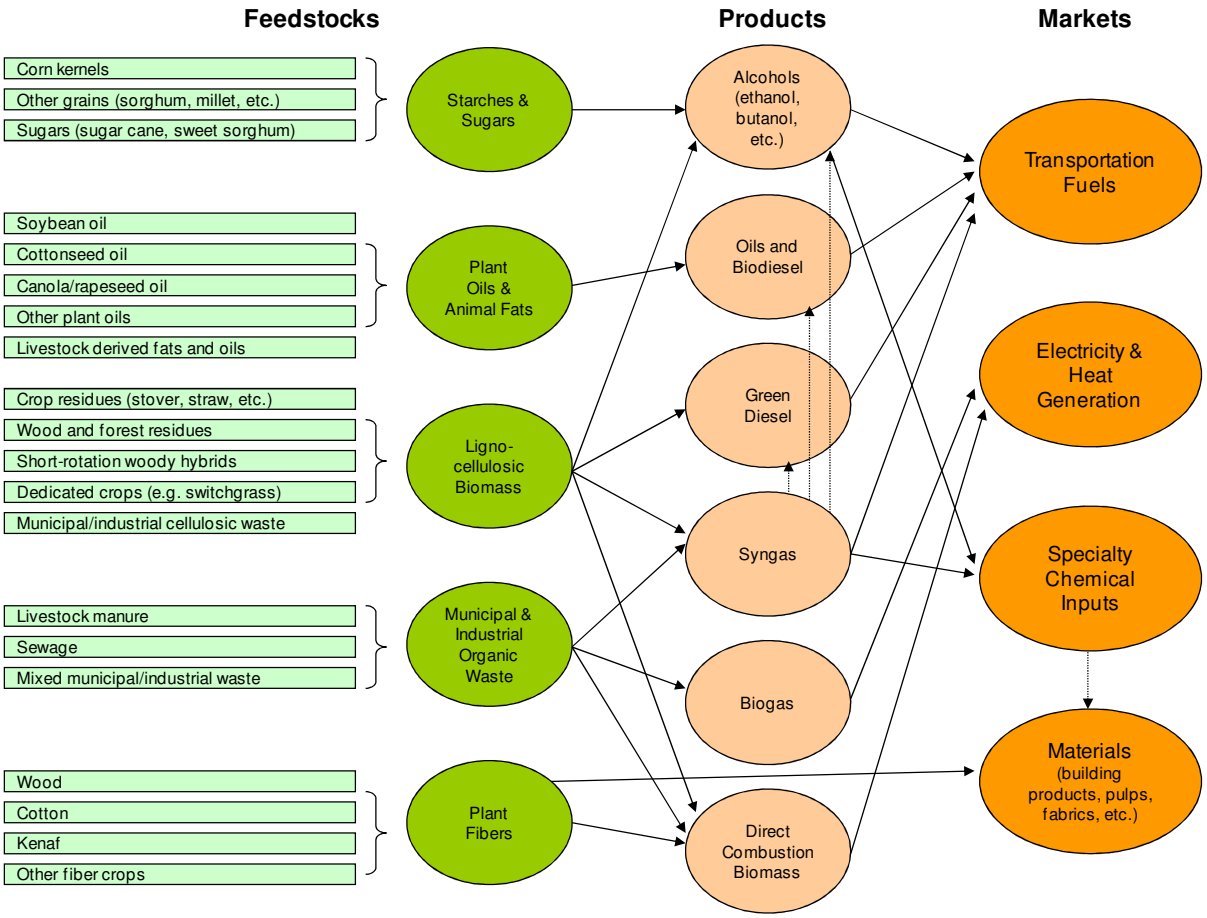
The bioeconomy already represents a substantial size market, with significant growth predicted into the future. In 2008, the global biofuels market was valued at $60.6 billion and forecasted to grow to $77.1 billion by 2013 (Frost & Sullivan, 2010). U.S. ethanol production increased more than four times between 2002 and 2008, increasing from 2 billion gallons per year to 9 billion gallons, while continued growth is mandated under the Energy Independence and Security Act of 2007 (EISA) which calls for corn ethanol production to reach 15 billion gallons by 2011. While first-generation biofuels (ethanol) will continue to dominate the market through 2013 second generation (cellulosic ethanol) and third-generation technologies (algae-based oils/fuels) will also emerge as key drivers of market growth. Beyond liquid biofuels, biobased chemicals and materials also address a large-scale market opportunity. In 2009, biobased chemicals had a market value of $45 billion and were forecasted to grow to $60 billion by 2014. Industry insiders project that the global biopolymers market will grow 27.3 percent between 2009 and 2015, and reach 2.7 million tons (GBI Research, 2010).

Why is Iowa well positioned?

The opportunity for bioeconomy development in Iowa was outlined in the original 2004 Battelle report, but embraced in advance of that by forward thinking academic researchers, private industries and Iowa government. Already, in 2004, Battelle found that Iowa's universities and private sector had invested successfully in the development of a series of R&D and commercial assets that placed Iowa at the forefront of biofuels and biobased products development. Since 2004, Iowa's early momentum in the bioeconomy has been sustained through additional strategic investments—including, but not limited to, the previously cited investments in the BioCentury Research Farm and the Bioeconomy Institute at ISU.

The promise for Iowa embodied in the bioeconomy is only just starting to be realized. Certainly the state was an early adopter of first generation corn distillation for the production of bulk commodity ethanol, but those engaged in R&D in the state are now focusing on the far higher value-added niche products that may be produced by more advanced biomass processing techniques and technologies. As Figure 10 illustrates, various types of biomass feedstocks provide pathways to a broad range of products and markets—many of which have high market value.

Figure 10: Simplified Categorization of Biomass Feedstocks, Biobased Products and Market Applications



Biomass presents opportunities for the production of chemical intermediates and specialty chemicals from plant oils, from sugars and starches, and (anticipated for the future) ligno-cellulosic (woody) biomass. These biomass resources will also be feedstocks for second and third generation advanced liquid biofuels also. Plant fibers, in combination with biobased resins, polymers and other chemicals form the basis for an advanced materials and composite materials industry also.

What are Iowa's key assets upon which to build?

What Iowa has done especially well is build capabilities across the spectrum of bioeconomy activity—from the basic science of plant breeding and transgenics, through agronomy, harvesting, storage, pre-processing and processing technologies. Key assets along this integrated bioeconomy development chain include:

- ***ISU Plant Sciences Institute (PSI)*** – Leveraging state investment, the PSI is among the premier institutions in basic and applied plant sciences—especially as they relate to crop plants. In particular the PSI uses the latest tools and techniques of genomics and bioinformatics to advance knowledge of crop biology, especially crops relevant to Iowa agronomy. The PSI also serves as a research initiative coordination organization for ISU, focusing activity in five core

areas that include: genomics for crop improvement; biopharmaceutical production via crop plants; enhancing the nutritional value of food and feed plants; developing optimal feedstock plants for bioeconomy applications, and research and development in crop protection.

- ***ISU Plant Transformation Facility*** – Established in 1995, the ISU PTF has an established track record in plant transformation (via genetics) in both crops (corn, rice and soybeans for example) and model plants. The facility includes lab, storage and greenhouse space, together with field plots for seed production.
- ***Specialized Labs at ISU for Metabolomics, Plant Genomics and Proteomics*** – These include the WM Keck Metabolomics Research Laboratory, Pioneer Hi-Bred International Plant Genomics Laboratory and the Roy L. Carver Co-Lab Proteomics Facility.
- ***The ISU Center for Crops Utilization Research (CCUR)*** – CCUR is an award winning institution dedicated to adding value to mid-west crops along both food and bioeconomy pathways. On the bioeconomy front CCUR is leading work in biobased substitutes for petrochemicals, corn utilization and soybean utilization research. The Center is also active in the development of ag-based building materials, degradable and biobased plastics, fermentation production of organic acids, soy oil, safe solvents, and biodiesel.
- ***ISU Center for Biorenewable Chemicals*** (CBiRC) –An NSF funded Engineering Research Center focused on the development of biocatalysis and chemical catalysis to produce chemicals from biomaterials. CBiRC is funded by an $18.5 million, five-year award from the NSF Engineering Research Center Program, with additional support from institutional matches and industry memberships.
- ***Biocentury Research Farm –*** An integrated research and demonstration farm devoted to biomass production and processing. The research farm provides pilot and scale-up operations for various biomass processing technologies, such as pyrolysis and biofuels production. By integrating with a farm, the facility provides onsite growth of biomass crops plus integration with biochemical and thermochemical processing and technologies for bio-oil, syngas and fermentation.
- ***The Iowa Energy Center's Biomass Energy Conversion facility (BECON)*** – Located in Nevada, Iowa, this is a further resource for research and development for biobased fuels and chemicals. In particular the facility allows researchers to go beyond bench and pilot scale research into scaled-up production scale testing.

No other location in the country has such a complete suite of capabilities for bioeconomy development—a suite of capabilities spanning basic plant improvement through to the production of full-scale biobased products. Iowa State has further reinforced its leadership position in bioeconomy R&D with the construction of the Biorenewables Research Lab (BRL) building—a purpose designed 70,000 square foot facility designed to bring major ISU institutes and centers together for multidisciplinary bioeconomy project development. The new facility houses the Bioeconomy Institute, CBiRC and the Biobased Industry Center and is slated for further expansion.

In addition to the ISU facilities, the presence and operations of the U.S. Department of Energy's Ames Lab is a further key asset for bioeconomy development. The Ames Lab has a long-standing track-record

as the premiere materials sciences lab for the DOE, and is directly applying its expertise in materials science to the challenges of bio-based materials development.

Niche areas for Iowa

While other regions of the country are focusing in on specific sub-niches of biobased development, the uniquely comprehensive and robust suite of assets in Iowa allows the state (with ISU as the hub) to have a leading role across a broad spectrum of biofuels and biobased product developments. There is not a single biobased products niche for Iowa—rather the comprehensive nature of Iowa's assets provides a rather unique opportunity to examine holistic bioeconomy opportunities, leveraging the "agronomic ecosystem" and its biomass resources to develop an optimized and diversified portfolio of value-added bioeconomy products. Coupled with Iowa's strengths in agricultural economics and environmental sciences, Iowa is uniquely positioned to address the emerging bioeconomy in its entirety—as a system, rather than just discrete elements.

"One Health" Infectious Diseases Platform.

Why is this an area of opportunity?

In the 2004 Iowa biosciences report, Battelle recommended a platform termed "Integrated Biosecurity" with the goal of deploying the strengths across Iowa's institutions in human, animal and plant disease prevention, protection, and treatment—establishing an integrated approach to securing the environment, food production systems, human health and safety. Battelle also recommended somewhat related platforms in "animal systems" and "host-parasite biology."

> The One Health Initiative is a movement to forge co-equal, all inclusive collaborations between physicians, osteopaths, veterinarians, dentists, nurses and other scientific-health and environmentally related disciplines, including the American Medical Association, American Veterinary Medical Association, the American Society of Tropical Medicine and Hygiene, the Centers for Disease Control and Prevention (CDC), the United States Department of Agriculture (USDA), and the U.S. National Environmental Health Association (NEHA). Additionally, more than 535 prominent scientists, physicians and veterinarians worldwide have endorsed the initiative.
>
> http://www.onehealthinitiative.com/

Since the release of the 2004 report, several areas of international and Iowa-centered work have emerged that leads to a suggestion to refine Iowa's focus into integrated work on infectious diseases—in particular emerging and re-emerging infectious diseases, vector-borne diseases and zoonotic infectious diseases. An international movement has begun in this arena termed "One Health" that is focused on the intersections between human and animal diseases and the various scientific disciplines pertaining to these. One Health is a component of the "New Biology for the 21st Century", which is expected to be a driving force of the future. The new biology, as defined by the National Research Council, is an "approach to research where physicists, chemists, computer scientists, engineers, mathematicians and other scientists are integrated into the field of biology to create the type of research community that can tackle society's big problems."[7] Iowa, with UI and ISU, has recognized that the core competencies of Iowa's institutions lend themselves well to focusing on both the new biology and the "One Health" model especially in relation to infectious diseases.

It is estimated that approximately 70 percent of emerging and reemerging infectious diseases worldwide are zoonotic or vector-borne. Infectious diseases represent a substantial issue globally, and thus also a very significant market opportunity. The global vaccine market alone was valued at $21.3 billion (Frost & Sullivan, 2009) and projected to grow at a compound annual growth rate (CAGR) of 12.1 percent to reach $47.3 billion by 2015. The anti-viral component of the U.S. pharmaceutical industry is $6.4 billion, while the demand for disease diagnostics is also significant with Freedonia in 2010 estimating U.S. in vitro diagnostics growing at six percent annually to reach a projected $25 billion by 2010.

Why is Iowa well positioned?

Several Iowa core competency areas converge to make the state a particularly robust location for R&D in this space.

- ***An Emerging Regional "One Health" Initiative*** – While the University of Iowa and Iowa State University have long-standing capabilities in infectious diseases, bacteriology, virology, immunology and associated sciences, there is now a nascent effort to coordinate a multi-institutional One Health initiative engaging not only ISU, UI and UNI, but also other regional institutions such as the Mayo Clinic and the University of Nebraska.
- ***The Center for Advanced Host Defense Immunobiotics and Translational Comparative Medicine (CAHDIT)*** at ISU examines host defense and host pathogen interactions for human and animal disease (ISU). Near term work at CAHDIT shows promise for applied innovations in vaccine immunobiotics and detection assays.
- ***Medical Entomology at ISU*** conducts R&D in zoonotic diseases, and disease vectors including arthropods and mosquitoes. Basic research is conducted in innate immunology and pathogen infection responses, while the program also operates a significant surveillance and population dynamics program.
- ***The United States Department of Agriculture's National Animal Diseases Center*** – Located in Ames, the NADC is the largest federal animal disease center in the U.S. and is focused on research to solve animal health and food safety problems faced by livestock producers and the public.
- ***The convergence of Iowa assets in human biomedical research, veterinary medicine, plant disease R&D***, and programs in parasites and disease vectors provide a particularly well-rounded suite of resources for deploying a holistic approach to vector-borne infectious diseases.
- The broader region also benefits from significant ***industry presence***, especially in the area of livestock and companion animal health companies—particularly along what has been termed the "I-70 Animal Health Corridor."

Taken together, Iowa's assets are suited to a one health infectious diseases model with opportunities for the development and deployment of multiple technologies. Opportunities exist for the development of surveillance systems, diagnostics tools, vector-management technologies, disease transmission interference technologies (e.g., via RNA projects), vaccines and therapeutic products.

What are Iowa's key assets upon which to build?

In addition to the assets listed in the bullets above, Iowa benefits from additional assets related to infectious diseases R&D. Among these are:

- ***The University of Iowa Division of Infectious Diseases*** – A clinical and research division with research focus areas in host defenses, microbial pathogenesis and infectious disease epidemiology.
- ***The University of Iowa's College of Public Health Center of Emerging Infectious Diseases(CEID)*** – Operating since 2003, the CEID has a particular focus in zoonotic emerging infectious diseases and ongoing R&D projects across a range of infections including avian influenza, swine and equine influenza, and zoonotic flu strains.
- ***University of Iowa College of Medicine BSL3 Facilities*** – Working with infectious agents requires environmental control of disease-causing organisms. Iowa benefits from the Carver College of Medicine's animal biological safety level 3 facilities.
- ***Iowa State University College of Veterinary Medicine*** – ISU veterinary medicine has a dedicated program in veterinary pathology, including faculty specifically focused on emerging infectious diseases.
- ***The Iowa Hygienic Lab at UI –*** The lab provides testing for a wide range of diseases and serves as the state's environmental testing lab. Every Iowan under 40 who was born in the state was screened as a newborn for a variety of defects and abnormalities.

An additional key asset as R&D progresses to the point of the development of products requiring GLP and GMP production processes is UI Pharmaceuticals.

Niche areas for Iowa

Core niche areas for Iowa to develop would relate to zoonotic infectious diseases and emerging infectious diseases that are vector-borne. These disease classifications lend themselves to the multi-institutional and multi-disciplinary collaborations that would best leverage the unique assets of Iowa across academe, clinical human and veterinary medicine, USDA research and the profile of regional industry. As noted previously, product and technology innovation opportunities for Iowa stemming from a focus on zoonotic and emerging vector-borne infectious diseases are broad and would include surveillance systems, diagnostics tools, vector-management technologies, disease transmission interference, vaccines and therapeutic products.

Personalized Medicine Platform

Why is this an area of opportunity?

> *I see a dramatic shift to individualized medicine—the ability to deliver therapeutics on an individual basis through molecular phenotyping of disease subtypes and to predict both patients' therapeutic and side effect responses to drugs…Understanding the molecular biology of an individual's disease by using early diagnostic testing and genetic profiling will allow therapy to be selected with a greater expectation of benefit.*
>
> Arthur D. Levinson,
> Chairman & CEO, Genentech

> *In five years, we predict there will be numerous new companion therapies and diagnostic tests—that is, drugs whose prescribing information is linked to the results of a molecular diagnostic test. There will be incremental progress. In 15 or 20 years, I'd like to think that we won't be talking about personalized medicine at all. It will just be the way medicine is practiced. The patient will ask the physician 'will this work for me?' and the physician will have various tools in his or her arsenal to find out.*
>
> Edward Abrahams, Executive Director,
> Personalized Medicine Coalition

Several substantial modern advancements in bioscience knowledge are advancing human medicine in dynamic and exciting ways. The decoding of the human genome and the expanding related sciences of genomics, proteomics, and metabolomics, have unveiled the relationship between genetic structure and the function of biological systems and diseases. Using the tools and technologies of molecular diagnostics, a patient's genetic, protein and metabolic profile can be used to customize medical care and the application of therapeutic products to best suite the individual characteristics of the patient. The promise of this application of personalized medicine is to limit adverse drug effects and significantly improve the efficacy of therapeutics and treatment protocols. Other key areas of scientific advancement pertaining to personalized medicine are contained within the fields of regenerative medicine and stem cells. The use of stem cells (cells able to differentiate into specific types of cells) opens pathways to cellular therapies and advanced screening of therapeutics for the treatment of diseases. Regenerative medicine provides pathways to the creation of living tissue to replace or repair tissues or whole organs. Taken together, these new fields of post-genomic medicine, stem cell therapy and regenerative medicine open-up new horizons of highly targeted personalized clinical care. It should also be noted that personalized medicine, in addition to treating emerged disease states, also opens paths to predicting individual disease susceptibility and to crafting preventative medical interventions.

It is fair to say that personalized medicine is moving the practice of medicine from a relatively inexact science of detection and generic therapeutic treatment to a modern individualized approach targeting the quantitative characteristics of the patient. While still in its early stages, the tools and techniques of personalized medicine will become the standard of practice in the future and those locations that build substantial leadership positions in the field will be well positioned for biomedical-based economic development and economic growth.

Why is Iowa well positioned?

It should be cautioned that personalized medicine, stem cell therapies and regenerative medicine are emerging disciplines subject to considerable attention in the scientific, business and economic development communities. As such, there is and will be considerable competition for achieving

leadership positions in these fields. That said, Iowa has strengths to build upon and a base of forward-thinking corporate and academic bioscience leaders who have shaped the development of Iowa-based capabilities.

Certainly a strong base of basic biomedical science and genomic science expertise is required as a fundamental underpinning of progress in personalized medicine. Iowa, in particular centered on UI, has good capabilities in required disciplines combined with assets in molecular imaging, stem cell characterization, modeling and simulation which will contribute to scientific advancement. Furthermore, UI's focal areas of strength in cancer, cardiovascular disease, and diabetes are in-line with areas targeted for advancement in personalized medicine approaches.

It should also be noted that Iowa is now home to a notable collaboration between the new non-profit John Paul II Stem Cell Research Institute (JP2SRI) and the for-profit Cellular Engineering Technologies (CET) making Iowa the base for the largest depository of adult stem cells globally. Concentrating on the application of adult stem cells to disease, the JP2SRI/CET collaborative is focused on ethically-preferred adult stem cell approach and provides opportunities for Iowa moving forward in producing patient and disease specific pluripotent stem cell/adult stem cell lines for drug screening.

What are Iowa's key assets upon which to build?

In many respects, the entire academic medical center complex of UI forms the foundational underpinning for advancing personalized medicine. Within the academic medical center, and the broader Iowa bioscience community, are specific assets that focus efforts in the personalized medicine arena—examples include:

- The ongoing development of the **John and Mary Pappajohn Biomedical Discovery Building and the Pappajohn Biomedical Discovery Institute** (BDI) at UI. Part of the specific programming for this Institute focuses on regenerative medicine including stem cell research focused on degenerative diseases and traumatic injury. In addition, the Institute will foster multi-disciplinary partnerships for personalized medicine approaches to established clinical expertise areas in cardiovascular disease, cancer, neuroscience, diabetes, obesity and metabolic diseases.

- The **UI Clinical and Translational Sciences (CTSA) award program** which directs translational bed-to-bedside biomedical science work.

- The aforementioned capacity being built by the non-profit **John Paul II Stem Cell Research Institute** at the UI BioVenture facility and its ongoing translational partnership with Cellular Engineering Technologies.

- Longer-term, the expertise of **UI Pharmaceuticals** in Good Lab Practice (GLP) and Good Manufacturing Practice (GMP) provides a distinct advantage in the development of small-batch, targeted therapeutics for personalized medicine approaches and the treatment of orphan diseases. The ultimate promise of personalized therapeutics will be facilitated, in part, by custom formulation of drugs to fit the patient's specific profile. Both the production and

regulatory environment expertise of UI in the pharmaceutical arena will be of significant value in realizing opportunities in personalized therapeutics moving forward.

Niche areas for Iowa

While this is an emerging field, and Battelle would caution that multiple development opportunities will arise for Iowa into the future, there are specific Iowa capabilities that are evident early niches for the state based on existing and developing assets:

- Reinforcement and further building of Iowa's emerging leadership position in adult stem cell research and development—including:
    - Identification and development of stem cell lines for drug screening
    - Testing of existing drugs against disease specific stem cell lines, including potential partnerships with the pharmaceutical industry
    - Development of tools and technologies for drug screening
    - Stem cell harvesting, processing and storage technologies
    - Application of stem cells to specific areas of clinical research expertise at UI, including cardiovascular disease, cancer, ophthalmic diseases, diabetes and congenital diseases and disorders.
- UI Pharmaceuticals is the only major university-based GMP pharmaceutical contract manufacturer in the U.S. The capabilities of UI hold potential for leverage in the personalized medicine platform in the development of manufacturing processes for small-batch customized pharmaceuticals, biologics, vaccines and diagnostic products. Building UI Pharmaceuticals capabilities to move into personalized medicine formulations and to work with the commercial sector in the development of production capabilities should be considered a priority activity.
- UI's Center for Biocatalysis and Bioprocessing has a very unique capability to purify and scale up proteins for clinical trials manufacturing under cGMP conditions.
- UI has also just created a new University Core Facility for High Throughput Screening to assist numerous investigators to identify targets for new drug discovery purposes, consistent with one of the major goals of its Clinical and Translational Science Award.

Advanced Food Products Platform

Why is this an area of opportunity?

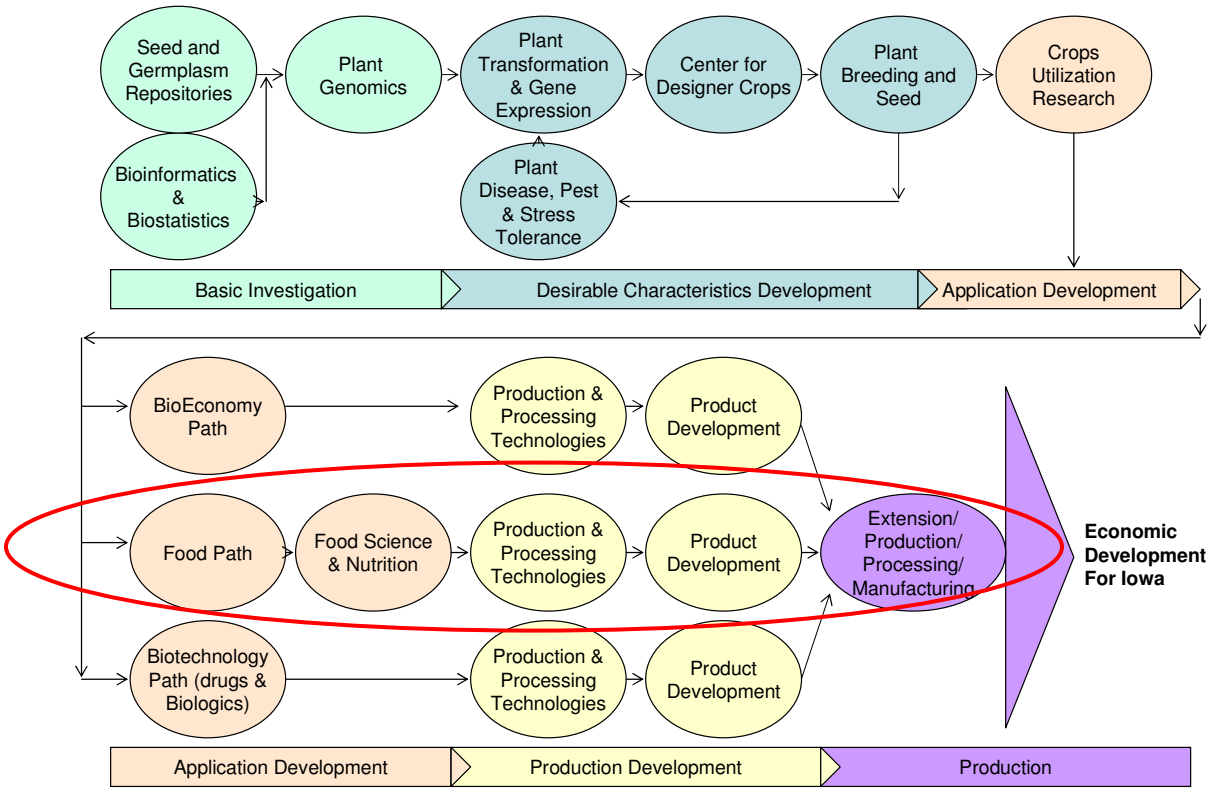
At the present time a high proportion of Iowa agricultural products are shipped out of state for further processing. Thus, the opportunity to produce high value-added processed and packaged food products is being realized predominantly in other states, rather than in Iowa. The traditional commodity food industry is highly consolidated and has high barriers to entry; however, the emerging marketplace for advanced food products is opening up new pathways to the development and production of high value-added niche food and health products, including:

- **Functional Foods**—characterized as food or food ingredients that may provide health benefits beyond the traditional nutrients they contain. Functional foods can be either plant- or animal-based.

- **Nutraceuticals**—A nutraceutical is "any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention or treatment of disease." (Source: ISU Extension).
- **Phytochemicals**—Nutritionists use the term phytochemical when referring to naturally occurring components of plants that have physiological effects on humans. Such physiological effects might include, for example, enhanced immune system activity, chemoprevention, and reduced cholesterol.

In many respects the opportunity for Iowa in advanced food products is the same as identified in the 2004 report. In the 2004 report the following figure was presented showing the integration of key R&D components in Iowa and their potential to drive development of an advanced foods economy for the state:

Figure 11: Potential Path for Advanced Food Economy in Iowa.



The economic rewards of achieving progress in the advanced foods economy can be significant. BCC Research notes that in 2008 the global nutraceutical market was valued at $123.9 billion and this leading market research organization forecasted nutraceuticals to reach $176.7 billion by 2013 (BCC Research, 2008). Just-foods.com research indicates that the global functional foods market will reach a market size of $90.5 billion in 2013. Industry experts anticipate the U.S. market for functional foods to grow between 8.5 percent and 20 percent annually in the near term, whereas the food industry overall is

forecasting growth rates of only 1–4 percent per year (Pricewaterhouse Coopers, 2009). In 2008 the U.S. dietary supplement market was worth $25.2 billion with annual growth rates expected to run at 4–5 percent through 2013 (Pricewaterhouse Coopers, 2009).

Why is Iowa well positioned?

As noted in 2004, much of the expertise is in place at both ISU and UI to make significant progress in advanced food research and applications possible. ISU operates a substantial Food Science and Human Nutrition program and has the basic science bases largely covered in terms of genomics, proteomics, metabolomics, chemistry, and biochemistry. The University also has the required strengths in gene expression, transgenics and plant and animal breeding to advance initiatives in the field.

It should be noted that much of the R&D capability applied to human food advancements is applicable to the needs for advanced animal nutrition products also.

In addition to the university based R&D, Iowa does have a base of companies active in the more advanced end of food and feed products, plus food ingredients and biopharming. Companies such as Kemin Industries Inc., Grain Processing Corporation, Diamond V, Embria Health Sciences, Horan BioProduction, StarchDesign and Feed Energy in Iowa are active across the sector.

What are Iowa's key assets upon which to build?

Iowa benefits from several distinct clusters of concentrated research and development expertise in food science, nutrition and associated advanced products. Key centers include:

- ***Center for Research on Botanical Dietary Supplements*** – This Center is operated as a collaboration between ISU and the UI College of Medicine. The key area of activity is R&D on botanical dietary supplements with a distinct focus on anti-infective and anti-inflammatory characteristics of phytochemicals from Echinacea, Hypericum and Prunella. It should be noted that the work of this Center also supports the "One Health" infectious diseases platform. The multi-disciplinary center brings together expertise at ISU and UI in natural products chemistry, metabolomics, bioinformatics, nutrition and immunology and is supported by NIH funding.
- ***Center for Crops Utilization Research (CCUR)*** – In addition to its activity in industrial bioeconomy products development, CCUR also maintains active R&D programs dedicated to adding value to Iowa's food and feed crops. In the advanced foods arena, CCUR has well established programs in the development of natural antioxidants and nutraceuticals, advanced soy-based foods, and advanced starch biosynthesis and corn fractionation products. CCUR actively engages industry in co-sponsored projects.
- ***Center for Designing Foods to Improve Nutrition (CDFIN) –*** This Center represents an initiative focused on ***improving*** animal and plant food fat content and enhancement of health-protectant factors in the human food supply.
- ***ISU Nutrition and Wellness Research Center*** – This center is predominantly focused on exercise and behavioral aspects of human nutrition, as opposed to the development of specific food or nutraceutical products. However, the resources of the Center represent a potential asset for

application to clinical studies and efficacy studies in relation to advanced food products, botanical supplements and nutraceuticals.

- ***University of Iowa College of Public Health*** – UI's College of Public Health contains a specific program focused on nutrition and has clinical research facilitation capabilities.

Underpinning much of ISU's expertise in the field is the Food Science and Human Nutrition Department jointly administered by the College of Agriculture and Life Sciences and the College of Human Sciences. With more than 40 faculty, this is a significant Department for ISU and President Gregory Geoffrey has called it "the strongest food science and human nutrition program in the nation, without question."[8]

It should be further noted that while much work in human nutrition focuses on plant-based advanced food and food supplement products, a large proportion of human diet comprises meat products. This is an area in which ISU, in particular, is internationally known with the Department of Animal Science's Meat Science Program and ISU Meats Laboratory being very well regarded internationally.

Niche areas for Iowa

While food ingredients represent a large scale commodity market for Iowa, it should be noted that even advanced packaged foods sold on supermarket shelves still have to compete in a relatively low-margin market. In comparison, packaged dietary supplement and nutraceutical products sell in a higher margin environment and represent potentially higher returns to investment. The work of the Center for Research on Botanical Dietary Supplements is the most focused effort in Iowa for the development of nutraceuticals and identification of functionally active phytochemicals for use as dietary supplements and health promotion agents, with complementary work performed by the CCUR. It is likely that the expertise of UI Pharmaceuticals in solid dosage pharmaceutical preparations could be applied across sectors into the development of nutraceutical products also.

"Open Platform" for Bioscience-Based Economic Development in Iowa

The above four platforms represent robust platforms for Iowa—leveraging significant R&D core competencies with state industry capabilities and a line-of-sight to large-scale market opportunities. These four platforms do not, however, represent Iowa's only opportunity areas for biobased development. Biosciences research at ISU and UI is broad and deep and innovation and associated development opportunities may present themselves in a variety of niche bioscience areas. Because of this, Battelle recommends that the steering committee have an "open platform" available for review and potential support of innovative ideas, concepts and technologies across the biosciences.

There are, for example, notable programs of research and development in Iowa that while smaller in size than the four major platforms still represent excellent opportunities for biomedical and bioscience-based development. For example, biomedical imaging, especially image analysis and the development of image analysis tools, is a distinct area of expertise at the University of Iowa. Indeed, with 11 engaged faculty, the University may have the largest image analysis group in the nation. A master agreement with Siemens in biomedical imaging stands as a testament to the significance of biomedical imaging expertise at UI. Such smaller but significant clusters of bioscience expertise should be paid attention to and not ignored because of primary attention focused on the four main platforms.

Iowa's Competitive Position in the Biosciences

Iowa has made significant progress in growing both its bioscience R&D base in specialized niche areas and its industry cluster. Indeed the state is well positioned to capitalize on rapidly expanding markets for advanced foods, personalized medicine and a wide range of bio-based products. But realizing the opportunities described above will require that Iowa maintain a competitive position in the biosciences and address any gaps in its bioscience infrastructure that exist. To maintain its competitive position, Iowa must ensure that the state has a robust bioscience R&D infrastructure, a significant pool of bioscience talent, and capital markets able to support bioscience companies through all stages of their development. Iowa's position with regard to each of these areas is discussed below.

Research and Commercialization Infrastructure

Why It's Important

To become a major bioscience center, a state or region must have a strong, world-class higher-education presence, with leading-edge researchers and clinicians in the medical, life, and biological sciences, as well as veterinary and agricultural sectors. Medical centers and teaching hospitals, multidisciplinary centers, and modern facilities, well-equipped for state-of-the-art research, are hallmarks of a respected regional bioscience center today.

Bioscience research programs can flourish only if they have world-class researchers and access to an excellent physical infrastructure. This infrastructure includes state-of-the-art laboratory facilities and equipment, telecommunications capacities, computer systems and software, and the buildings to house all of these elements. It also includes the creative use of land and other holdings in support of the R&D enterprise.

But in addition to having a robust bioscience R&D enterprise, the research community must be committed to commercializing research discoveries and have at their disposal a support infrastructure to enable them to successfully develop and introduce new products or services and start-up new businesses.

Iowa's Situation

The 2004 report identified Iowa's strong academic bioscience R&D base as a key strength but it also identified actions to be taken to enable the R&D enterprise to continue to grow and to further support the development of the state's bioscience industry cluster. The roadmap called for:

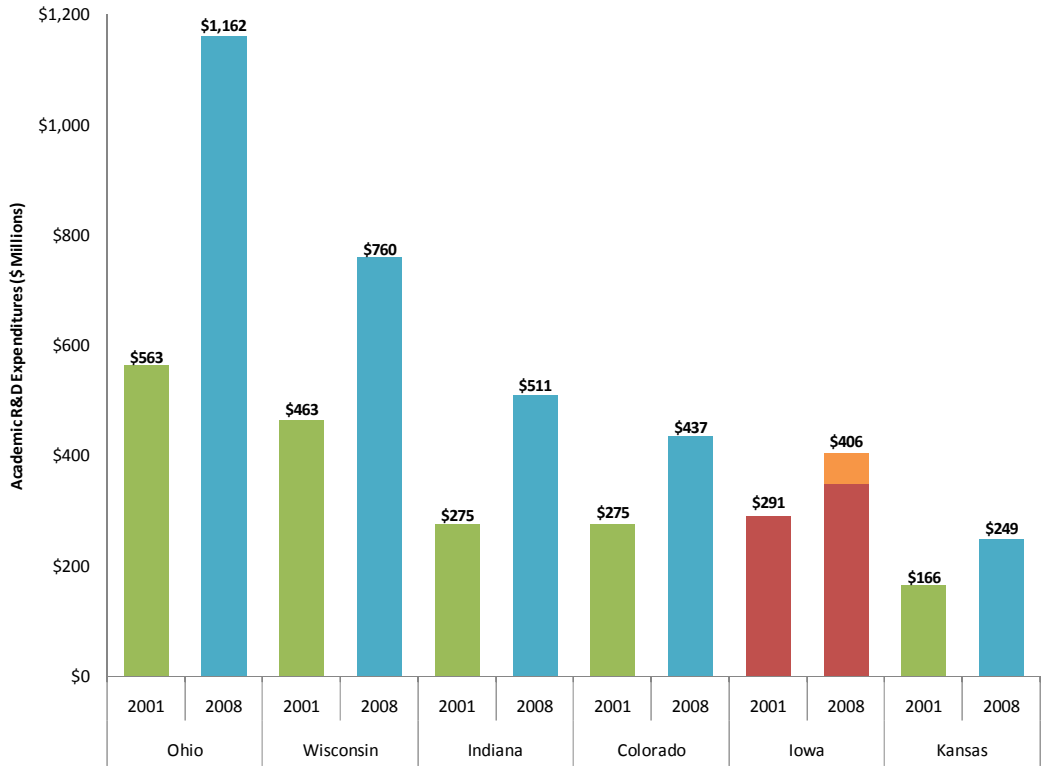
- Strengthening certain research areas with additional faculty, research personnel, equipment and resources
- Encouraging and rewarding faculty for R&D that leads to translational discoveries

- Encouraging and rewarding faculty and staff work in commercialization and collaborations with industry partners
- Providing incentives to encourage the formation of collaborative consortia to accelerate growth of the state's targeted bioscience platforms.

As discussed above, significant progress has been made to address these issues. Major investments have been made in bioscience R&D facilities and the universities have increased support for faculty entrepreneurship and commercialization. Industry-university collaborations have also increased.

At the same time, however, the state's academic bioscience R&D base has not kept pace with growth at the national level. Between 2004 and 2008, academic bioscience R&D grew 13.8 percent in Iowa as compared to a 22.3 percent increase at the national level. Iowa's bioscience academic R&D expenditures totaled more than $450 million in FY 2008, but this is less than a number of peer and competitor states. See Figure 12. Iowa will need to continue to invest to expand its bioscience R&D enterprise in order to remain, not only nationally but globally competitive.

Figure 12: Academic R&D Expenditures in Iowa & the Benchmarks, FY 2001, FY2008



Source: NSF Survey of Research and Development Expenditures at Universities and Colleges. Calculations for Iowa Academic R&D include $55 million from the University of Iowa that was not included in NSF data due to reporting differences.

Iowa's universities have taken significant steps to encourage faculty entrepreneurship, facilitate commercialization, and streamline technology transfer, but it is generally acknowledged by both the business and academic communities that more could be accomplished by increasing partnering and collaboration between the academic community and Iowa businesses.

Talent

Why It's Important

Ensuring the availability of an educated, skilled workforce is pivotal to developing and sustaining a highly competitive, robust bioscience cluster over the long term. Those states and regions that effectively address bioscience workforce needs will be in a stronger position to grow and develop their bioscience clusters. It is consistent across occupations and careers in the biosciences that the skills required extend beyond high school, even for production- and technician-level workers. Nearly all bioscience careers require post-secondary education that combines scientific principles and applied laboratory techniques. High school bioscience career–related programs are best viewed as a first step in a structured pathway to bioscience careers, based on industry standards and closely aligned with post-secondary education offerings.

Factors Driving Bioscience Workforce Needs

- Fast pace of innovation drives new skill development in the biosciences—stronger emphasis on technology skills along with bioscience knowledge
- Critical skill shortages can emerge quickly and pose major impediments to industry growth in niche areas
- Breadth of biosciences—involving research, manufacturing, and services—drives broad workforce skill demands
- Post-secondary education for bioscience positions, even in more production-oriented activities, is important
- Specific cross-cutting occupational skills are needed in good laboratory and manufacturing practices

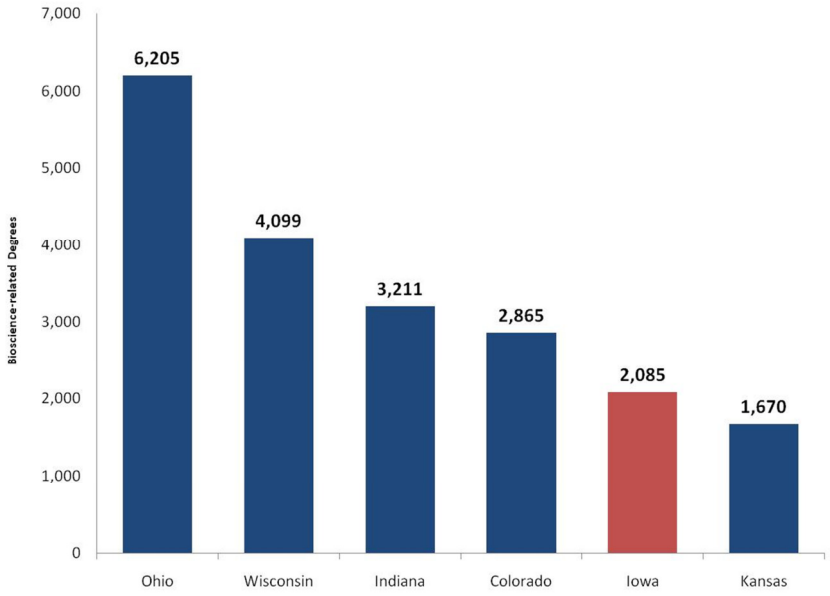
There is also a strong demand on bioscience workers to be lifelong learners who readily pick up new skill sets. Critical skill shortages can emerge quickly in the biosciences and pose major impediments to industry growth in particular niche areas. For example, developing new "biologic" drugs requires new biopharmaceutical production technologies and skills. Bioscience industry analysts at McKinsey and Company point out the impact of workforce gaps for this growing area of biotechnology: "What is less well understood is the biologics-manufacturing talent shortfall: the industry faces a looming shortage of the highly trained people needed to design, build and operate facilities. Experienced process-development scientists and engineers, validation engineers, quality assurance personnel and plant managers are already in short supply."[9] These same dynamics can be true in other niches, from medical devices to health care delivery.

States have become very active in addressing the talent needs of the bioscience sector. Across the board, states are implementing new program offerings at all levels of education, including K-12, community college, undergraduate, and graduate; new programs combining business with biosciences; and new types of degree offerings to address the need for people with expertise in regulatory affairs and clinical trials. New bioscience and biomedical institutes have been formed, some of which are multi-institutional; and specialized science and technology high schools and biotechnology magnet programs have been instituted. States are working with the biosciences industry to develop career pathways in the biosciences, offering programs to equip teachers with bioscience skills and knowledge, and encouraging existing workers to retrain for careers in the biosciences.

Iowa's Situation

In 2008, Iowa educational institutions awarded 2,085 bioscience degrees, 75 percent of which were at the bachelor's level. The majority of the degrees (1,033) were in the biological sciences; 411 were awarded in biomedical sciences and engineering and 387 were awarded in agricultural, food, and nutrition sciences. Only Kansas, among the benchmarks awarded fewer degrees than Iowa.

Figure 13: Higher Education Degrees in Iowa and the Benchmarks, AY 2008



Iowa's bioscience executives suggested that Iowa's workforce is both a strength and a challenge. Iowans have a strong work ethic and are excellent workers. But finding more senior talent can be a challenge and firms often have to recruit people willing to relocate to Iowa. Some company representatives, particularly those located in more rural areas, expressed serious concerns about meeting their future workforce needs in Iowa. It is clear that Iowa must consider ways to develop, recruit and retain bioscience talent.

Capital

Why It's Important

Most people realize that the discovery of new knowledge resulting in the development of new technologies is a very expensive process running, in some cases, into millions of dollars. What many people do not realize is that the costs associated with developing and taking a technology product or service to market are also very substantial. Major costs incurred after the research has been completed include the cost of assessing the market to determine the competition, the likely market, and the price points for competitive advantage; developing a prototype; preparing a marketing and sales plan; and scaling up for manufacturing. Finally, actual product distribution, sales, and marketing must be

undertaken. These activities require the availability of sufficient capital to finance business growth and economic development.

While these needs apply to all technology-based companies, many bioscience companies, at least those involved in biomedicine, need to access larger amounts of capital for longer time periods to cover the time needed to complete clinical trials and obtain regulatory approvals before products can be introduced into the market.

Yet, few sources of funding bridge the gap between the points at which (1) a discovery has been identified and demonstrated and (2) a business case has been validated and venture or other debt capital can be obtained. It is also difficult to obtain seed and early-stage investment because venture funds, as they have become larger, tend to make larger, later-stage investments. As a result, angel investors have also moved downstream (further away from pre-seed and seed investments), making more post-seed and later-stage investments than previously. This trend has been exacerbated during the recession which has caused venture firms to invest primarily in their portfolio companies who do not have other options for accessing capital. So, in addition to the difficulty of obtaining translational research and pre-commercialization funding, firms are facing a gap at the start-up phase, as well.

Iowa's Position

Lack of available capital for bioscience firms was identified as a key challenge facing Iowa in 2004. The 2004 report found that:

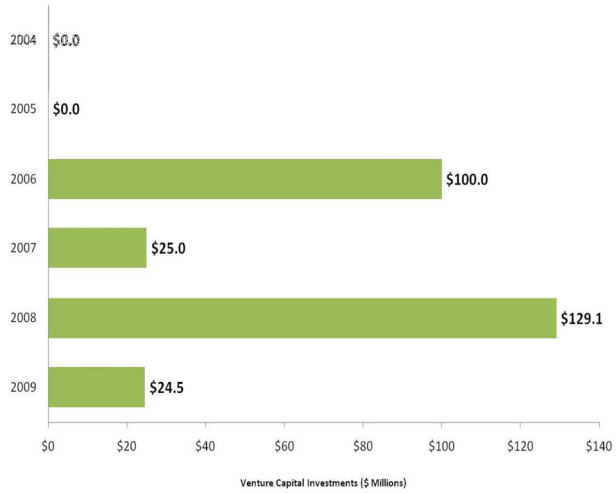
- Pre-seed/seed capital and prototype development funds were very limited in Iowa.
- While the state had some venture capital and angel investors, very few were willing to consider bioscience investments.
- National venture capital firms generally lacked interest in and awareness of Iowa bioscience investment opportunities.
- Iowa's philanthropic community is limited and not focused on investing in economic development.
- Agriculture-related organizations were a source of funding for value-added agriculture and other agbioscience endeavors.
- The Iowa Values Fund and other state initiatives were available to support business development initiatives.

In 2006, the legislature provided $8.2 million to fund projects at the Regent Universities designed to build research capacity around the bioscience technology platforms identified in the 2004 strategy. The funds were used to support proof-of-concept activities. The universities report that these funds were very beneficial, leveraging additional funding of about $49.5million, and helped to support faculty entrepreneurship and commercialization but the dollars dedicated to this activity were limited and are no longer available. A number of initiatives were taken to address the need for seed and venture capital. The Iowa Fund of Funds became operational, raised $10 million and committed $30 million to seven venture funds that agreed to make a good faith effort to invest in Iowa companies. Iowa also implemented two tax credits, the angel investor credit and a credit for investing in seed funds, to

encourage private venture investments. A number of new angel funds were created in Iowa, approximately 10 of which are still active.

Between 2004 and 2009, $278.6 million in venture capital was invested in Iowa bioscience companies; however, $222 million of this total was invested in one biofuel company. See Figure 14. The vast majority of these investments, 207.8 million was in acquisitions, with only $3 million or one percent invested at the seed stage.

Figure 14: Iowa Bioscience Venture Capital Investments, 2004–2009



Iowa Companies Receiving Bioscience Venture Capital Financing, 2004-09	
Company	Investments ($ in Millions)
Renewable Energy Group	$221.9
NewLink Genetics	$37.5
MediNotes	$7.9
Asoyia	$4.0
KemPharm	$3.9
Catilin	$3.0
Global ID Group	$0.5

Unfortunately, some of the initiatives put in place to address the need for early-stage capital are no longer available. In 2009, the legislature reduced the tax credit authorization for the Iowa Fund of Funds to $60 million, and eliminated the angel investor and seed capital tax credits. Access to early-stage capital remains a challenge for Iowa's bioscience companies and entrepreneurs.

Critical issues to Address

Iowa must continue to build its bioscience research base in its targeted platform areas and efforts should continue to increase the flow of research discoveries into the commercial marketplace. Iowa must continue to put in place a comprehensive approach to advancing bioscience talent development and actions are needed to continue to develop the state's risk capital markets.

Realizing Iowa's Bioscience Potential

Iowa's public and private leadership has developed the following Vision for Iowa's bioscience future.

> ***By 2020, Iowa's bioscience industry is a key driver of the state's economy, providing high-wage jobs and a high quality of life for its citizens. Iowa has a robust cluster of companies and a highly talented workforce that are developing innovative products that provide nutritious and healthy foods, renewable sources of energy, sustainable and environmentally-friendly products and medical innovations that promote wellness and health care.***

Achieving this Vision will require strong leadership and long-term commitment on the part of Iowa's research and higher education institutions, business community, economic development organizations, and state and local governments. Iowa must commit to:

- Invest in its research and industry base to achieve world-class leadership in targeted bioscience fields
- Accelerate the commercialization of research discoveries to benefit the growth and expansion of existing and formation of new businesses and jobs.
- Create a culture that supports and encourages entrepreneurship and new firm creation by:
  - Nurturing talent
  - Fostering capital formation
  - Forging public and private partnerships.

The following set of strategies and actions are proposed to achieve Iowa's Bioscience Vision.

Strategies and Actions

Iowa must continue to grow its bioscience R&D base, create and grow new companies based on new discoveries emerging from that R&D, and create a climate in which established bioscience companies can grow and prosper by ensuring that they can meet their talent and capital needs in the state. Four strategies are proposed to achieve Iowa's vision of having a very robust bioscience industry cluster.

- **Strategy One:** Invest aggressively to build Iowa's bioscience R&D enterprise around the state's key bioscience platforms and incentivize commercialization of bioscience discoveries in Iowa
- **Strategy Two:** Build Iowa's Risk Capital Market
- **Strategy Three:** Develop Iowa's Bioscience Talent Pool
- **Strategy Four:** Create a business climate that is supportive of bioscience firm growth and expansion

Each strategy and the actions proposed to achieve it are described next. It is anticipated that most of these strategies and actions would be implemented during a 5-year period, with some continuing for as long as 10 years.

Strategy One: Invest aggressively to build Iowa's bioscience R&D enterprise around the state's key bioscience technology platforms and incentivize commercialization of bioscience discoveries in Iowa

Action One: Provide adequate resources to Iowa's universities to enable them to recruit and retain bioscience faculty and invest in bioscience R&D infrastructure

Rationale

As discussed throughout this report, Iowa's research universities are the foundation on which Iowa can build its bioscience economy. Iowa's public and private sectors have made significant investments in the state's bioscience R&D infrastructure since the original strategy was developed in 2004, positioning Iowa to be a national and international leader in key areas of the biosciences. In recent years, however, cuts in state funding for higher education are threatening Iowa's universities' ability to not only attract but retain key researchers. If Iowa is to continue to grow its bioscience R&D enterprise, a prerequisite for growing its bioscience industry cluster, adequate funding must be available to support and retain world-class faculty and researchers and to provide the state-of-the-art facilities needed to house them.

Wisconsin Seeks to Grow Its Bioscience Industry by Investing in Wisconsin Institutes for Discovery

Wisconsin Institutes of Discovery (WID), an initiative begun as part of Governor Doyle's "Grow Wisconsin Plan" of 2003, is a partnership of the Morgridge Institute, a newly endowed private-nonprofit dedicated to human-health research, and the public Wisconsin Institute for Discovery, a multidisciplinary program of the University of Wisconsin. The three-building physical campus-within-a-campus was financed by $50 million donated by the Morgridge family, $50 million from the state, and $50 million from the Wisconsin Alumni Research Foundation, the exclusive patent, licensing and commercialization/tech transfer agent for the University of Wisconsin System that regularly recycles its earnings into programs of the UW Graduate School. While the WID also embraces IT and nanotechnology, a strong third thrust is on clinical and translational medical research, including collaboration with the nearby Wisconsin Institute of Medical Research. The first tower of WID opened in 2008. A second building is under construction and a third is in the planning and development phase. Physical construction will be accompanied by 100 "cluster faculty hires."

Proposed Action

It is proposed that Iowa's bioscience community develop and pursue a legislative agenda to ensure adequate funding to enable the state's research universities to continue to grow the bioscience technology platforms identified in this strategy. Consideration should be given to developing an initiative that would provide funding, through grants and/or loans, for faculty recruitment and retention as well as for facilities and buildings. One of the factors that sets Iowa apart in the bioscience arena is the number of research centers and pilot facilities available. As noted previously, no other location in the country has such a complete suite of capabilities for bioeconomy development. Continued

investment will be required to ensure that researchers have access to the latest equipment and core labs needed to support their work.

Additional investment will also be needed to provide facilities that facilitate interactions and collaborations between university researchers and their counterparts in the private sector. The universities should be encouraged to continue to expand their mixed use research park campuses to house bioscience companies, educational facilities and research operations. Additional incubator and accelerator space will be needed to house start-up and emerging bioscience companies.

Action Two: Continue to streamline technology transfer processes and incentivize the state's research institutions to increase support for technology transfer and commercialization

Rationale

The 2004 strategy called for developing and implementing policies and procedures that actively encourage faculty entrepreneurship and commercialization activities at the regent universities. It also called for increasing funding to the regent universities to allow for sufficient staffing and resources for commercialization activities. Much progress has been made in implementing these recommendations. The University of Iowa established its Iowa Centers for Enterprise whose mission is to "foster economic development by connecting experts, entrepreneurs, and innovators inside and outside the University." IOWA Centers for Innovation includes the John PappaJohn Entrepreneurial Center, the Office of Corporate Partnerships, the UI Research Foundation, a Small Business Development Center, and the university's incubators and research park. In the last five years, the University launched an Entrepreneur-in-Residence program that matches experienced serial entrepreneurs with start-up companies created around university-developed technologies. ISU and NIU have also increased their technology transfer and commercialization efforts during the last five years. But, changing a university's culture to be more entrepreneurial is not an easy process. While positive changes have been made and university leadership is supportive, these efforts need to be continued and expanded in order to realize the potential economic impact that the universities could have on Iowa's economy.

Proposed Action

It is proposed that Iowa's research universities be encouraged to continue the efforts that have already begun designed to encourage faculty to be entrepreneurial and to streamline the technology transfer process. Specifically, it is proposed that

- Entrepreneur-in-residence programs be continued and expanded
- Sufficient resources be allocated to support technology transfer operations
- Efforts be undertaken to promote an entrepreneurial environment for faculty and researchers
- Programs be put in place to educate researchers on the commercialization process.

Action Three: Provide funding for assessing the commercial potential of university-developed technologies and advancing those judged to have commercial potential

Rationale

Proof-of-concept (PoC)/commercialization funding refers to funds needed to do the additional prototype development, clinical research, and testing and development needed to prove that a technology has commercial potential. Such funding is usually provided in the form of a grant that does not require any repayment. Such funding is often needed to commercialize university-owned IP at the highest value—and sometimes to license it at all—as such technology usually is at an early stage of development and requires additional studies, sometimes involving animal trials, or in the case of engineering discoveries, a working prototype, before it can be shown to have commercial value. It also is often necessary to surround the original discovery with additional patents and protections. Such activities are almost never fundable through conventional peer-reviewed federal programs and, if they are to take place at all, must be separately funded under a different set of criteria focused mainly on economic development. Companies seeking to develop a product or process also often require funding for PoC activities.

Thirty-three states reported offering PoC funding in 2008.[10] About half of these programs fund university principal investigators and/or for-profit companies. Ten or slightly less than a third of the programs fund university principal investigators only in an active university/industry partnership, and eight fund for-profit companies only in an active industry/university partnership. Seven of the programs provide funding to university technology transfer programs.

Between 2007 and 2010, Iowa's research universities received Grow Iowa Values Funds that could be used to support commercialization projects. The universities report that these funds have been very valuable in preparing research discoveries for commercailization.

Georgia Research Alliance's VentureLab Program

GRA's VentureLab was created to move university technologies out of the lab and into the marketplace and to grow university-based start-up companies in Georgia. To accomplish these goals, GRA awards the following:

- Phase I grants (up to **$50,000**) to university researchers to answer the question, "Is it commercially feasible to build a company around this technology?"
- Phase II grants (up to **$100,000**) to university researchers to continue prototype development and formulate a company.
- Phase III loans (up to **$250,000**) to eligible VentureLab companies that have a fully executed license from the university. These companies must also have Georgia-based management. The noncollateralized loan has favorable repayment terms and conditions.

Since 2002, GRA has evaluated the commercial potential of more than 300 inventions or discoveries at universities. The most promising of these were awarded VentureLab grants to help fund the technology research necessary to further develop the invention or discovery. This process has led to the formation of more than 80 early-stage companies that employ more than 450 people and have attracted $300 million in private equity investment.

Proposed Activities

It is proposed that Iowa continue to provide funding to faculty researchers and/or start/up bioscience companies to support PoC activities. These funds could be used to support the following:

- Translational research
- Prototype development

- Testing
- Due diligence
- Market research
- Business plan development.

Action Four: Create a university/industry matching grant program

While Iowa bioscience companies recognize the excellence found in the state's research universities, business executives indicated that their interactions with the state's universities were not as deep as might be desired. It was suggested that Iowa can further build its bioscience industry cluster by building sustained relationships between the state's bioscience companies and its research universities. One way to accomplish this is to provide funding for collaborative university/industry research projects. Such projects help build relationships between researchers and companies and provide support for activities that help to move technology to the point where private investment capital can be obtained. Twenty-eight states and Puerto Rico reported having programs that provide financial support for university/industry partnerships in 2008.[11] Grow Iowa Values Fund can be used to support university/industry collaborative projects but no program exists that is dedicated to encouraging and supporting such partnerships.

Proposed Activities

It is proposed that Iowa create and fund an industry/university research partnership program. The program would award funds on a statewide, competitive basis to support faculty conducting research for industry partners. Start-up companies licensing technology from an Iowa university and established companies licensing technology to create a new product or business line would also be eligible for an award. State funding must be matched on a one-to-one basis by the private partner. Awards would be up to $100,000. The program would be targeted to projects that are both technically sound and likely to have positive economic impact.

Maryland Industrial Partnerships Program

The Maryland Industrial Partnerships Program (MIPS) has a proven track record of working with industry to accelerate technology commercialization by funding collaborative university/industry product R&D projects. MIPS projects are conducted by university faculty and graduate students in conjunction with company researchers. With more than $160 million awarded to more than 400 companies since 1987, MIPS projects have generated solid results.

MIPS-supported products have generated more than $19.5 billion in sales, added jobs to Maryland, and exported state-of-the-art Maryland-originated technology into the global marketplace. Products developed with MIPS support include MedImmune's Synagis,® which prevents a respiratory disease in infants, and Martek Biosciences' additive for infant formulas, which is currently available in 79 countries. Total sales of Synagis® since 1998 exceed $6.4 billion.

Source: University of Maryland, MTech Web site http://www.mtech.umd.edu/mips/projects/success_stories.html

Action Five: Hold technology partnering events to showcase university-developed IP that is available for commercialization

Rationale

Often, emphasis is placed on creating start-up companies to commercialize university-developed technologies. While this is one route to commercialization, it is often a long and difficult journey that requires success in putting together an experienced management team and obtaining substantial amounts of high-risk capital. Iowa is fortunate to have a base of very established, globally competitive

bioscience companies, many of which would have the resources to more easily introduce new products or services into the market but most bioscience executives indicated that they were unaware of potential technologies that might be available for licensing from the state's universities.

Proposed Action

It is proposed that technology partnering events be held to showcase university-developed IP that is available for commercialization. These could be in-person events that would feature presentations by faculty members and provide opportunities for one-on-one meetings between researchers and industry representatives or they could be held virtually. Ideally, this effort would involve multiple approaches. Showcases could also feature networking and poster sessions as well as tours of facilities to make businesses more aware of the facilities, equipment and expertise available to them. Technology showcases could be sponsored by individual Centers or Institutes and held at different sites throughout the state.

Strategy Two: Build Iowa's Risk Capital Market

Action Six: Enact legislation reinstating the angel investor and seed capital tax credits

Rationale:

Both in 2004 and 2010, lack of locally-based risk capital for bioscience companies is a key challenge facing Iowa. Iowa was at the forefront of states that used tax policies to encourage private investment in early-stage companies and in funds that make early-stage investments. In 2002, Iowa enacted legislation creating the Qualified Business or Community-based Seed Capital Tax Credit, which provided a 20 percent tax credit for equity investments made in a qualified business or community-based seed capital fund, i.e. to angel investors. This credit reached its lifetime cap in 2008. Also in 2002, Iowa enacted its Venture Capital Tax Credit, Iowa Fund of Funds that provided contingent tax credits for investments made in the Iowa Fund of Funds. The aggregate contingent tax credit cap was reduced from $100 million to $60 million in 2010. The Iowa Venture Capital Tax Credit—Venture Capital Funds was also created in 2002. It provided a 6 percent tax credit

Wisconsin enacted a major package of venture investment tax credits under Act 255 in 2004, under which, qualifying angel—both individuals and angel networks (An angel investment network is a group of accredited investors organized for the sole purpose of investing in a single Qualified New Business Venture)—and venture capital investors in Qualified Small Business Ventures (as certified by the Department of Commerce) may receive tax credits of 25 percent. Qualified businesses include biotechnology firms. The annual statewide pool of credits was tripled to $18.25 million for the angel credit and $18.75 million for the venture credit in 2009.

The credit appears to be having an impact. In 2003, the average Wisconsin angel investment was $158,000 in 11 deals; in 2008, the average Wisconsin angel investment was $283,000 in 53 deals. Wisconsin angel investors invested $15 million in 2008 and $22.1 million in 2009 in Wisconsin companies. Wisconsin had 6 angel networks in 2003; this number had grown to 22 angel groups in 2009, 14 of which made investments in 2009.

for equity investments in a venture fund approved by the Iowa Capital Investment Board. This credit was repealed in 2010.

Proposed Action

It is recommended that Iowa enact legislation to reauthorize an angel investor tax credit and to also reinstate the tax credit for investment in seed capital funds. The credits should be designed to address issues raised by the Tax Credit Review Panel in its report issued on January 8, 2010, which called for greater transparency of tax credits, eliminating transferability and establishing a 5-year sunset. It is recommended that an annual cap be established for both programs. The credits should be modeled on successful policies being implemented in other states, such as Wisconsin. See text box.

Action Seven: Create a state-funded but privately-managed bioscience seed fund

Rationale

The majority of Iowa's bioscience start-up companies are at a very early stage of development. As a result, they need access to early-stage seed capital more so than to later-stage venture capital. This is the money needed to obtain third-party validation of technology, to develop prototypes and to test market products or services. Yet there is little such capital available to Iowa's bioscience entrepreneurs. A variety of approaches can be taken to grow a locally-based seed and venture capital industry. The most common approach to creating a seed fund is for state government to capitalize the fund. In some cases, state funds are invested in partnership with other investors, including universities, medical centers and private foundations. In other cases, the seed fund is funded entirely with state funds but may seek co-investors.

Proposed Action:

It is proposed that state and private funds be used to fund a privately-managed bioscience seed fund. An example of such a fund is the Kentucky Seed Capital Fund, which was launched in 2005 with more than $5 million in funding provided by the University of Louisville Foundation, the state's Commonwealth Seed Capital Fund, and Humana Inc., which each invested $1 million. Additional investors included Baptist Hospital Systems, Jewish Hospital & St. Mary's Healthcare, Kosair Charities, the James Graham Brown Foundation, and the Kentucky State District Council of Carpenters Pension Trust Fund. The fund invests in early-stage Kentucky or Louisville metropolitan-based businesses that specialize in biomedical and healthcare services, medical device development and healthcare IT. The Kentucky Seed Capital Fund is managed by a private firm. In its first year of operation, the KSCF invested in three companies founded by University of Louisville scientists.

Action Eight: Undertake an aggressive SBIR outreach and technical assistance effort and provide matching funds for Phase I awards

Rationale

The federal Small Business Innovation Research program and its smaller Small Business Technology Transfer program (SBIR and STTR) represent over $2.5 billion in grant and contract opportunities for small firms to develop innovative products and services in response to national needs. Between 2005 and 2009, 79 Iowa companies (39bioscience companies) received $20 million in SBIR/STTR awards. ISU's

Office of Intellectual Property and Technology Transfer (OIPTT) provides information on SBIR opportunities via an SBIR newsletter. OIPTT also helps companies identify solicitations and can assist in writing proposals and reviewing them for technical, financial and business content. Iowa could leverage even greater capital by providing more in-depth assistance as well as financial assistance to SBIR applicants.

Proposed Action

It is proposed that Iowa expand its SBIR outreach efforts and provide increased technical assistance, including offering workshops on preparing SBIR applications, reviewing SBIR applications, connecting companies with university researchers and larger companies interested in the technology area, and offering a mentoring process with those who have been successful in winning SBIR awards. In addition, it is proposed that Iowa provide matching funds of up to $100,000 to companies that have won Phase I SBIR awards. The matching funds, which could be awarded on a competitive basis, would encourage more firms to apply for SBIR Phase I awards; increase the intensity of the R&D performed in Phase I, thus better positioning the firms to compete for Phase II awards; and help bridge the gap between Phase I and Phase II funding.

Action Nine: Continue and enhance the Demonstration Fund

Rationale

Iowa's Demonstration Fund provides up to $150,000 to encourage commercialization activities by small and medium-sized Iowa companies in the advanced manufacturing, biosciences, and information technology industries. The fund is designed to encourage product refinements, market planning and market entry activities of unique products to foster competitive, profitable companies that create high-paying jobs and wealth in Iowa. Companies must match the award with at least one dollar of non-state funding for every two dollars of state funding.

The Demonstration Fund is viewed as an effective tool for promoting the growth of Iowa's emerging bioscience firms.

Example of Demonstration Fund Award

Performance Biolubes, located in Cedar Falls, is an 18 month old Iowa startup company that is the emerging leader in bio-based metalworking fluids. The company has provided solutions to stabilize plant-based oils, stabilize water-soluble coolants and reduce the cost of water-soluble coolants by 40 percent. With the help of a $150,000 award from the Iowa Demonstration Fund, Performance Biolubes will implement a scaled up version of their new manufacturing process in their Cedar Falls facility.

Proposed Action

It is proposed that the Demonstration Fund be continued and expanded to meet the current need. It is also recommended that clearer criteria be established for selecting projects for funding. Concern was expressed by some that the program has become more risk averse and as a result may not be funding the most promising companies. Selection criteria and the review process should be examined to assure that the program is supporting innovation in Iowa's small and medium size companies.

Strategy Three: Develop Iowa's Bioscience Talent Pool

Action Ten: Continue and expand efforts to improve STEM education

Rationale

Workforce development is a critical requirement of the bioscience industry in Iowa and elsewhere. In a study of bioscience education achievement, Iowa ranked highly among the states in terms of student achievement in the biosciences. Iowa ranked 5th among the states in term of its average ACT Science score in 2008 and 9th among the states in terms of the percentage of students that tested as ready for college-level biology in 2008.[12] While Iowa appears to be doing a better job than many other states in preparing its students in science and math, it is also the case that only 27.3 percent of its 8th grade students tested at or above proficient in the science component of the National Assessment of Educational Progress in 2005. In order to create a talent pipeline to meet future bioscience workforce needs, Iowa must produce a sufficient supply of graduates who are proficient in math and science.

Proposed Action

The Board of Regents, State of Iowa and the Iowa Legislature established the Iowa Mathematics and Science Education Partnership (IMSEP) in early 2007. UNI leads the initiative in collaboration with the UI and ISU. IMSEP has four core programs:

- Math and science teacher real world internships — Summer-long paid internships for current science and math teachers in business and industry to update skills while modernizing the curriculum. In 2010, 33 teachers participated in the program; it is proposed that the program be expanded to include 50 participants in 2011.
- Project Lead The Way® (PLTW) expansion — A national pre-engineering curriculum package for middle and high school students to learn science and math through engineering is being implemented in more than 100 Iowa high schools. This effort should be expanded to include the biotechnology engineering curriculum. UNI is also offering a curriculum that will allow teachers to graduate with PLTW certification.
- A special STEM community college teaching certificate program is being offered at ISU to address the shortage of math and science instructors at community colleges.
- I-Teach project: to recruit more talented and diverse candidates to math and science teaching. Offers tuition-waived courses exploring teaching, followed by paid internships in educational settings with mentors.

In addition to coordinating these core programs, the IMSEP promotes and coordinates business-school partnerships, studies and reports on state science and math education trends, and promotes science and technology careers through multimedia assets for schools and other educational entities. Initiatives, such as those supported by IMSEP, should be continued and expanded.

Action Eleven: Increase student awareness of local bioscience opportunities through internships and other activities that expose students to Iowa's bioscience industry

Rationale

A student internship program is one of the best mechanisms for retaining graduates. A 2010 survey of the 884 members of the National Association of Colleges and Employers revealed that 86.5 percent of employers surveyed have an internship or co-op program. Furthermore, more than 50 percent of interns accept full-time employment with the company for whom they interned.[13]

Student internships can serve to establish relationships between bioscience employers and students in Iowa. Such internships can enhance the educational experience for students, providing them the opportunity for enriched, real-world problem solving, something that bioscience executives said was needed and not necessarily being provided to students. Companies not only get to raise their profile on college campuses, but also have the opportunity to receive new ideas and energy from students involved through various mechanisms.

Proposed Action

The Iowa Student Internship Program, which is administered by IDED, provides grants to small and medium-sized companies in the advanced manufacturing, biosciences, and information technology industries to help support their internship programs with a goal of transitioning the interns to full-time employment in the state upon graduation. Students enrolled in Iowa's community colleges, private colleges and regent universities and Iowa high school graduates who attend college out of state are eligible for the program. The state pays $1 for every $2 paid by the awards. Students must be paid twice the minimum wage and awards are available up to $3,100 for a single internship. This program should be actively marketed to both students and companies.

Iowa's bioscience companies should be strongly encouraged to implement internship programs as many of the state's larger companies already do. The state's universities should work with bioscience companies to identify internship opportunities and help match students to them. Consideration should be given to establishing a single, user-friendly and accessible web site that would list bioscience positions and internships available throughout the state.

Action Twelve: Initiate an effort to identify and address bioscience workforce education and training needs

Rationale

In Iowa, as elsewhere, bioscience executives indicated that many of the programs offered by colleges and universities are not producing the skills required of their workers. For their part, the colleges and universities do not have information on the skills that are needed or the demand for different types of education and training programs. In addition, resources are limited to initiate new course and degree offerings.

Proposed Action

Over the long term, Iowa needs a bioscience workforce effort that has the resources to work alongside education and training providers to help create the programs, curriculum, instructional labs, and teacher professional development that respond to the specific needs of the bioscience industry. As a first step in developing a systematic approach to bioscience workforce development, it is proposed that Iowa undertake an asset mapping exercise to identify the state's bioscience employers and document their skill needs. If sufficient demand exists, resources should be made available to enable Iowa's universities and community colleges to develop new curriculum working in partnership with the state's bioscience companies.

Strategy Four: Create a business climate that is supportive of bioscience firm growth and expansion

Action Thirteen: Review and refine Iowa's economic development programs to focus on innovation and high value-added industry growth

Rationale

Iowa has invested significant resources in its economic development programs in the last 7 years. The Grow Iowa Values Financial Assistance program, which is funded at $10 million annually, is the funding source for projects that are focused on job creation or retention, value added agriculture and entrepreneurial efforts. Between July, 2003 and February, 2010, IDED awarded 579 job creation or retention projects at a total cost of $12.4 billion. The GIVFA program, like most traditional economic development programs, places a heavy emphasis on job creation and retention as criteria for selecting projects for funding. But often times, technology-based companies, including bioscience companies, are not necessarily creating large numbers of jobs. Rather they are creating very high-skilled, high wage jobs. Focusing primarily on job creation may mean that funds are less likely to be used to support higher-risk but also potentially higher impact projects.

Proposed Action

It is proposed that Iowa conduct a comprehensive analysis of the state's economic development portfolio of programs to determine if there are programs or policies that should be amended and/or enhanced to ensure that Iowa is able to support the growth of innovative, technology-based companies. This analysis should also seek to identify gaps in the state's economic development infrastructure that should be addressed to accelerate the growth of the state's targeted industry clusters.

Action Fourteen: Better market and support Iowa's entrepreneurial support initiatives

Rationale

Iowa has a number of excellent entrepreneurial support programs that assist start-up and emerging companies. These include the John Pappajohn Entrepreneurship Centers (JPEC), Small Business

Development Centers (SBDC), local economic development agencies, local accelerators and programs directly administered by IDED. In 2005, IDED engaged Battelle to conduct an assessment of Iowa's entrepreneurial support infrastructure. The study concluded that while Iowa had many effective entrepreneurial support programs, most of the programs were underfunded and organizations were not functioning as a unified network of support services. The report went on to say that "while each of these programs can contribute, more could be accomplished if they are able to leverage each others resources and present a seamless delivery system for entrepreneurs."

Since that time, the Iowa Entrepreneurial Network (IEN) was created. It is a statewide collaborative, staffed by IDED, designed to 1) identify deal flow, 2) provide direct technical and management assistance services, and 3) link capital sources to accelerate technology commercialization and business formation for the targeted industries of advanced manufacturing, biosciences and IT. The IEN provides information on the resources available to Iowa entrepreneurs in a single on-line location. In addition, the entrepreneurial support organizations work together as a network referring clients as appropriate. The issue that hasn't been addressed is that many of these efforts lack scale due to limited resources.

Proposed Action

It is proposed that the state of Iowa create a program that would provide financial support on a competitive basis to organizations to enable them to provide comprehensive, intensive, in-depth commercialization services to technology entrepreneurs and early-stage technology companies. The types of commercialization services to be provided would include the following:

- Assisting with organizational documentation, preliminary technology and market assessments, and start-up strategic planning
- Providing management and in-depth business planning support to technology entrepreneurs and start-up companies
- Linking companies to mentors
- Conducting due diligence
- Providing consultation and ongoing entrepreneurial education
- Preparing companies to seek venture financing
- Linking companies to sources of capital
- Supporting development of angel networks.

Ohio's Entrepreneurial Signature Program

Ohio's Third Frontier (OTF) is a $2.3 billion initiative designed to grow Ohio's technology-based economy. OTF supports applied research and commercialization, entrepreneurial assistance, early-stage capital formation, and expansion of a skilled talent pool that can support technology-based economic growth. Under its Entrepreneurial Signature Program, OTF has funded six organizations to provide entrepreneurial support services in a specific geographic region of the state. Each ESP represents a comprehensive, coordinated network of high-value services and assistance providers that is visible and easily accessible to technology-based entrepreneurs and small tech-based companies throughout its region. Each ESP provides an approach that tightly integrates sources of deal flow, entrepreneurial support, and capital to effectively grow the technology-based entrepreneurial commercialization outcomes throughout its region.

Consideration should also be given to providing small amounts of capital to be used to establish pre-seed funds as most successful commercialization support programs have access to small amounts of pre-seed capital.

Action Fifteen: Provide in-depth support to bioscience entrepreneurs and start-up companies

Rationale

State efforts to develop a bioscience cluster, or any technology cluster, usually include a focus on providing support to individuals who are trying to get a new venture off the ground. Entrepreneurs and the managers of start-up companies need access to management talent, technology, capital, professional expertise, and a host of other services. They often need assistance in determining economic feasibility and identifying markets and distribution channels. They may also need access to specialized equipment and laboratories and to expertise to solve technical issues that arise during product development. They must be able to recruit key personnel and have access to pre-seed capital.

Support services that bioscience entrepreneurs value include business mentoring by experienced CEOs who have succeeded in growing a bioscience company; in-depth assistance in preparing to present a business plan to potential investors; connections to sources of capital at the pre-seed, seed, and later stages; and help in forming a business team of managers with commercial vision. Bioscience CEOs also often need advice in finding lab space and dealing with regulatory and other issues that are specific to the bioscience sector.

Proposed Action

While Iowa does not have a large pool of serial bioscience entrepreneurs, the state does have a large number of established bioscience companies with senior managers who have spent their careers in the bioscience industry. It is proposed that a bioscience mentoring network be established that could link these seasoned industry experts with emerging companies to advise them on issues that arise related to technical problems, marketing, regulatory affairs and other issues.

To address the needs that arise in launching a new bioscience venture, it is proposed that a statewide Bioscience Executive-in-Residence program be established. An Executive in Residence program would make seasoned executives with experience as CEOs, chief executive officers (COOs), and marketing officers available to leaders of start-up companies.

Action Sixteen: Enhance and extend the R&D Tax Credit

Rationale

Iowa is one of 38 states that offer an R&D tax credit. Such credits can be very valuable for bioscience firms that are research-intensive and whose products have a long development cycle. The availability of an R&D credit can also influence where a major corporation with multiple locations conducts its R&D. Iowa is one of only seven states in which the R&D tax credit is refundable meaning that a business that does not have any tax liability can exchange its unused credits with the state for a percentage of the value of the credit. This makes the credit of greater value to start-up bioscience firms that often are not profitable for a number of years. Iowa's refundable R&D tax credit offers the state a competitive advantage in seeking bioscience development.

Proposed Action

It is proposed that Iowa retain its R&D tax credit as well as its refundability provision. Consideration should also be given to increasing the size of the credit if the research is conducted by an in-state university. In Nebraska, for example, the state offers a refundable R&D tax credit that is equal to 15 percent of the federal R&D credit. Legislation passed in 2009 increases the credit to 35 percent if the research is performed by a Nebraska university. Most states put a cap on the total level of R&D tax credits that can be issued in a single year. Iowa's R&D tax credit does not presently have a cap although it is one of several tax credits managed by IDED that in total have a tax cap of $120 million per fiscal year. If desired, a tax cap could be adopted for the R&D tax credit. The amount of the cap should be set based on prior year demands.

Action Seventeen: Develop and implement a marketing and branding strategy

Rationale

In marketing for bioscience industry development, it is important to recognize that the opportunities in the biosciences are actively being pursued by many regions across the nation, as well as by other countries. While Iowa has a strong bioscience industry presence, the state is not currently recognized as a leader in the biosciences. It is important for Iowa to distinguish itself in this increasingly competitive environment by undertaking a branding and marketing effort to make both people within the state as well as outside the state aware of the state's bioscience strengths and assets. It also is important to demonstrate and communicate that companies and institutions coming to Iowa will find a supportive environment in which they can thrive in finding the talent, research, and commercial relationships and access to capital and specialized facilities that are critical to growing a successful bioscience company.

Proposed Action

Iowa's bioscience community should work to develop a common theme that can be incorporated in state marketing materials as well as those of the various organizations that are committed to growing the state's bioscience sector. An active earned media campaign should be undertaken following release of this strategy. Having articles appear in newspapers and magazines nationwide describing Iowa's plans to build its bioscience industry will play a key role in changing the state's image. The placement of such articles, however, will require an active public relations outreach to key publications and the active development of news stories.

St. Louis BioBelt

In 2001, St. Louis embarked on its "BioBelt" campaign to create an image of itself as a leading center for plant and life sciences. Since that time, the St. Louis region has gained recognition as the nation's leading center for plant sciences and a major center for life sciences. As a result, East and West Coast venture firms are paying greater attention to the region and the region has been chosen to host major plant and life science conferences, such as the Ag Innovation Showcase, a leading global event for agricultural industry leaders, venture capitalists and entrepreneurs, which was held in St. Louis in 2010.

Iowa should also seek to attract national and international conferences that would bring key bioscience industry officials and leading bioscience researchers to the state. Such conferences can be important not only in that they bring people to see the available assets and resources but they can also focus attention on areas of key strengths.

An internal education campaign also should be initiated to increase Iowa policymakers', legislators' and residents' knowledge and understanding of the biosciences; the role they play in Iowa's economic future; the opportunities they provide for them and their children; and the role new discoveries and inventions will play in their lives. It will be particularly important to brief legislators so that they understand the impact that state investments in education and research and development can have on their constituents. The internal campaign should be aligned with the branding and marketing campaign, but it will require a distinct set of activities. These could include public service announcements, a bioscience ambassador program to reach schools and local civic organizations, regular monthly and quarterly events and a Web site to keep citizens informed of development in the biosciences.

Conclusion

Iowa has made progress on many fronts in growing its bioscience cluster. Bioscience employment has been growing rapidly outpacing growth at the national level and Iowa is a national leader in the agricultural biosciences. In addition, the state has an emerging presence in research, testing and medical labs and in drugs and pharmaceuticals. Significant progress has also been made in advancing the state's biomedical and agbioscience-related technology R&D platforms. While these are positive developments, it must also be acknowledged that gaps remain in Iowa's bioscience infrastructure. Iowa has limited sources of investment capital and bioscience firms struggle to find top management talent. It is time to reassess the state's approach to advancing bioscience development and recommit to investing the resources that will be needed to make Iowa a leader in the biosciences.

Success in implementing this strategy will depend on a number of key factors:

- The commitment of key stakeholders—the academic community, the business community and state and local governments—to implementing the strategy and providing the financial support required to support it.
- The willingness of the state's universities and colleges to work in partnership to develop research excellence in the technology platform areas, something that they have demonstrated they have been willing to do during the last several years.
- The willingness of state government to endorse this strategy, adequately fund higher education, and support economic development policies and programs aimed at helping grow bioscience companies.
- Recognition by both public and private sector leaders that this is a long-term commitment. It will take sustained investment and support to enable Iowa's bioscience industry to be globally competitive and continue to be a key driver of the state's economy.

Looking forward, the biosciences offer enormous potential for linking basic research innovations with new market opportunities. Iowa can seize the opportunities presented by the biosciences and build an industry that will not only benefit economic development but also improve the health and well-being of both Iowans and the global community.

[1] *Battelle/BIO State Bioscience Initiatives 2010*. Full report available at http://www.bio.org/local/battelle2010/main.asp.

[2] This total employment figure may be underestimated given that some of Iowa's seed R&D companies may be classified as farm supply wholesalers and thus would not be included in the data.

[3] *Battelle/BIO State Bioscience Initiatives 2010*.

[4] Please note that definition of the biosciences used in this report differs from the definition used in the 2004 Iowa Bioscience Roadmap, which was broader and included a number of agricultural-related industries, such as agricultural machinery.

[5] This total employment figure may be underestimated given that some of Iowa's seed R&D companies may be classified as farm supply wholesalers and thus would not be included in the data.

[6] *Battelle/BIO State Bioscience Initiatives 2010*. Full report available at http://www.bio.org/local/battelle2010/main.asp.

[7] "National New Biology Initiative Offers Potential for Remarkable and Far-Reaching Benefits". News from the National Academies, September 17, 2009, http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12764.

[8] ISU, Department of Food Science and Nutrition homepage, http://www.fshn.hs.iastate.edu/.

[9] Mallik, A., G. Pinkus, and S. Sheffer. "Biopharma's Capacity Crunch," The McKinsey Quarterly 2002 Special Edition: Risk and Resilience. McKinsey and Company, 2002, pp. 9–11.

[10] *Battelle/BIO State Bioscience Initiatives 2010*.

[11] Ibid, p. 58.

[12] *Taking the Pulse of Bioscience Education in America: A State by-State Analysis*. Prepared by Battelle in cooperation with the Biotechnology Industry Organization and the Biotechnology Institute, May 2009.

[13] 2010 Internship and Co-op Survey, National Association of Colleges and Employers, May 2010, available at http://www.naceweb.org/Reserach.aspx?fid=193&menuID=123&ispub=False&nodetype=2&navurl=.